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PREFACE

World Congress on Conservation Agriculture 7 WCCA7

Nowadays, human being´s demand for the global agriculture is to increase quantity and quality of food production, taking care of environment, using less fossil fuel and purchased inputs, promoting biodiversity, efficiency, resilience, climate change adaptation and mitigation. In the Southern Cone of America, we have been working on addressing this challenge for more than 40 years now. Argentina, Brazil, Paraguay and Uruguay have massively implemented advanced technological, organizational and institutional innovations that have increased competitiveness and productivity with farming systems, which are environmentally friendly.

The world is supposed to produce 50% more food by 2050 using available natural resources efficiently and sustainably while reducing greenhouse gases emissions (GHG) per unit produced. However, some 89% of the current world crop production is managed under conventional tillage based systems, which degrade the environment, are inefficient in terms of resource use, and contribute to global warming. The intensive crop production (cereals and oilseeds) in these four countries is also associated with pastures and other fodder crops for intensive livestock production.

This modern agriculture is based on what is internationally known as Conservation Agriculture, a No-Till System with no soil disturbance, permanently covered soils and diversity in the crops grown including rotation, along with the integration of crop-livestock-tree systems,crop-livestock-agroforestry systems, strategic and balanced nutrition of soil health, integrated management of insects,weeds and diseases with a responsible use of agrochemicals and veterinary drugs.

The rapid adoption of this system particularly since 1990 was possible in part because local companies manufactured machinery adapted to the demands of local farmers. Conservation Agriculture systems reduce soil erosion and degradation, improves rainwater storage in the soil and increases its use efficiency and increases water use efficiency, recovers, maintains and improves soil health, promotes nutrient cycling, reduces GHG emissions, increases carbon sequestration, allows greater and more stable productivity.

Science and technology development are crucial for the challenge to increase production while taking care of environment and human health. Despite scientists, policy makers and others keep discussing how to feed the increasing population on this planet; farmers are not involved centrally in such discussions.

The global Conservation Agriculture Community has more than 40 years of field experience and scientific evidence showing that this revolution began with farmers. Later the scientist community validated and expanded the technology. Conservation Agriculture farmers represent more than 75%

in the Southern Cone of South America but only 11% of total cropland in the world. Therefore, it is the aim of this World Congress on Conservation Agriculture to demonstrate that CA is actually the best tool to mitigate climate change as well as to adapt to the effects of climate change, contributing to food security, promoting resilience and biodiversity and at the same time reversing the trend of soil degradation.

The organizers also wanted to show the needs of having the adequate policies and applied prospective research to take decisions at the same roundtable with farmers. With around 795 million people suffering hunger, most of them living in agricultural areas associated to smallholders and family farming, policy makers have an important role of providing the tools those communities need. In order to accomplish the goal of eradicating hunger there is there is plenty of scientific evidence to show that supportive policies in the agricultural sector pay off better than others when it comes to food security issues. Gender equality, smallholder and family agriculture are also relegated spots of conventional agriculture systems, but it should not be a barrier for adopting more sustainable systems such as Conservation Agriculture, with the collaboration mechanisms and organizations connecting farmers, researchers, educationalists, policy makers and local industries, such as machinery manufacturers across the world.

The organizers intended to bring together at the 7WCCA, farmers, policy makers, scientists and educationalist from all around the world, along with financing organisms, risk brokers and other stakeholders to identify the best solutions for all regions. The 7WCCA, as the global forum gathering the worldwide Conservation Agriculture Community, took place in Madrid (2001), Brazil (2003), Kenia (2005), India (2009), Australia (2011), Canada (2014), and this time is being organized side by side with the 25°Aapresid Annual Congress, consolidated as the most important meeting of technological reference in the Subcontinent and globally recognized, gathering the best experts and proposing a real networking for update, exchange and knowledge of advanced technologies as technical beacon for highlighting future challenges and innovative scenarios to address them.

Organizing Committee 7th WCCA

ON COURAGE, FOR CONSERVATION

By John N. Landers[1]
Dedicated to the World Congress on Conservation Agriculture 7

Throw your plough through the window
And revel in the crash
Of broken glass and paradigms
And non-organic trash

History had many reasons,
Learned from going wrong
But when there is a breakthrough
Don´t listen to the throng

Inventions break the ancient mould
And open up the doors
To spread a new technology
That sets a better course

Man spent a lot of energy
Breaking down the soil
But ploughs and heavy tractors
Give less and less for toil

Horse and ox did not compact
The way a steam plough could
And later, heavy tractors
Turned our soils to pudd.

We´ve burnt the saintly particles
That held our crumbs as bread
And lost organic matter
So our soils are nought but dea

The devil takes the hindmost
And those who don´t evolve
Will pay the price of blindness
And their problems never solve.

Conservation is for soils, sir
Not for clinging on
To now outdated practice
In an everlasting con

So throw your plough through the window
And revel in the crash
Of broken glass and paradigms
And non-organic trash

Amen!

Inspired by seeing the huge increase in earthworms and all soil life that Zero Tillage engenders and Abraham Lincoln, who observed: "A nation which destroys its soil, destroys itself".

©J.N. Landers, 2016

[1]Pioneer of Zero Tillage/CA in tropical Brazil, since 1976, and president of the final plenary session of the First WCCA (2001), whose "Declaration of Madrid" merits a second reading.

SOBRE A CORAGEM, RUMO À CONSERVAÇÃO

Por John N. Landers[1]
Dedicado ao Congresso Mundial de Agricultura de Conservação 7

Jogue seu arado pela janela
E se delicie com o barulho
De vidro e paradigmas quebrados
E livres dos entulhos inorgânicos

A história guarda muitas lições
Aprendidas pelos erros e pela apatia
Mas quando aparece inovação
Não escute as multidões

Inventos quebram velhos padrões
Ao mostrarem novos conceitos
Abrindo muitos portões
Para rumos sempre melhores

Àtoa o homem gastou muita energia
Para deixar o solo em frangalhos
Arados e tratores gigantes
Dão sempre menos para o trabalho

O cavalo e o boi não compactaram
Como o arado a vapor o fez
O estopim? Os tratores ainda mais pesados
Fazem dos nossos solos, um pudim.
Queimamos as partículas santificadas
Que geram os grumos do pão
Ao perdermos a matéria orgânica
Os nossos solos, assim, perecerão

O capeta pega os retardatários
E aqueles que não evoluem
Pagarão o preço da cegueira
E de seus problemas nunca resolvidos

Conservação, meus Senhores, é para os solos
Não para ficar grudado
Em práticas ultrapassadas
De um sofisma eternizado

Jogue seu arado pela janela
E se delicie com o barulho
De vidro e paradigmas quebrados,
Livres dos entulhos de ferro

Amém!

Inspirado ao constatar o incremento incrível em minhocas e outras formas da vida do solo, que engendra o Sistema Plantio Direto. E também pelo ditado de Abraham Lincoln: "Uma nação que destrói seu solo, destrói a si mesma".

©J.N. Landers, 2016

Tradução Inglês-Português por Ricardo Ralisch, Rafael Fuente e Marie Bartz

[1]Pioneiro de PlantioDireto no Brasil tropical, desde 1976, e presidente da plenário final do 1oCongresso Mundial de Agricultura de Conservação (2001), cuja "Declaração de Madri" merece uma segunda leitura.

EL CORAJE, PARA LA CONSERVACIÓN

Por John N. Landers[1]
Dedicado al Congreso Mundial de Agricultura de Conservación 7

Lanza el arado por la ventana
y disfruta el estallido
de cristales y paradigmas rotos
y basura inorgánica

La historia tenía muchas razones
que aprendió de los errores
pero cuando hay un avance
no escuches a la multitud

Las innovaciones rompen los moldes antiguos
y abren las puertas
para difundir una nueva tecnología
que traza un rumbo mejor

El hombre gastó mucha energía
rompiendo el suelo
pero los arados y los tractores pesados
dan menos y menos por el trabajo

El caballo y el buey no compactaban
igual que un arado a vapor
Y más tarde, los pesados tractores
transformaron nuestros suelos en lodo

Quemamos las santas partículas
que sostenían nuestras migas como pan
y perdimos la materia orgánica
Así que nuestros suelos son nada, están muertos

Sálvese quien pueda
aquellos que no evolucionen
pagarán el precio de la ceguera
Y sus problemas nunca se resolverán

La conservación es para los suelos, señor
no para aferrarse
a una práctica ya obsoleta
en una eterna sofisma

Entonces lanza el arado por la ventana
Y disfruta el estallido
de cristales y paradigmas rotos
Y basura inorgánica

Amén!

Inspirado al ver el enorme aumento de lombrices y toda la vida del suelo
que la Siembra Directa engendra y enAbraham Lincoln quien observó:
"Una nación que destruye su suelo, se destruye a sí misma".

©J.N. Landers, 2016

Traducción Inglés-Español por Maria Beatriz (Pilu) Giraudo y Santiago Nocelli Pac.

[1]Pionero de la Siembra Directa en Brasil tropical, desde 1976, y presidente del plenario final del 1er Congreso Mundial de Agricultura de Conservación (2001), cuya "Declaración de Madrí" merece una segunda lectura.

The written language, concepts and opinions expressed in the abtracts in this publication are responsibility of the authors.

The Organizing Committee does not assume responsibility for the data and conclusions issued by the authors.

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EXTENTED ABSTRACTS

ORAL PRESENTATIONS

GLOBAL SPREAD OF CONSERVATION AGRICULTURE: INTERIM UPDATE 2015/16

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ABSTRACT

Conservation Agriculture (CA) is practiced in all continents and in most land-based agro-ecologies, both rainfed and irrigated. In 2013, CA covered some 157 Mha, or 11% of the total global annual cropland, with the spread being split equally between the industrialized regions and the developing regions. Between 2008/09 and 2013/14, the global CA cropland area expanded at an annual rate of some 10 Mha. Continental distribution of CA land in 2013 was: South America, 66.4 Mha (60% of cropland); North America, 54.0 Mha (24%); Australia & NZ, 17.9 Mha (35.9%), Russia & Ukraine, 5.2 Mha (3.2%), Asia, 10.3 Mha (3%), Europe, 2 Mha (2.8%), and Africa 1.2 Mha (0.9%). The CA information base is being updated and will be finalized soon. The updated information will be presented at the 7th World Congress on Conservation Agriculture in Rosario, Argentina in August 2017. The interim updated information for 2015/16 presented in this abstract applies only to annual cropland and is based on several sources: official statistics; no-till farmer organizations; Ministry of Agriculture, NGOs, and well-informed individuals from national and international research and development organizations. It has been possible to update the information base for most countries except: Russia, Ukraine, India, Turkey, DPR Korea, Lebanon, Azerbaijan, Chile, Columbia, Mexico, Venezuela, Mozambique, Kenya, Ghana and Sudan. For these countries, the information from the 2013/14 update is used in this abstract. The global total CA cropland area in 2015/16 is more than 180 Mha, corresponding to some 12.5% of the total global cropland, with the spread being more or less equally split between the industrialized regions (52%) and the developing regions (48%). Overall, the increase in the global CA cropland area since 2008/09 has continued at an annual rate of about 10 Mha, from 107 Mha in 2008/09 to 180 Mha in 2015/16. The global CA cropland area increased by some 68% since 2008/09, and since 2013/14, the increase has been some 15%, based on the interim information. The change in the CA cropland area in the different continents since 2008/09 has been: 40.9% (from 49.6 to 69.9 Mha) in South America; 58% (from 40.0 to 63.2 Mha) in North America; 86% (from 12.2 to 22.7 Mha) in Australia & NZ; 408% (from 2.6 to 13.2 Mha) in Asia; 56% (from 1.6 to 2.5 Mha) in Europe; and 440% (from 0.5 to 2.7 Mha) in Africa.

Keywords: Conservation Agriculture, No-Till, global spread, cropland, update

DESCRIPTION

Conservation Agriculture (CA) is now practiced in all continents and in most land-based agro-ecologies, both rainfed and irrigated, non-organic and organic systems. CA systems include annual cropland systems, perennial crop systems including orchard and plantation systems, pasture systems, mixed annual and perennial systems, agroforesty systems, and rice-based systems.

In 2013/14, CA annual cropland systems covered some 157 Mha, or 11% of the total global annual cropland, with the spread being split equally between the industrialized regions and the developing regions (Kassam et al., 2015). In 2008/09, the CA annual cropland area was 107 Mha (Kassam et al., 2009). Between 2008/09 and 2013/14, the global CA annual cropland area expanded at an annual rate of some 10 Mha.

Continental distribution of CA land in 2013 was: South America, 66.4 Mha (60% of total cropland in the CA countries); North America, 54.0 Mha (24%); Australia & NZ, 17.9 Mha (35.9%), Russia & Ukraine, 5.2 Mha (3.2%), Asia, 10.3 Mha (3%), Europe, 2 Mha (2.8%), and Africa 1.2 Mha (0.9%) (Kassam et al., 2015).

The CA information base is currently being updated and will be finalized soon. The updated information will be presented as a 'work in progress', or as an interim update, at the 7th World Congress on Conservation Agriculture in Rosario, Argentina in August 2017. The interim updated CA area information for 2015/16 presented in this extended abstract applies only to annual cropland CA systems and is based on several sources: official statistics; no-till farmer organizations; Ministry of Agriculture, NGOs, and well-informed individuals from national and international research and development organizations.

It has been possible to update the information base for most countries except: Russia, Ukraine, India, Turkey, DPR Korea, Lebanon, Azerbaijan, Chile, Columbia, Mexico, Venezuela, Mozambique, Kenya, Ghana and Sudan. For these countries, the information from the 2013/14 update is used in this abstract. Also, since 2013/14 update, CA annual cropland systems have been recorded in new countries such as Burkina Faso, Uganda, Ethiopia, Swaziland and Algeria, in Africa; and in Tajikistan, Iran, Bangladesh, Laos, Vieztnam and Cambodia, in Asia.

The incomplete update shows that the global total CA cropland area in 2015/16 is at least 180 Mha, corresponding to some 12.5% of the total global cropland, with the spread being more or less equally split between the industrialized regions (52%) and the developing regions (48%). The continental distribution of the CA cropland area is shown in Table 1.

The change in the CA cropland area in the different continents since 2008/09 has been: 40.9% in South America, (from 49.6 Mha to 69.9 Mha); 58% in North America (from 40.0 Mha to 63.2 Mha); 86% in Australia & NZ (from 12.2 Mha to 22.7 Mha); 408% in Asia (from 2.6 Mha to 13.2 Mha); 5000% in Russia and Ukraine (from 0.1 Mha to 5.2 Mha); 477% in Africa (from 0.5 Mha to 2.7 Mha) and 56% in Europe (from 1.6 Mha to 2.5 Mha).

Overall, the increase in the global CA cropland area since 2008/09 has continued at an annual rate of about 10 Mha, from 107 Mha in 2008/09 to 180 Mha in 2015/16 (Figure 1). The global CA cropland area increased by some 69% since 2008/09, and since 2013/14, the increase has been some 15%, from 157 Mha, based on the interim information for 2015/16.

Table 1: Area of annual cropland under CA by continent – 2015/16:

Continent	Cropland under CA (MA ha)	Per cent of global CA area	Per cent of arable cropland of reporting countries
South America	69.9 (49.6)	39.0 (40.9)	63.2
North America	63.2 (40.0)	35.2 (58.0)	28.1
Australia & NZ	22.7 (12.2)	12.7 (86.1)	45.5
Asia	13.2 (2.6)	7.4 (80.3)	3.8
Russia & Ukraine	5.2 (0.1)	2.9 (5000)	3.3
Africa	2.7 (0.5)	1.5 (447)	2.0
Europe	2.5 (1.6)	1.4 (56.3)	3.5
Global total	**179.5 ( ) 107 in 2008/09**	**100 ( ) 69.2% change since 2008/09**	**12.5* *% global cropland 7.4% in 2008/09**

Source: 2008/09 FAO AquaStat; 2015/16 personal database:

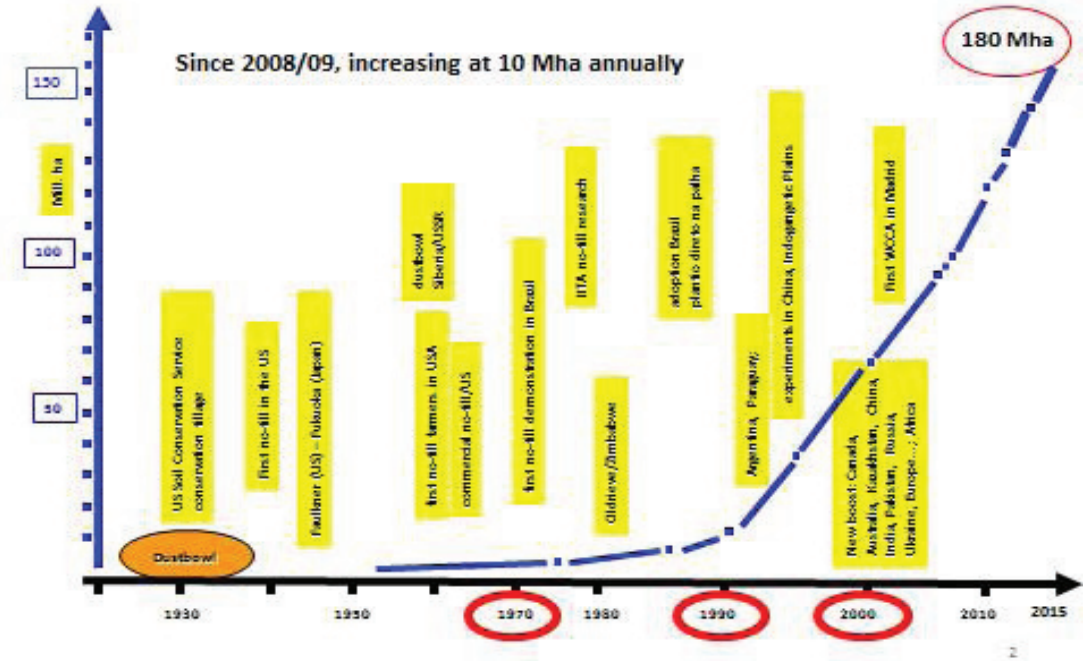

Figure 1: History of global adoption of CA annual cropland systems since 1974 (Mha). (Source: FAO AquaStat; 2015/16 personal database)

In Asia, most of the increase in the CA area since 2008/09 has been in China, Kazakhstan, India and Pakistan. In south Asia, CA-based rice-wheat systems in the Indo-Gangetic Plains are being adopted. In Africa, most of the increase since 2008/09 has been in South Africa, Zambia, Malawi, Mozambique, Morocco and Tunisia. In Europe, Spain, Italy, France and the UK have shown significant increases in their CA area in recent years.

There are now a multiple set of drivers supporting the adoption and spread of CA globally. In the early years, particularly in North and South America, and in Russia and China, the main driver for change was soil erosion and degradation (the dust bawls in America and elsewhere), and this has continued to be so today given the extensive soil erosion and degradation caused by conventional tillage agriculture. Even in the earlier years, drought would exacerbate the situation because degraded and eroded agricultural soils would be more vulnerable to dry periods during the rainy season. This too has continued to be so today, given that there is an increase in the occurrence of extreme events (i.e. droughts) due to climate change.

Since the 1970s, there has been continuing increase in the cost of energy from fossil fuels, and cost of machinery and labour, as well as the cost of production inputs such as mineral fertilizer and biocides (herbicides and all forms of pesticides). Consequently, farmers have been trying to reduce their production costs, and CA has allowed farmers to not only reduce production costs but also minimise erosion, degradation and effects of droughts.

Since 2000, more attention has been paid to combating the loss of ecosystem services and resilience to biotic and abiotic stresses arising from the practice of conventional tillage agriculture. Damage to ecosystem services include: pollution of water due to runoff and erosion, leaching of plant nutrients into the water systems, disruption of all parts of the water, nutrient and carbon cycles, increased emission of CO2 from the soil into the atmosphere, loss of biological nitrogen fixation, and loss of biodiversity and the constituent food webs and food chains below and above the ground, leading to loss wild life and of natural biological control of pests and of pollination services. Through the adoption of CA systems, farmers are bale to reverse these negative externalities and enhance the productivity and resilience of their production systems.

Above drivers of CA adoption and spread are now also serving the global need to mitigate and adapt to climate change, as well as to intensify production sustainably. Equally important is the fact the CA production systems have shown to be relevant and important in pro-poor agriculture development strategies for small-scale farmers particularly in Asia and Africa, but also in Latin America and Europe.

CA systems are becoming increasingly recognized as being climate-smart, and fit naturally as a core production component of climate smart agriculture, offering simultaneously the ability to achieve sustainable production intensification, improve climate change mitigation and adaptability, harness ecosystem services, strengthen food and agricultural security, and contribute to rural livelihoods and national economic growth.

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ADOPTION VS. UTILISATION: BROADENING OUR UNDERSTANDING OF THE UPTAKE OF CONSERVATION AGRICULTURE IN EASTERN AND SOUTHERN AFRICA

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ABSTRACT

Despite the large and ongoing investment in the promotion of Conservation Agriculture (CA) to African smallholder farmers, currently available estimates of adoption provide limited insight into the realities of their use. Both the technologies and their adoption tend to be poorly defined, leading to large variation in estimates and validity issues. To address this void, the Conservation Agriculture Appraisal Framework (CAAF) and the Process of Agricultural Utilisation Framework (PAUF) were proposed as new pathways to explore the utilisation of CA (*Brown et al., 2017 in J. Agricultural Systems*). The CAAF quantifies the intensity of implementation of CA, whilst the PAUF classifies various types of adoption that occur. In doing so, the status of CA is investigated not in a binary manner (i.e. adoption or non-adoption) but a broader utilisation (both type and intensity). Using large CIMMYT baseline surveys across two time periods in five African countries, we extend the application of these two frameworks by: 1] updating the classification system to allow a more robust classification; and 2] applying this updated classification system to a more recent dataset. This allows us to update current estimates of the uptake of CA utilisation, as well as compare and assess patterns of change. By considering in more detail the intensity of implementation and the types of use and non-use, new meaning is found in the status and contributors to limited CA utilisation.

BACKGROUND

Conservation agriculture (CA) has been the focus of nearly three decades of efforts to sustainably intensify African smallholder agriculture. With this focus has come studies that attempt to quantify the uptake of CA. Most of these studies do this through the application of 'adoption' as a binary outcome, either positive (adoption) or negative (non-adoption). This has two major limitations:

1] Uptake isn't a binary outcome, it's a process: Farmers first build awareness, then familiarity. This will either generate disinterest or further interest and experimentation. After assessment, a farmer may disadopt or chose various forms of utilisation (i.e. modification, partial or total use). Such a process is ongoing and may occur at varying intensities making it difficult to classify under a binary framework, particularly noting the importance of incentivised CA adoption in the African context.

2] CA isn't practically framed within a binary classification: In theory, CA is the simultaneous application of three interrelated and strictly defined principles: minimum soil disturbance (disturbed area of less than 25%); stover cover (30% at planting) and crop diversification (>3 crops in rotation; see http://www.fao.org/ag/ca/6c.html). Yet in practice, there is ambiguity on what constitutes CA adoption in the African context (Andersson and D'Souza, 2014) and various definitions applied (e.g. many studies use minimum tillage, zero tillage and conservation agriculture synonymously). Adoption studies are often unclear on how they classify modified use and the intensity of implementation of CA due to their application of binary frameworks.

APPLICATION AND IMPLICATIONS FOR CA

Because of the ambiguity over what constitutes 'CA adoption', currently available estimates of adoption provide limited insight into the practical utilisation by farmers. Comparisons between studies are difficult and substantial variation can lead to questions regarding the validity of CA adoption estimates (Andersson and D'Souza, 2014).

EXPERIMENTAL APPROACH

Instead of 'adoption' with its binary connotations, we propose framing uptake within a process of 'utilisation'. In this context, 'utilisation' is defined as the process of learning of, evaluating, experimenting with and making various utilisation decisions in implementing an agricultural practice. By doing so, it is possible to obtain a deeper and more granular understanding of the uptake of agricultural practices, particularly multi-component and complex practices such as CA.

To do this, we apply two frameworks: the Process of Agricultural Utilisation Framework (PAUF; Figure 1) defines a farmer's status of utilisation via ten stages; and the Conservation Agriculture Appraisal Framework (CAAF) provides a structured nomenclature for CA and quantifies the intensity of CA use through plot and farm level intensity indexes. Detailed information on the conceptualisation of the frameworks can be found in Brown et al. (2017). These frameworks are applied to large household surveys implemented by CIMMYT and local NARS across five African countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) and two time periods (2010 and 2013).

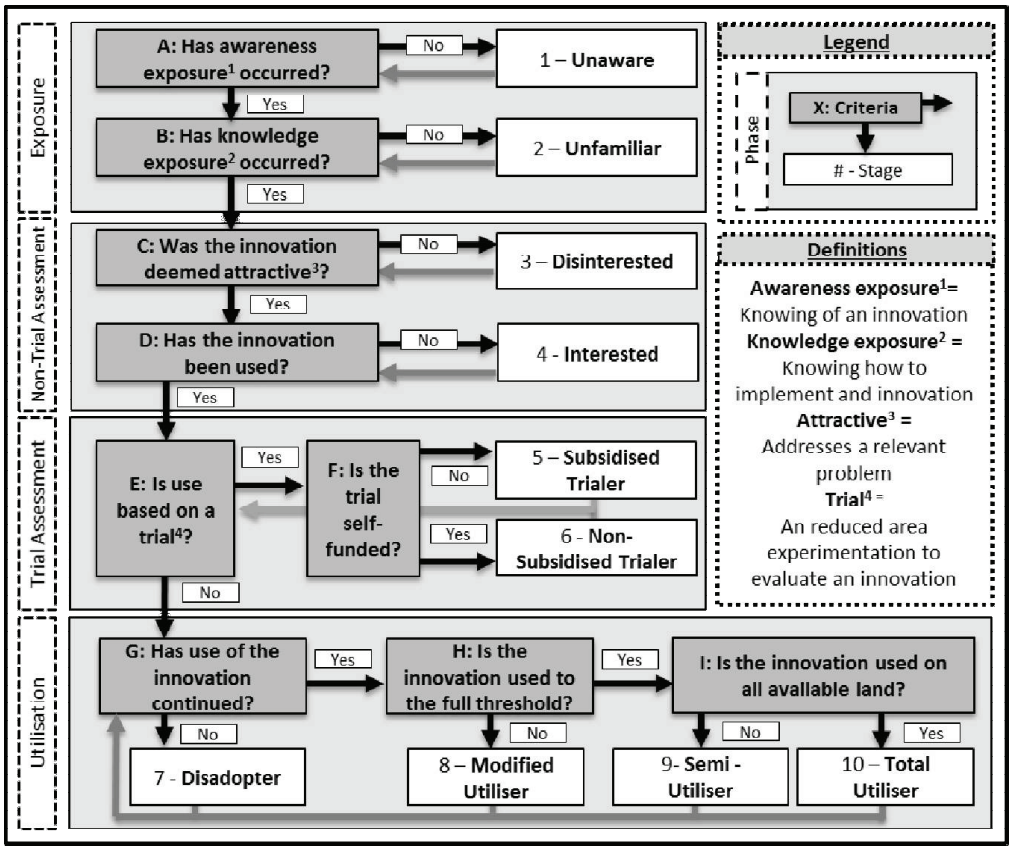

Figure 1. The Process of Agricultural Utilisation Framework (PAUF) proposed in Brown et al. (2017).

RESULTS AND DISCUSSION

Conservation Agriculture in 2010

Under a binary classification where any use of any component at any intensity constitutes adoption, CA was adopted at the following rates: 57% (Ethiopia); 89% (Kenya); 94% (Tanzania); 94% (Malawi); and 98% (Mozambique).

An analysis of utilisation provides an alternate perspective. At plot level, only 0.3% of plots had all three CA components used to threshold levels (see Brown et al., 2017) and 63% had no CA components used to threshold levels. Only 0.8% of plots had three components of CA used (in any intensity) and 52% of plots have no principles of CA used at any intensity. This was reflected in farm level analysis, where modified use represented between 95% and 100% of farmer use of CA. As such, the majority of farmers scored below 10% intensity measured by the CAAF farm index (Figure 2).

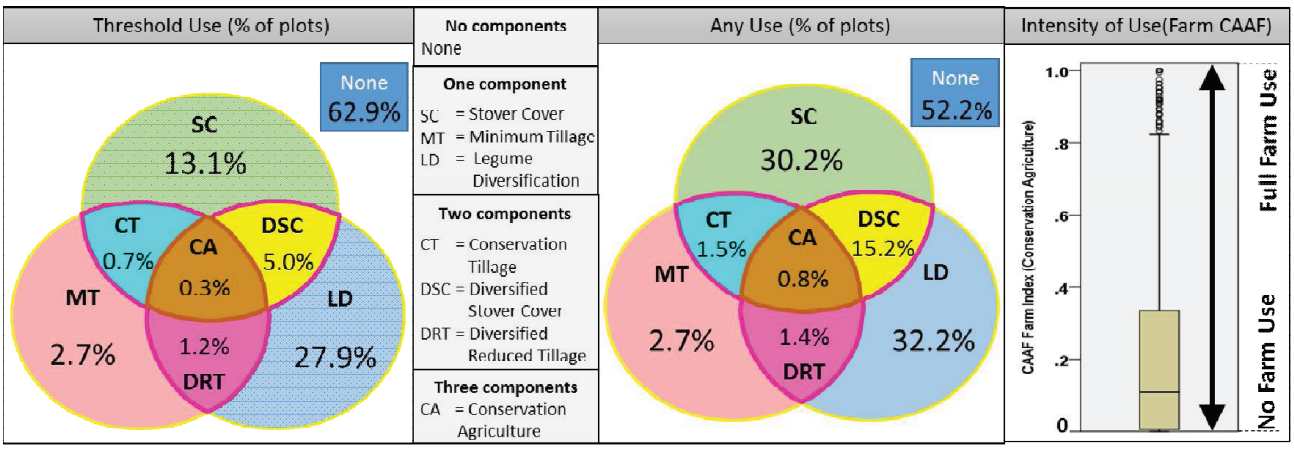

Figure 2. Types and intensity of CA utilisation at plot and farm level (aggregate of five countries) using the CAAF.

Minimum tillage in 2013

Binary adoption of minimum tillage in 2013 was estimated as follows: 3.3% (Ethiopia); 15.4% (Kenya); 27.0% (Tanzania); 4.9% (Malawi); and 9.0% (Mozambique), but a deeper analysis of utilisation provides a more granular understanding of this status. In understanding the types of utilisation, four key themes emerged (Figure 3): 1] substantial constraints to farmers obtaining information on minimum tillage; 2] negative evaluation is common after obtaining information on minimum tillage; 3] issues with advancing farmer interest in minimum tillage through to implementation; and 4] when used, a tendency for minimum tillage to be in highly modified or semi-spatial forms.

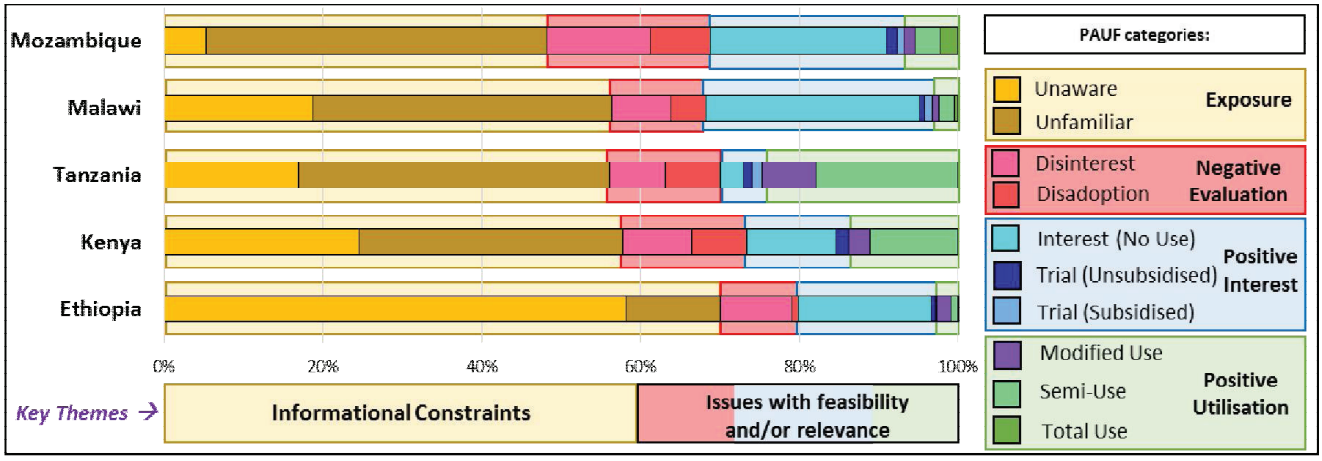

Figure 3. Classification of utilisation types for minimum tillage in 2013 using the PAUF.

CONCLUSIONS

Utilisation of CA is potentially beneficial to the livelihoods of African smallholder farmers, but adoption is only an early step towards this. Our findings highlight the need to move beyond binary analysis of adoption and towards a more nuanced analysis of the process of utilisation in order to generate a deeper understanding of the status of agricultural practices. We find binary estimates

are likely to overestimate the impact of CA, noting the complex multi-component nature of CA and the subsequent dominance of modified utilisation by farmers. By considering in more detail the intensity of implementation and the types of use and non-use, deeper meaning can be found in the status and contributors to low levels of utilisation. Our analysis indicates that to foster the utilisation of CA in the African smallholder context, two key themes will need to be addressed: 1] the benefit, feasibility and relevance of CA to local contexts; and 2] the functionality of informational exchange and extension systems.

FUNDING INSTITUTIONS

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BIOLOGICAL ATTRIBUTES IN AREAS COMPARING NO-TILL SYSTEM, CONVENTIONAL SYSTEM AND NATIVE FOREST

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ABSTRACT

As a technique in search of sustainability in the agricultural sector, No-Till System (NTS) is recognized worldwide as conservation agriculture. Soil Microbial Biomass (MB) is the living and most active fraction of Soil Organic Matter (SOM). The Microbial Quotient (qMic) can be used to qualify SOM. In the presence of good quality SOM, or the absence of stressful conditions to microorganisms' development, there is an increase in MB, as well as in the qMic. SOM and MB Carbon (MBC) can be used as indicators of soil quality, and microbiological indicators have been highlighted by responding quickly to changes in the environment, allowing the adoption of adequate production system. The aim of this work was to quantify MBC and the qMIC in soils of 13 areas under NTS comparing with Conventional System (CS), using as reference a Native Forest (NF). Five samples are collected per area in the Paraná Watershed 3, western region of Paraná State, Brazil, from 0 to 0.2 m. The fumigation-extraction method was used for MBC analysis. Total organic carbon was determined by the method proposed by Walkley-Black. The comparison of means was performed by the Scott-Knott test at 5%. The contents of SOM, MBC and qMic of the Native Forest were statistically superior to the cultivated areas (3.71%, 549.13 mg.kg-1 of soil, e 3.19 %, respectively), reflecting a more favorable condition for the development of soil microbiota. NTS11 presented SOM similar to the NF; this area being classified as good in relation to its management by the Participative Quality Index for the No-Till System (IQP). In this area, the NTS was implanted 24 years ago, without soil disturbance and high intensity of crop rotation. CS19 and CS36, cultivated with cassava and considered conventional by the soil disturbance, showed MBC content 218.81 and 198.55 mg.kg-1, respectively. Only 8% lower than the average of cultivated areas under NTS, but 62% lower than NF! The qMic of NTS12, NTS13, NTS15, NTS16, NTS17 and CS36 were statistically equals to NF, being considered cultivated areas with good biological balance. It was concluded that crop rotation and non-soil revetment favored maintenance of SOM. On the other hand, soil disturbance may accelerate the oxidation of SOM, reflected in an unwanted momentary increase in soil microbiota.

INTRODUCTION

As a technique in search of sustainability in the agricultural sector, No-Till System (NTS) is recognized worldwide as conservation agriculture. Soil Microbial Biomass (MB) is the living and most active fraction of Soil Organic Matter (SOM), and the Microbial Quotient (qMic) can be used to qualify SOM. In the presence of good quality of SOM or with the absence of stressful conditions to microorganisms' development, there is an increase in MB, as well as in the qMic. SOM and MB Carbon (MBC) can be used as indicators of soil quality, and microbiological indicators have been highlighted by responding quickly to changes in the environment, allowing the adoption of adequate farm system.

Recent studies have shown that the soil microbiota can reveal changes in soil quality resulting from soil and crop management in the tropics (BABUJIA et al., 2010; HUNGRIA et al., 2009) before changes in physical and chemical attributes are noticeable (BABUJIA et al., 2010; KASCHUK et al., 2010). The aim of this work was to quantify MBC and the qMIC in soils of 13 areas under NTS comparing with Conventional System (CS), using as reference a Native Forest (NF).

MATERIAL AND METHODS

Five samples are collected per area in the Paraná Watershed 3, western region of Paraná State, Brazil, from 0 to 0.2 m. The fumigation-extraction method was used for MBC analysis. Total organic carbon was determined by the method proposed by Walkley-Black. Microbial quotient (qMic) was estimated as follows: (MB-C/TSOC) x 100 (considering the values corrected to m3 of soil). The Participative Quality Index for the No-Till System (IQP) was calculated according to Roloff et al. (2011). The Soil Strutuctural Quality was calculated according to Ralisch et al. (2017). The comparison of means was performed by the Scott-Knott test at 5%.

RESULTS AND DISCUSSION

The contents of SOM, MBC and qMic of the Native Forest were statistically superior to the cultivated areas (3.71%, 549.13 mg.kg-1 of soil, e 3.19%, respectively), reflecting a more favorable condition for the development of soil microbiota. The results corroborate with Mercante et al. (2008) and Nogueira et al. (2016), where natural ecosystems exhibited higher values of SOM and MBC. Ferreira, Stone and Martin-Didonet, (2017), verified that cropping systems provoke modifications in the microbiological attributes of the soil in relation to the preserved forest areas. NTS11 presented SOM similar to the NF; this area being classified as good in relation to its management by the IQP. In this area, the NTS was implanted 24 years ago, without soil disturbance and high intensity of crop rotation. CS19 and CS36, cultivated with cassava and considered conventional by the soil disturbance, showed MBC content 218.81 and 198.55 mg.kg-1, respectively. Areas under Conventional System presented the worst structural qualities scores (Sq) according to visual assessment methodology. Only 8% lower than the average of cultivated areas under NTS, but 62% lower than NF! The qMic of NTS12, NTS13, NTS15, NTS16, NTS17 and CS36 were statistically equals to NF, being considered cultivated areas with good biological balance.

Table 1. Soil Organic Matter (SOM), Soil Microbial Biomass Carbon (MBC), Microbial Quotient (qMic), Participative Quality Index for the No-Till System (IQP) and Soil Structural Quality (Sq) in areas under No-till System (NTS), Conventional System (CS) and Native Forest as reference (NF) evaluated in the Paraná Watersheed 3, western region of Paraná State, Brazil, from 0 to 0.2 m, June and July 2015.

Area	SOM %	MBC ($mg.kg^{-1}$)	*q*Mic %	IQP	Sq
NF6	3.71 a	549.13 a	3.19 a	-	6.0
NTS11	2.87 a	255.43 c	1.60 b	7.8	2.3
NTS12	2.44 b	320.26 b	2.31 a	7.2	4.2
NTS13	2.38 b	323.76 b	2.44 a	5.8	4.0
NTS14	2.14 b	133.54 c	1.14 b	8.3	4.0
NTS15	1.68 b	336.94 b	3.56 a	7.5	2.5
NTS16	1.65 b	218.81 c	2.42 a	6.8	3.9
NTS17	2.25 b	341.19 b	2.67 a	6.4	4.5
CS19	1.81 b	133.52 c	1.28 b	7.4	1.2
NTS20	2.46 b	180.20 c	1.48 b	7.8	1.9
CS36	1.62 b	198.55 c	2.24 a	5.7	1.7
NTS37	2.68 b	165.92 c	1.03 b	6.3	3.6
NTS38	2.14 b	127.51 c	1.22 b	6.6	3.8
NTS39	2.06 b	177.73 c	1.65 b	5.4	3.9

Means followed by different lowercase letters, in each column, indicate differences (Scott-Knott, at $P \leq 0.05$).

CONCLUSIONS

It was concluded that crop rotation and non-soil disturbance favored maintenance of SOM. On the other hand, soil disturbance may accelerate the oxidation of SOM, reflected in an unwanted momentary increase in soil microbiota.

The No-Till System was effective in providing favorable conditions for the development of the soil microbiota, confirming its position as a Conservation Agriculture technique.

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BLADE SPECIFICATIONS FOR STRIP-TILLAGE ON EXCESSIVELY MOIST CLAY SOILS IN SOUTHERN BANGLADESH

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ABSTRACT

Intensifying cropping on fallow lands during southern Bangladesh's dry winter season is challenged by predominantly clay soils that retain excess post-monsoon season soil moisture. Use of conventional machinery to repetitively till and manually establish crops can delay dry season sowing by days or weeks, precluding timely crop establishment and exposing crops to late-season soil salinity, terminal heat, flash floods, and other risks. Two-wheeled tractors with attachable rotavators are used for strip-tillage by removing some of the tillage blades which allows rapid single-pass strip-till furrow formation and crop establishment. Current practice of using commercially available bent or straight C blades operated at the depth of 50–60 mm however results in either excessive soil throwing (with bent blades) or an incomplete furrow (with straight blades) in the excessively moist clay soil condition. Both result in poor seed coverage, increased seed predation, reduced germination and suboptimal plant stands. This study aimed to improve seedbed furrow quality in the moist clay soils (moisture content of 28.2%, bulk density 1.44 gcm-1). We tested three blade designs (conventional, medium and straight) at 50–100 mm depths in a soil bin. The blades (4 blades/row providing a cutting width of 50 mm and rotor diameter of 342 mm) were operated at 470 rpm and a forward speed of 0.4 ms-1. Both blade design and operating depth significantly affected seedbed furrow depth, width, backfill (loose soil remaining in the furrow after strip-tillage), and production of optimum clods (1–20 mm) and unwanted fines (<1 mm). While none of the blades could produce enough backfill at the cutting depth of 50 mm, use of greater depths produced sufficient backfill only in case of the straight blades. Irrespective of the cutting depth, the all the blades produced a high percentage of optimum clods, but a low percentage of fines. We consequently recommend use of straight blades (slightly longer to provide a rotor diameter of 420–450 mm) and an operating depth of 75–100 mm so that the rotor or blade holders do not touch the ground or hinder residue flows.

BACKGROUND

Bangladesh is the most densely populated country in the world supporting 161 million people on a land area of 130.2 million ha (World Bank, 2015). Due to population growth, urbanization, and demand of land for other non-agricultural purposes, per capita availability of arable land has decreased to one-thirds during the last four decades. In order to continue feeding the growing population, the country has been looking for opportunities to sustainably intensify cropping in the single cropped area of the southern Bangladesh where 1.7 million farming households fallow their lands after harvesting the monsoon rice (Krupnik et. al., 2017). However, cropping on these fallow lands during dry winter season is challenged by predominantly clay soils that retain excess post-monsoon season soil moisture. Use of conventional tillage machinery (e.g. rotavators) to repetitively till and dry soil and later manually broadcast seeds to establish crops can delay dry season sowing by days or even weeks, precluding timely crop establishment and exposing the crops to late-season soil salinity, terminal heat, and early monsoon season storms. Use of conservation agriculture (CA) machinery can play an important role to reduce the turnaround time and produce an additional crop.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Two-wheeled tractors with attachable rotary seeders are becoming increasingly popular among farmers for rapid land preparation and seeding in one or two passes of the seeders. These seeders can be converted in to strip-till drills (e.g. Haque et. al., 2010; Hossain et. al., 2009) and used for CA to reduce costs and turnaround time between crops. This conversion requires removal of 50–83% of the rotary blades to enable tilling only narrow furrows (50–60 mm wide and 50–60 mm deep) while simultaneously sowing seeds in one pass of the seeder. Thus, the strip-tillage leaves the rest of the field undisturbed and covered with crop residues and help conserve soil moisture. Use of these drills can therefore facilitate early crop establishment in relatively moist soil (>80% of field capacity) opening up the opportunity to produce an additional crop during the dry winter season while minimizing costs and increasing farmers' profit potential.

Conventionally used C type blades of the rotary seeders perform well for traditional full disturbance soil tillage. However, their use for strip-tillage tends to result in excessive soil throw out of the furrow producing inadequate furrow backfill[1] resulting in poor seed coverage, increased seed predation, reduced germination, and sub-optimal plant stands. The soil throwing occurs mainly during the exit of the blade by its sidelong section (Matin et. al., 2014). In order to reduce soil throw Matin et. al. (2015, 2016) therefore suggested an alternate blade design (straight blade) for strip-tillage that can reduce soil throw, improve furrow backfill, produce soil tilth optimum for seed germination, and also reduce energy requirement. However, preliminary field test with the straight blades in a moist clay soil of the southern Bangladesh has shown that the straight blades (at the common setting of 4 blades/row, 50–60 mm operating depth) cannot break the soil completely to create a furrow; mere create two independent slots (each 6–10 mm wide) and thus are not suitable for strip-till seeding. Since the soil carrying ability of a certain width of blade is fixed, it is expected that increase in tilling depth would produce a complete furrow while reducing soil throw, increasing backfill and improving soil tilth due to increased re-tillage[2]. Therefore, this soil bin study tested the conventional, straight and medium (shorter sidelong section) blade designs at a range of operating depths to quantify their effect on furrow depth, width, backfill, and soil tilth and recommend a blade design and setting for strip-tillage in excessively moist clay soil condition.

[1]Backfill is defined as the amount (kgm-1) of loose soil (or percentage of the original soil) retained in the furrow after tillage.

[2]Re-tillage is tilling of the same soil more than once (by either more than blade or more than once by the same blade, or both).

EXPERIMENTAL APPROACH

To maintain accurate tillage depths and a uniform soil condition, the study was conducted using the indoor soil bin and seeding test rig facility at the Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. The soil bin was filled with clay soil (47.2% sand, 22.0% silt and 30.8% clay) collected from the field. The soil was watered, spaded, mixed, levelled, and finally compacted with 50 passes of a roller to obtain a 125 mm soil bed ready for testing (1440 kgm-3 bulk density and 28.4% moisture content that corresponds to 85% of field capacity). A two-factor completely randomised design with three replications conducted over time with newly remoulded bins, was thus used for the experiment, with treatments being as follows.

Factor A (blade design) – 3 treatments: conventional, medium, and straight

Factor B (blade operating depth) – 3 treatments: 50 mm, 75 mm, and 100 mm

The forward travel and rotary speeds were maintained at 0.4 ms-1 and 480 rpm (forward rotation), respectively using the rig. The conventional and the medium blades were 43 mm and 23 mm wide, respectively while the straight blades were 4 mm thick. The blades were set for a cutting width of 50 mm (4 blades/row as recommended by Lee et. al., 2003 and Matin et. al., 2014) and a rotor diameter of 355 mm.

Data collection process in the following three days included cleaning away the soil clods thrown outside the furrow, collecting loose soil (i.e., furrow backfill) from a 500 mm furrow section, oven drying the collected soil at 105 °C at least for 24 hours, weighing, and hand sieving through 20 mm and 1 mm sieves. Amount of furrow backfill was calculated as the weight of dried soil collected from the furrow and expressed in kgm-1. Similarly, amounts of large, optimum, and fine clods were calculated as the weight of the dried soil retained on 20 mm sieve, 1 mm sieve, and pan, respectively and also expressed in kgm-1. The furrow center depth and top width were also calculated as mean of readings taken at 10 consecutive locations spaced 50 mm along the furrow run using a 0.5 mm graduated ruler as described by Matin et. al. (2014). The collected data sets were statistically analyzed for variance (F-test).

RESULTS AND DISCUSSION

Analyses of variance (F-test) of furrow parameters (Tab. 1) showed that the furrow width, backfill, and amounts of optimum and fines clods were significantly affected by both the blade design and the operating depth. However, the furrow depth was not significantly affected by the blade design, but by the operating depth. The interaction effect of the blade design and operating depth was significant for all the furrow parameters except furrow width.

Table 1. Analysis of variance of furrow parameters.

Sources of variation	Degrees of freedom	*F-value*				
		Furrow depth, mm	Furrow width, mm	Backfill, kgm^{-1}	Optimum clods, kgm^{-1}	Fines, kgm^{-1}
Blade (B)	2	2.81^{ns}	10.7^{**}	48.6^{**}	48.4^{**}	20.3^{**}
Depth (D)	2	238^{**}	7.57^{**}	25.2^{**}	21.5^{**}	11.2^{**}
B x D	4	6.03^{**}	1.40^{ns}	6.03^{**}	5.81^{**}	4.08^{*}
Error	18					

'*' means significantly different at $p < 0.05$; '**' means significantly different at $p < 0.01$; 'ns' means not significantly different at $p < 0.05$.

Furrow depth and width

The furrow depth increased with the blade operating depth irrespective of the blade designs (Fig. 1, left). All the blades generally tilled furrows slightly deeper than the blade operating depth (except for the straight blade at 75 mm which left uncut bottom ridge along the furrow center). At the 100 mm operating depth, the straight blade produced the deepest furrow. This indicates that the soil failure ability of the straight blade increases at a high operating depth of 100 mm which would help cut complete furrows on excessively moist clay soil condition as found in the southern Bangladesh. Due to the widest sidelong section, the conventional blade produced furrows much wider than that produced by the medium or straight blade (Fig. 1, right) similar to that was observed in previous studies conducted in a sandy loam soil condition (Matin et. al., 2014). This suggests that to obtain a 50 mm wide furrow, the cutting width of blades could be set at <50 mm (e.g. 40–45 mm) to help reduce power requirement and cost of operation.

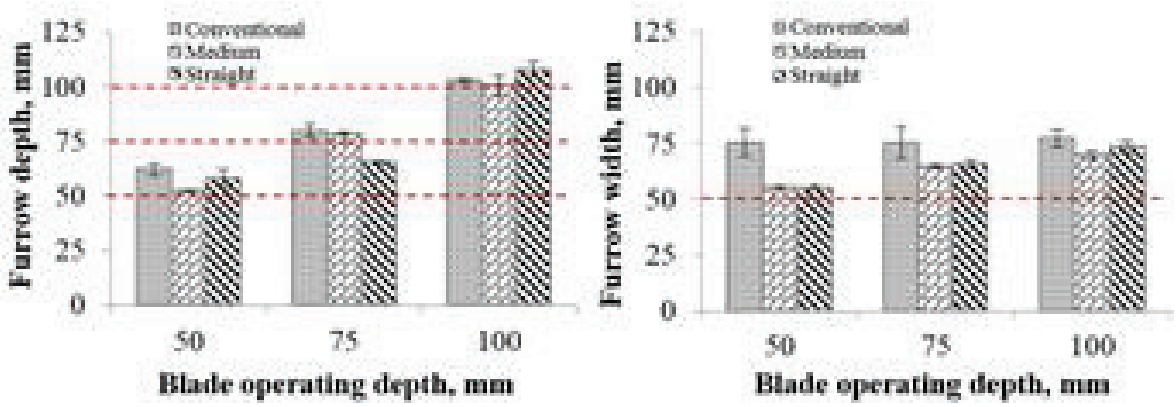

Figure 1. Effect of blade design and operating depth on furrow depth (left) and furrow width (right) (Vertical bars represent standard error of means).

Furrow backfill and soil tilth

As seen from Fig. 2 (left), irrespective of the operating depth, the straight blade produced the highest backfill which was 2–3 times of that produced by the other blades. However, visual assessment suggested that the backfill was sufficient for seed covering only in case of the straight blade at 75–100 mm depths.

Quality of the soil tilth significantly varied due to the blade design or the operating depth. All the blades produced negligible amounts (by ratio 1.1–2.5% only) of fines (Fig. 2, right). This would help reduce the chance of formation of surface crust that frequently observed after irrigating a tilled soil having high percentage of fines. The rotary and forward speeds used in this study provided a short bite length of 13 mm which helped achieve high percentages of optimum clods (65–82%) for all the treatments. Although these percentages were high for the conventional and medium blades, quantity wise they were insufficient to cover seeds (Fig. 2, right). Therefore, considering the straight blades ability to till a complete furrow of desired depth and width that contains high amounts of backfill and optimum soil clods, the study recommends the use of straight blades (slightly longer to provide a rotor diameter of 420–450 mm) and an operating depth of 75–100 mm so that the rotor shaft or blade holders do not touch the ground or rake residues.

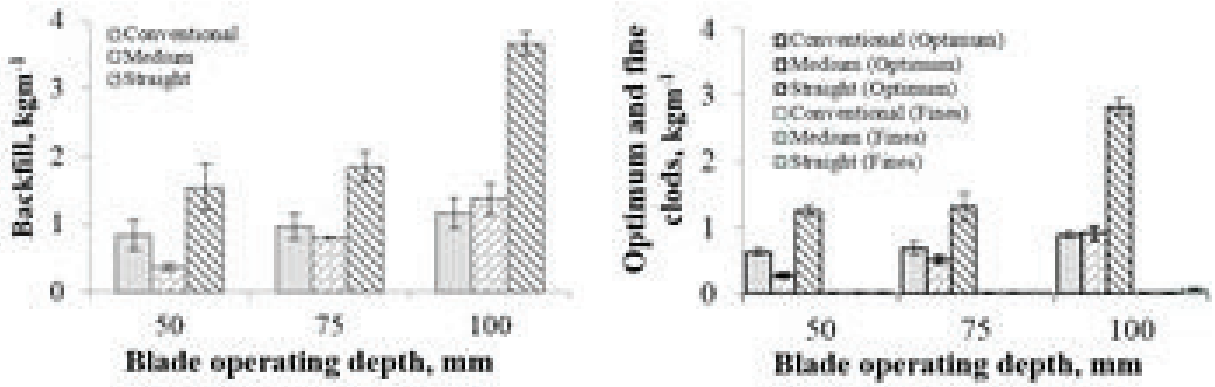

Figure 2. Effect of blade design and operating depth on furrow backfill (left), and soil tilth (right) (Vertical bars represent standard error of means)

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CO-EVOLUTION OF CONSERVATION AGRICULTURE AND WEED MANAGEMENT SYSTEMS IN AUSTRALIAN GRAIN GROWING REGIONS

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ABSTRACT

Australian grain growers are recognised as major adopters of conservation agriculture practices. They are also now recognised for their extensive adoption of weed seed control practices. The availability of cost-effective herbicide options was a major influence on the rate of adoption of no-tillage cropping systems but extensive herbicide resistance soon motivated weed management innovation primarily aimed at managing weed seedbanks. This included practices aimed at killing or removing weed seeds at harvest and herbicide applications specifically targeted at preventing weed seed set. Despite the challenges of extensive and continually increasing levels of herbicide resistance, Australian grain growers have kept in-crop weed populations relatively low while also increasing the intensity of cropping. Using data collected from Australian grain growers, we demonstrate how weed management demands are challenging aspects of conservation agriculture (CA) practice such as full stubble retention, but at the same time are contributing to greater use of another key CA component - diverse crop rotations. We explore the primary drivers in the co-evolution of sustainable weed management and conservation cropping systems, and some emerging new synergies. The study examines patterns of adoption of weed management and CA practices over time, including no-tillage and residue retention, across the major grain growing zones of Australia. Data was primarily drawn from interviews conducted in 2014 with 602 producers selected at random to represent each agro-ecological zone and the major crop types of wheat, barley, oats, canola, pulses and grain sorghum. Emerging practices were included such as chaff tramlining which places residue containing weed seeds on controlled traffic lines, harvest weed seed destruction and inversion ploughing aimed at weed seedbank management. In several major cropping regions over 50% of growers are now using the narrow windrow burning practice aimed at killing weed seeds that pass through the harvester with crop residue. Australian grain growers are shown to invest heavily in practices to keep weed densities low as a management priority. This includes taking a flexible approach when managing the new weed challenges that are evolving under no-tillage systems, with increasing implications for the practice of conservation agriculture.

BACKGROUND

Australian grain growers are recognised as a major adopters of conservation agriculture practices (Kassam et al. 2012), including the use of no-tillage practices across the vast majority of crop land (Llewellyn et al. 2012). They are also now recognised for their extensive adoption of weed seed control practices (Walsh et al. 2017). The availability of cost-effective herbicide options was a major influence on the rate of adoption of no-tillage cropping systems but extensive herbicide resistance in major weeds such as Lolium rigidum soon motivated weed management innovation focused on managing weed seedbanks rather than just preventing yield loss in the year of application (Owen et al. 2014; Boutsalis et al. 2012).

This involved practices aimed at killing or removing weed seeds during or post-harvest late-season and herbicide applications specifically targeted at preventing weed seed set. Despite the challenges of increasing levels of herbicide resistance and weeds adapting quickly to no-till systems (e.g. Kleeman et al. 2013), Australian grain growers have kept in-crop weed populations and consequent crop yield losses due to weeds relatively low while also increasing the intensity of cropping (Llewellyn et al 2016). At the same time they have increasingly foregone pre-seeding weed control opportunities to seed crops earlier to improve water use efficiency in a changing climate. Achieving this has involved what has been described as a flexible and pragmatic approach to conservation agriculture principles (Kirkegaard et al. 2014).

We use data collected from growers across Australian grain growing regions to demonstrate how weed management demands are challenging some aspects of conservation agriculture practice such as full stubble retention and maintaining no soil disturbance, but at the same time contributing to greater utilisation of other key CA components such as more diverse crop rotations. We explore the question of what is driving co-evolution of sustainable weed management and conservation cropping systems, emerging synergies, and what lessons have been learnt about innovation for long-term application of conservation agriculture principles.

APPLICATION AND IMPLICATIONS FOR CA

No-tillage, stubble retention, more diverse crop rotation, earlier seeding and flexible systems have contributed to the cropping system evolution that has maintained productivity despite declines in climatic opportunity (Hochman et al. 2017). To facilitate this, grain growers have given high priority to maintaining low weed seedbanks while continually cropping, even though faced with exceptionally challenging weed issues. This has often required temporarily prioritising weed management needs over otherwise preferred conservation agriculture practices. The rapid and extensive adoption of the narrow windrow burning weed seed kill practice demonstrates this prioritisation and pragmatism. Industry-driven innovation now appears to be in the direction of physical weed seed control that is consistent with preferred CA principles, such as new physical weed seed control technologies that do not require residue loss from the field. The importance of an agricultural innovation system that can not only lead to widespread use of localised CA systems but also be flexible, pragmatic and innovative in adapting to new challenges has been clearly demonstrated.

EXPERIMENTAL APPROACH

The study examines adoption of weed management practices and CA practices, including no-tillage and residue retention over time across all major grain growing zones of the Western (Western Australia), Southern (South Australia, Victoria, Tasmania and Southern New South Wales) and Northern (Northern New South Wales and Southern Queensland) cropping regions of Australia. The data was primarily drawn from interviews conducted in 2014 with 602 producers selected at random to represent each agro-ecological zone and the major rainfed crop types of wheat, barley, oats, canola, pulses and, in the Northern region where summer cropping is possible, grain sorghum (Llewellyn et al. 2016). The extent of use of each practice was collected along with the year that the practice was first used on the farm, allowing trends in adoption across regions to be identified for cropping practices including herbicide and non-herbicide weed control practices.

RESULTS AND DISCUSSION

The annual average annual crop area was 1981ha and a majority of growers have some livestock. A majority (82%) grew either pulses or canola in addition to cereals. In the northern region, 58% grew sorghum. On average, 92% of growers have used no-till (Figure 1) and less than 20% used tillage as part of seeding in 2014 (Table 1). Overall, 71% of growers seeding with prior cultivation cite weed management as a main reason for their use of cultivation. Although no-till is the most common seeding system, in the southern region 27% of land is cultivated at or prior to seeding. Use of some cultivation to kill summer fallow weeds can be common (40% of growers nationally in 2014) (Table 1). This reflects increasing difficulty managing fallow weeds, including those that are tolerant or resistant to the key herbicide glyphosate (e.g. Walker et al. 2011). On farms where fallow cultivation is used, it is often used on over a quarter of the cropping land (Table 1). Increasing use of the double knockdown practice involving two sequential herbicides with different modes of actions also reflects increasing challenges with herbicide efficacy and resistance risk (Figure 1).

As the proportion of growers using no-tillage cropping reaches a high plateau, there has been increasing adoption of practices aimed at controlling weed seed set through pre-harvest herbicide applications (crop topping) or capture and destruction in the harvest process such as narrow windrow burning and to a lesser extent chaff carts (Figure 1). Narrow windrow burning, a practice that involves burning at least half of the crop residue (Walsh and Newman 2007), is shown to be one of the most rapidly adopted non-herbicide weed management practices in Australia, and is already being used by a majority of growers in several districts. Other innovative practices with emerging adoption levels include chaff tramlining where crop residue containing weed seeds is delivered from the harvester to traffic lines, and harvest weed seed destruction using mills fitted to the harvester that crush weed seeds to avoid the need to kill seeds in a separate process (usually burning).

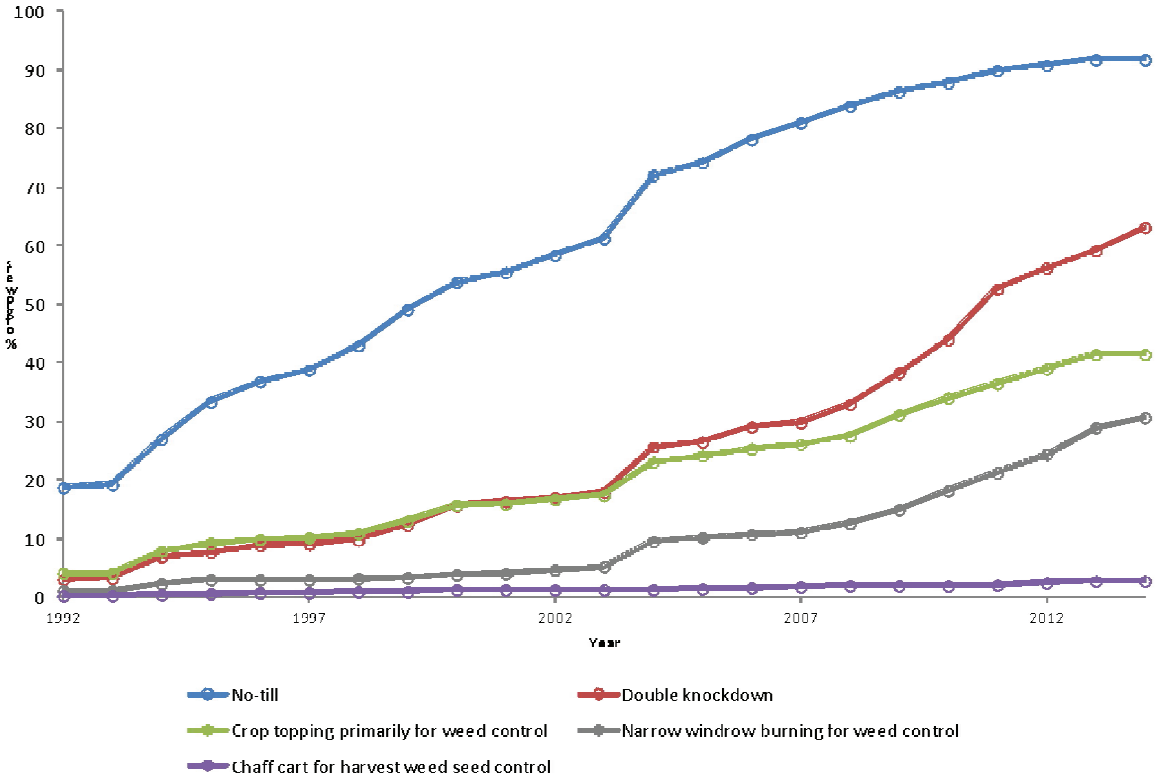

Figure 1. Use of no-till and selected weed management practices by Australian grain growers (showing proportion of growers who have used practice).

Table 1. Use of practices for weed management by grain growers in the three Australian regions.

	South	West	North
Cropping land cultivated prior to or at seeding (i.e. not under zero or no-till) (%)	27	9	20
Growers who cite weed management as the main reason for cultivation prior to seeding as proportion of growers seeding with prior cultivation (%)	67	76	78
Growers who cite weed management as main reason for cultivation prior to seeding expressed as proportion of all growers (%)	30	15	27
Growers using cultivation of fallows primarily for weed control (%)	37	30	66
Area to be cropped that is cultivated during the fallow by users (%)	31	19	28
Growers burning stubble – whole field (%)	52	40	12
Proportion of cropping land burnt by users – not including windrow burning (%)	19	11	3
Growers who cite weed management as the main reason for burning (whole paddock) as a proportion of users (%)	66	68	29
Growers using narrow windrow burning (%)	28	51	4
Proportion of crop area treated with narrow windrow burning by users (%)	23	30	23

Another impact of weeds is on crop sequence and land use decisions. Growers were asked if they would change the areas of what they would grow if they had no weed considerations. In the western region 26% said they would change what they grow; 25% in the southern region and 32% in the northern region. Weed considerations are most commonly leading to greater crop rotation i.e. greater use of legume and canola and reduced cereal crops.

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CONSERVATION AGRICULTURE IN TURKEY: A HOLISTIC APPROACH TO SUSTAINABLE LAND MANAGEMENT AND CLIMATE-SMART AGRICULTURE AND ECOSYSTEMS ADAPTATION TO CLIMATE CHANGE

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ABSTRACT

Turkey is a country with high potential for adopting Conservation Agriculture (CA). In the last few years a number of projects have addressed the issue, especially taking into consideration the need to mitigate and adapt to climate change, whilst improving sustainability of agriculture through the diffusion and adoption of low-carbon technologies with win-win benefits for farmers and the environment. The EU funded project GCP/TUR/063/EC has provided assistance in reviewing the status of CA and developing the national strategy for its promotion in Turkey. FAO as a working agency of Global Environmental Facility is implementing CA within the Konya Closed Basin (KCB) in the framework of the project GCP/TUR/056/GFF. In KCB agriculture leads the local economy. Main crops include: cereals, animal fodder, fruits, vegetables and legumes, and livestock. Konya produces on average 1 M t of cereal with an average of 2,600 kg/ha. The agricultural lands of the region are heavily degraded, being wind erosion a major problem. This has decreased the organic matter of the soil and increased its susceptibility to further degradation. CA principles have been demonstrated in similar conditions to KCB, and that is why CA is the core of this project. But there is another issue receiving close review: KCB agriculture is highly dependent upon irrigation. The total arable land in the basin is approximately 2.2 million ha, where approximately 427,000 ha of this are officially irrigated. Therefore, not only for increasing soil organic matter and avoid erosion CA is needed, but also to improve water balance, and therefore require less irrigation. The results of CA to date are promising. Over 5,000 farmers have received trainings, due to the collaboration with about 600 national extension officers of the Ministry of Food, Agriculture and Livestock. This has resulted in more than 4,600 hectares of Conservation Agriculture in the province only in the last season. The recent foundation of the National Turkish Association of Conservation Agriculture (TACA) will consolidate the extension of CA across the region and country. As well, the integration in ECAF will provide TACA access to know-how in topics of broad and current interest.

Keywords: Climate Smart Agriculture, no tillage, soil degradation.

BACKGROUND

Agriculture is a fundamental sector that provides food for both people and animals, produces fibres for the textile sector, and many other products and services essential for the maintenance of humanity. Like any economic activity, agriculture in Turkey is linked to the natural and social environment in which it is developed, and interacts with it. If there is any productive activity that depends directly on the climate and its variability, this is undoubtedly agriculture.

According to climate models, in Turkey we can expect a change of temperature and precipitation, due to the increase in the concentration of atmospheric CO2, and it will significantly affect the development of the crops. Therefore, practical solutions are needed to overcome this situation.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Turkey is a country with high potential for adopting Conservation Agriculture (CA). In the last few years a number of projects have addressed the issue, especially taking into consideration the need to mitigate and adapt to climate change, whilst improving sustainability of agriculture through the diffusion and adoption of low-carbon technologies with win-win benefits for farmers and the environment.

In essence, CA is concerned with profitable and sustainable agricultural production – that is, maximizing farm profits in the long-term by optimizing agricultural production while conserving inputs (labor, fuel, seed, fertilizer, pesticides, etc.) and minimizing or mitigating any impacts on natural resources (soil, water and air). In most parts of the world, CA concepts are primarily applied to crop production, but the underlying philosophies can and should also be applied to the whole farming system including animal production, especially where crop and livestock production are highly integrated, as in the Middle East, North Africa, and many parts of Turkey.

The adoption of CA principles in locally adapted production systems for the growth of annual and perennial crops, pastures and forages, together with good quality seeds and optimally integrated nutrient, water and pest management, would achieve environmental challenges in Turkey by:

- Providing similar or even higher yields through improvements in soil structure, organic matter and overall soil fertility.
- Lowering production costs through reduced inputs of energy, labour, machinery, fertilizers, water and pesticides, thus raising related productivity and efficiency.
- Mitigating CO2 emissions through reduced fuel consumption and sequestration of atmospheric carbon into soil organic matter, and reducing N2O and CH4 emissions through reduced use of mineral nitrogen and improved soil drainage.
- Reducing runoff and wind/water erosion through better soil aggregate stability and improved water infiltration and protective cover of the soil by crops and/or crop residues.
- Diminishing off-site damage of infrastructures and pollution of water bodies through less runoff with a much reduced sediment load.
- Maintaining in-field and off-site biodiversity through the absence of destructive soil disturbance, protective soil shelter and less off-site transport of contaminants.
- Maintaining the diversity of rural landscape through enhanced crop and species diversity and cover crops.
- Maintaining less favoured rural areas under production through adoption of economically and environmentally viable production methods.

DESCRIPTION

The results of CA to date are promising. Over 5,000 farmers have received trainings, due to the collaboration with about 600 national extension officers of the Ministry of Food, Agriculture and Livestock. This has resulted in more than 4,600 hectares of Conservation Agriculture in the province only in the last season. The recent foundation of the National Turkish Association of Conservation Agriculture (TACA) will consolidate the extension of CA across the region and country. As well, the integration in the European Conservation Agriculture Federation (ECAF) will provide TACA access to know-how in topics of broad and current interest.

The EU-funded project GCP/TUR/063/EC has provided assistance in reviewing the status of CA and developing the national strategy for its promotion in Turkey. FAO as a working agency of Global Environmental Facility is implementing CA within the Konya Closed Basin (KCB) in the framework of the project GCP/TUR/056/GFF. In KCB agriculture leads the local economy. Main crops include: cereals, animal fodder, fruits, vegetables and legumes, and livestock. Konya produces on average 1 M t of cereal with an average of 2,600 kg/ha. The agricultural lands of the region are heavily degraded, being wind erosion a major problem. This has decreased the organic matter of the soil and increased its susceptibility to further degradation. CA principles have been demonstrated in similar conditions to KCB, and that is why CA is the core of this project. But there is another issue receiving close review: KCB agriculture is highly dependent upon irrigation. The total arable land in the basin is approximately 2.2 million ha, where approximately 427,000 ha of this are officially irrigated. Therefore, not only for increasing soil organic matter and avoid erosion CA is needed, but also to improve water balance, and therefore require less irrigation.

Figure 1. Comparison of wheat crop after wheat (top picture) and wheat after chickpea (bottom picture) in Konya (Turkey). Pictures are taken at the same location on the same date within a long term CA trial.

Figure 2. Conventional seeded wheat versus no-till seeded wheat clearly illustrating the soil moisture conservation and productivity benefit of CA systems. Pictures are taken from the same field, on the same day. There were no differences of management between the two treatments except the tillage.

Some elements to be considered for Konya Closed Basin follow. As it is well known, the key to success in CA is the management of the stubble. Indeed, in CA, residues of previous crops are most needed to rehabilitate soil quality. Therefore, a 4 season crop rotation based on the following is considered suitable for rainfed crops:

- First crop. Start with a winter cereal (wheat or barley). This crop will allow leaving a higher amount of residues than other crops, such as legumes.
- Second crop. Follow by a legume (lentils, chickpeas) that will start improving the soil quality. However, as residues will be not enough to follow another low residue crop.
- Third crop. Therefore, the next crop should be another winter cereal (barley or wheat). This will increase again the residue cover over the soil.
- Fourth crop. Finally, a taproot crops would help prevent compaction to happen at deeper layers. For instance, sunflower not only prevents compaction but also extracts water and nutrients from deeper soil layers.

No project can restore the ecological structure and function of a complex ecosystem, such as KCB, within a few years. Nevertheless, lessons learned at global level, and in similar agroclimatic areas to Konya, have demonstrated which could be the right path to follow that will lead to the recovery of ecological processes and habitat quality within a reasonable period. Among other technical interventions, such as windbreakers and water boxes, the introduction of climate smart agriculture practices, as Conservation Agriculture (no-tillage, permanent soil cover, crop rotations) in annual and permanent crops, together with a rational irrigation scheme are considered key elements to achieve a sustainable agricultural system in Konya Closed Basin.

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CONSERVATION AGRICULTURE INFLUENCE ON SOIL, CROP AND THE ENVIRONMENT IN SEMI-ARID NORTHWEST CHINA

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ABSTRACT

There is an urgent need to match food production with increasing world population through identification of sustainable crop and soil management strategies. However, the strategies to achieve food security should be carried without confounding effect on environmental quality. Conservation farming systems is being promoted as an agricultural practice that could increase the soil C, crop yield and mitigate greenhouse gas emissions. A study was conducted to assess the influence of tillage systems on soil, crop yield and CO2, N2O and CH4 fluxes in a long term spring wheat−field pea double sequence rotation in a rain–fed semiarid Loess Plateau. The experiment was established in 2001 and has been maintained without any alterations. Experimental work included the following treatments: conventional tillage with straw removed (T), no till with straw removed (NT), no till with straw retention (NTS) and conventional tillage with straw incorporated (TS). The contribution to increased soil organic carbon and microbial biomass carbon was much higher under straw treated soils. NTS and TS treatments significantly increased soil organic C by 20.81% and 10.60%, respectively at a depth of 0–10 cm compared with T soils. No till soils, particularly with straw amendment decreased cumulative N2O and CO2 emissions and increased CH4 uptake due to improved soil properties. NTS decreased cumulative N2O emission (by 30.63% and 20.49%) and CO2 emission (by 22.03% and 12.06%) compared with T and TS treatments, respectively. There was approximately 27.41% increase in CH4 uptake in NTS soils compared with T field. Reduced overall emissions in straw amended soils translated into a dual benefit of lower emission intensities and global warming potential. Improved soil quality in straw amended soils, particularly no tillage plots translated into higher biomass production and therefore grain yield in those treatments. NTS soils recorded positive C balance and to a lesser extent TS soils, largely due to the increased C inputs. NTS farming practices demonstrated sustained increases in soil quality and crop productivity, and reduced greenhouse gas emissions in dryland cropping system.

BACKGROUND

China has a long history of agricultural production, dating back approximately 8,000 to 9,000 years. Rain-fed agriculture is the most widespread land use system in the semiarid Loess Plateau(Wei and Wang, 1999). However, soil erosion on the Loess Plateau is the highest in China(Liu, 1999), and indeed it is amongst the highest in the world(Fu, 1989), due to intense thunderstorms during the summer-dominant rainfall period, the low soil aggregate stability, the poor vegetative cover of the loess soils, and intensive tillage in traditional agricultural production systems(Huang et al., 2006). Serious soil erosion leads to high nutrient losses and low soil water use efficiency, resulting in low crop yields, and fragile agricultural production systems highly susceptible to droughts. It also results in high sediment yields in downstream areas, and negative environmental impact (Huang, 2003).

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Severe erosion and related problems have been recognized by central and provincial governments. In Gansu, provincial strategies aim to reduce farmer reliance on grain production (wheat, potato, field peas etc. are the main crops), increase the production of cash crops and livestock, and relocate farming villages to more fertile lands(Feng et al., 2003). However, implementation has met with some resistance on the western Loess Plateau, as the area has a tradition of crop cultivation for several thousand years, and local farmers are reluctant to convert their cropland to grass and forestry (Rui et al., 2002). Therefore, developing techniques that can reduce soil and water erosion, improve soil water use efficiency, impart some degree of drought proofing, and improve the environmental impacts is critical to sustained crop production in this region. Conservation agriculture has been promoted as an agricultural practice that could increase the soil C, crop yield and mitigate greenhouse gas emissions(Kassam et al., 2009). However, conservation agriculture represents a complex technological intervention that raises many challenges when applied in smallholder, subsistence-orientated farming systems (Giller et al., 2009). Therefore, a field experiment was set up in semiarid Loess Plateau since 2001, to develop conservation agriculture practices for the area.

EXPERIMENTAL APPROACH

The field experiment was conducted at the Dingxi Experimental Station (35°28′N, 104°44′ E, elevation 1971 m a.s.l.) of Gansu Agricultural University, in Lijiabu Village, Anding County, Dingxi, Gansu Province, northwest China. The soil at the experimental site is called Huangmian soil, in the Chinese soil taxonomy (Chinese Soil Taxonomy Cooperative Research Group, 1995) and Calcaric Cambisols in the FAO soil map of the world (FAO, 1990). This soil, typical of the major cropping soils of the Loess Plateau, is sandy-loam with low fertility (Zhu et al., 1983). Average annual rainfall at Dingxi is 391 mm, ranging from 246 mm in 1986 to 564 mm in 2003. On average, about 54% of annual rainfall is received between July and September. Daily maximum temperatures can reach up to 38 °C in July, while minimum temperatures can drop to -22 °C in January. Hence, summers are warm and moist, whereas winters are cold and dry. Accumulated temperature above 10 °C averages 2,239 °C over the year, average radiation is 5,929 MJ m-2, and sunshine hours are 2,477 hours per year. The site had a long history of continuous cropping using conventional tillage. The previous crop prior to commencement of the experiment in 2001 was flax (Linum usitatissimum L.).

The experiment had 6 treatments, 2 phases, replicated 4 times (blocks). Spring wheat (cv. Dingxi No. 35) and field pea (cv. Yannong) were sown in sequence in both phases each year. Phase 1 started with spring wheat, followed by field pea, and phase 2 started with field pea, followed by spring wheat. There were 48 plots in total, each plot being 4 m wide by 17 m long in block 1, 21 m long in blocks 2 and 3, and 20 m long in block 4.

Treatments described as following:

- Conventional tillage with no stubble (T). The was plowed three times and harrowed twice using animal power. All stubble was removed before cultivation. This treatment represents the typical tillage practice in the western Loess Plateau.
- No-till with no stubble (NT). No cultivation was performed throughout the season. The crops were sown with the no-till seeder, but all stubble was removed at crop harvest. The crops were sown with the no-till seeder.
- Conventional tillage with stubble incorporated (TS). Cultivation was the same as T, but all stubble from the previous crop was returned to the original plot immediately after threshing and then incorporated into the soil with the first cultivation. In 2001, chopped wheat straw (5-10 cm in length) was used at 6.8 t ha-1 for both crops.
- No-till with stubble retention (NTS). No cultivation was performed throughout the season, but stubble from the previous crop was retained on the soil surface but without incorporation. Chopped wheat straw was used as described in TS in 2001. The crops were sown with the no-till seeder.
- Conventional tillage with plastic film mulching (TP). Plots were cultivated 3 times and harrowed 2 times before the plastic film (0.5 mm thick) was laid out in October. All the stubble was removed before cultivation. A local seeder was used to sow both spring wheat and field pea.
- No-till with plastic film mulching (NTP). No cultivation was carried out throughout the season, and stubble was removed before the plastic film (0.5 mm thick) was laid out in October. The crops were sown by the local seeder.

For all the treatments, spring wheat was sown at 187.5 kg ha-1 in mid-March and harvested in late July to early August each year. Field pea was sown at 180 kg ha-1 in early April, and harvested in early July each year. The row spacing was 20 cm for spring wheat and 24 cm for field pea for all treatments in group 1. In group 2, each crop was sown in paired rows on both sides of the furrow, 10 cm apart. Thus, the crop row spacing was 10 and 40 cm alternately, averaging 25 cm. Nitrogen and phosphorus were applied at 105 kg N ha-1 as urea (46% N) and at 45.9 kg P ha-1 as calcium superphosphate (6.1% P) for spring wheat, and 20 kg N ha-1 and 45.9 kg P ha-1 for field pea. No farm manure was used in the experiment. Roundup® (glyphosate, 10%) was used for weed control during fallow after harvesting as per the product guidelines. During the growing season, weeds were removed by hand. Pests and diseases were monitored and controlled as per conventional practices in the area. The plastic film was removed from plots after the crops were harvested for treatments TP and NTP.

RESULTS AND DISCUSSION

Measurements showed that the non-capillary porosity and soil aggregates (>0.25 mm) under NTS were significantly increased. Thus, soil saturated conductivity was much improved, and soil infiltration was increased. Stubble retained on the soil surface also helped decrease soil evaporation. As a result, no till with stubble retention could considerably increase surface (0-10 cm) soil moisture at sowing, this is not only important for crop emergence, but also to mitigate against the spring droughts which are frequent in the area. Different conservation tillage practices had no strong effect on total soil water storage (0-200 cm). The ratio between plant transpiration and soil evaporation of NTS increased significantly, water use efficiency(WUE) of NTS were improved significantly compared with conventional tillage.

Soil organic carbon and microbial biomass carbon was much higher under straw treated soils, NTS and TS treatments significantly increased soil organic C by 20.81% and 10.60%, respectively at a depth of 0–10 cm compared with T soils.

Improved soil quality in straw amended soils, particularly no tillage plots translated into higher biomass production and therefore grain yield in those treatments. NTS farming practices demonstrated sustained increases in soil quality and crop productivity.

No till soils, particularly with straw amendment decreased cumulative N2O and CO2 emissions and increased CH4 uptake due to improved soil properties. NTS decreased cumulative N2O emission (by 30.63% and 20.49%) and CO2 emission (by 22.03% and 12.06%) compared with T and TS treatments, respectively. There was approximately 27.41% increase in CH4 uptake in NTS soils compared with T field. NTS soils recorded positive C balance and to a lesser extent TS soils, largely due to the increased C inputs. Reduced overall emissions in straw amended soils translated into a dual benefit of lower emission intensities and global warming potential.

Data from rainfall simulation showed that cumulated infiltration was significantly increased and runoff was decreased by NTS, and soil loss (sediment load) from erosion was reduced by 62.4%.

To conclude, no tillage in combination with stubble retention could improve soil quality, increase soil water, improve crop productivity and WUE, reduce greenhouse gas emission and soil erosion in semiarid Loess Plateau, it is the optimal practice for sustainable intensification in the area.

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DOCUMENTING THE EVOLUTION OF AGRICULTURAL CHEMICAL USE UNDER ZERO-TILLAGE/CONSERVATION AGRICULTURE IN TROPICAL BRAZIL

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[4.]Latin periculum = danger.

The consuming public gets all sorts of negative publicity on the use of agricultural chemicals but, in general, press reports lack measured data and risk evaluation lacks a specific indicator. A detailed survey was undertaken of ten farmers in Southwest Goiás state, Brazil, to establish a baseline for future comparisons. This is especially relevant with the recent rapid increase in use of commercial products for biological controls and the continuing trends towards increased yields and less toxic chemicals. A simple empirical calculation was adopted and christened the 'Periculosity Index' (PI) to express the danger level of agricultural chemicals used on the farm. It may be expressed per hectare of crop, but the authors recommend expressing this indicator per ton of yield, which is more relevant to food safety.
The formula adopted is :

$$PI = \Sigma \text{ (Active Ingredient (\%/100) xToxicology Rating x kg or lits applied/ha)}$$

Where toxicology rating is 0 for organic products, 1 for Toxicity Class 1 (green), 2 for Class 2 (blue), 3 for Class 3 (yellow) and 4 for Class 4 (red), following the Brazilian national standard. The PI only measures the relative use of the toxicity-rated chemicals as a measure of progress towards better working conditions on the farm and reduction of the total risk level of agricultural inputs used. Although there will be some correlation, it is not a reliable indicator for danger levels of chemicals in food; this requires laboratory measures of residual chemicals, but a reduction in the PI index indicates the farmer's contribution to lower the risk element in the inputs used on-farm. This progress in food safety needs to be communicated to consumers and the PI should be used as a standard for this purpose, while also giving the farmer an easily-calculated measure of his environmental performance in crop protection.

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EUROPEAN INDEX FOR SUSTAINABLE AND PRODUCTIVE AGRICULTURE: INSPIA

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ABSTRACT

Sustainable development requires integrated approach to agricultural production that efficiently uses natural resources to meet basic human needs; this implies management measures that sustain the ability of natural systems (build resilience) to continue to provide the ecosystem services upon which our economy and society depends. Agriculture faces important global challenges: to intensify food production to satisfy the increasing demand of a growing population, whilst also contributing to economic prosperity, climate change mitigation and adaptation, social wellbeing, and the preservation of natural capital. A more productive and resource efficient agriculture that integrates natural resource protection enables us to produce more, increase biodiversity, while reducing GHG emissions. In this context, INSPIA is an innovative project that demonstrates that sustainable productive agriculture is achievable thanks to the implementation of a set of 15 Best Management Practices (BMPs). More than 50 farms make up the project network in Belgium, Denmark, France and Spain. INSPIA's objectives are to: - Demonstrate that BMPs deliver sustainable agriculture; - Provide an index of farm sustainability based on a set of verifiable indicators; - Create a farm network to validate, demonstrate and communicate the BMPs; - Promote sustainable agricultural practices; - Raise awareness among EU stakeholders. The effectiveness of INSPIA BMPs is calculated on individual farm basis with a set of defined indicators (economic, social, and environmental). In the last 3 growing seasons, around 75% of INSPIA BMPs have enjoyed a 10-20% increase in level of implementation. A key part of INSPIA are BMPs related to biodiversity enhancement and soil management, where Conservation Agriculture (CA) plays an important role. Indeed, soil biodiversity is widely recognised as an indicato r of soil health and quality, and an important factor for the soil to fulfil its ecological functions. CA based BMPs as well as the optimised use of agricultural technologies (e.g. machinery, and plant protection products) are considered crucial in the extent to which they help farmers achieve sustainable productivity.

Keywords: Best Management Practices, biodiversity, indicators, Conservation Agriculture, agricultural technology.

BACKGROUND

Sustainable development requires integrated approach to agricultural production that efficiently uses natural resources to meet basic human needs; this implies management measures that sustain the ability of natural systems (build resilience) to continue to provide the ecosystem services upon which our economy and society depends.

Agriculture faces important global challenges: food production intensification to satisfy the increasing demand of a growing population, whilst also contributing to economic prosperity, climate change mitigation and adaptation, social wellbeing, and the preservation of natural capital. Society needs a more productive and resource efficient agriculture that integrates natural resource protection, and that enables farmers to produce more, increasing biodiversity, while reducing GHG emissions.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

INSPIA counts on 15 Best Management Practices (BMPs) for agriculture focused on protecting biodiversity and natural resources, while maintaining productivity. They are related to soil, water, crop protection and fertilizer, precision farming and pollution prevention — a wide range of topics. Conservation Agriculture (CA) is at INSPIA's heart. Indeed, taking care of the soil via CA (no tillage with permanent soil cover and use of crop rotation) is one of our major calls to action. Other BMPs address optimizing the use of inputs like crop protection products via integrated pest management and precision farming, implementing field margins and buffer strips, cleaning sprayers and machinery, and managing empty product containers.

A key part of INSPIA are BMPs related to biodiversity enhancement and soil management, where Conservation Agriculture plays an important role. Indeed, soil biodiversity is widely recognised as an indicator of soil health and quality, and an important factor for the soil to fulfil its ecological functions. CA based BMPs as well as the optimised use of agricultural technologies (e.g. adapted machinery, and plant protection products) are considered crucial in the extent to which they help farmers achieve sustainable productivity.

DESCRIPTION

INSPIA is an innovative project demonstrating that sustainable productive agriculture is achievable thanks to the implementation of a set of 15 BMPs. INSPIA is currently operating on 56 farms located mostly in France and Spain, with a few in Belgium and Denmark. INSPIA seeks to offer farmers a user-friendly way to monitor their sustainable productivity through an on-line platform that measure the evolution of a set of sustainability indicators and identifies potential areas for improvement where the implementation of best management practices should be enhanced. INSPIA's objectives are to:

- Demonstrate that BMPs deliver sustainable agriculture.
- Provide an index of farm sustainability based on a set of verifiable indicators.
- Create a farm network to validate, demonstrate and communicate the BMPs.
- Promote sustainable agricultural practices.
- Raise awareness among EU stakeholders.

There is strong empirical evidence that an increase in agricultural productivity can be achieved at the same time as environmental protection. Today, more and more production systems look towards

what is often described as 'ecosystem based approaches' which aim to enhance both ecosystem functions and agricultural productivity. INSPIA's BMPs can be measured through 25 sustainability indicators that fall into three categories: 1) economic (profit and production efficiency); 2) social (farmer welfare and well-being) and 3) environmental (biodiversity enhancement plus natural resource use and protection).

Specific indicators include use levels of crop inputs like nitrogen, phosphorus, energy, water and crop protection products. All farms in INSPIA network are audited to measure all indicators to demonstrate that the BMPs create an impact at the farm level. That's why INSPIA aims to build awareness that agriculture must both protect the environment and produce sufficient high-quality food, feed and fiber.

The effectiveness of INSPIA BMPs is calculated on individual farm basis. In the 3 growing seasons of INSPIA, around 75% of BMPs have increased 10-20% in their level of implementation.

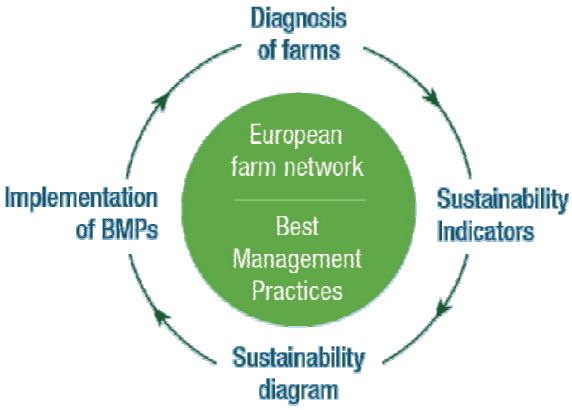

Figure 1. INSPIA working cycle.

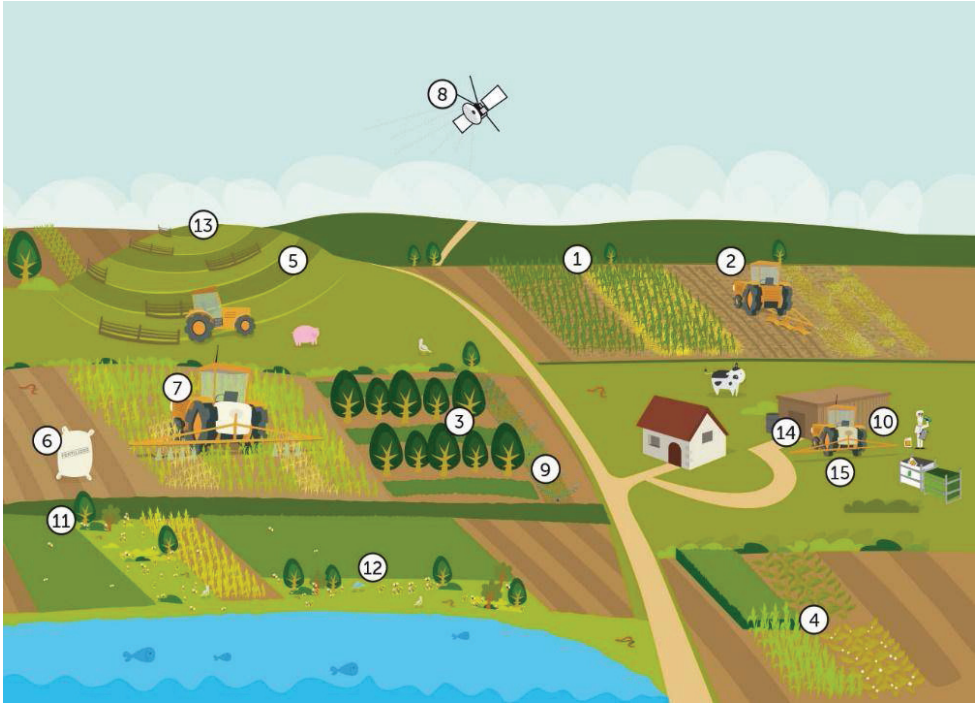

Figure 2. INSPIA's BMPs. A full description is available at www.inspia-europe.eu.

Figure 3. Permanent soil cover is one of the essential INSPIA's BMPs.

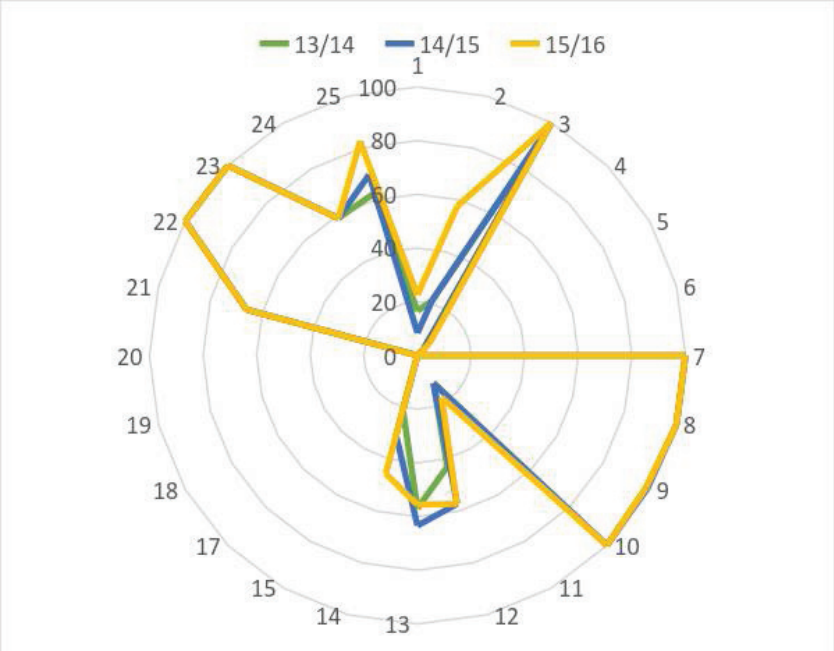

Figure 4. An example of INSPIA's indicator evolution from a CA farm.

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IMPROVING LAND USE EFFICIENCY THROUGH CONSERVATION AGRICULTURE IN CENTRAL ASIA

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ABSTRACT

After the collapse of the former Soviet Union, the production performance of the agriculture sector, including horticulture, in the Central Asia region has declined sharply. At the same time, population growth has led to decrease in cropland per capita and competition for land and water resources is increasing causing increased food insecurity in the region. There is an urgent need to pilot innovations and changes in agricultural practices in the region in order to increase grain output and productivity (efficiency). Double cropping or adding a second crop to existing single crop per year systems can address above-mentioned challenges. In the irrigated areas of Central Asia, farmers usually finish harvesting of winter wheat and barley during the period mid-June through mid-July and undertake next planting of these crops during the first fortnight of October. In double-cropping systems, timing of planting the second crop becomes limited along with pressures of harvesting the preceding mature crop. The main objective of this experiment is to study effect of different conventional tillage system and Conservation Agriculture (CA) system on productivity of double-cropping (cereal followed by mung bean) in irrigated conditions of Uzbekistan and Tajikistan. Mung bean grain yield increased with no tillage. The largest grain yield response was recorded with no-till mung bean, 1898 and 2365 kg/ha in 2014 and 2015 year respectively. Conventional tillage mung bean crops had the lowest yields, 1595 and 1365 kg/ha in 2014 and 2015 year respectively. The reason for the differences in the mung bean grain yields between conventional till and no-till is not fully clear yet, but we hypothesize that improved soil moisture content under no-till CA system could have been a cause of yield increase in mung bean. Under the prevailing scenario of challenges arising from: increasing fuel and purchased input prices and decreasing per capita crop land, from salinization of irrigated lands, drought and heat problems, and from low priority given to fodder production and preservation, CA-based double cropping can help to reduce the effect of the mentioned challenges in the years ahead.

BACKGROUND

After the collapse of the former Soviet Union, the production performance of the agriculture sector, including horticulture, in the Central Asia region has declined sharply. At the same time, population growth has led to decrease in cropland per capita and competition for land and water resources is increasing causing increased food insecurity in the region. There is an urgent need to pilot innovations and changes in agricultural practices in the region in order to increase grain output and productivity (efficiency). Climatic conditions of the Central Asian countries allow the production of various kinds of crops and also it allows growing two crops per year. Double cropping or adding a second crop to existing single crop per year systems can address above-mentioned challenges. Multiple cropping is one of the most important modern agricultural developments for production intensification and offers a good opportunity to increase annual production. In the irrigated areas of Central Asia, farmers usually complete harvesting of winter wheat and barley during the period mid-June through mid-July and undertake next planting of these crops during the first fortnight of October. In double-cropping systems, timing of planting the second crop becomes limited along with pressures of harvesting the preceding mature crop.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE (CA)

Application of CA cropping systems can reduce the time element while retaining any soil moisture that may be present at harvest of the winter cereal crop, and reducing runoff, soil erosion and soil evaporation; and grain production per year can be increased. There is also the possibility that double cropping can help break pest cycles that are encouraged by monocultures, and thus reduce pesticide use (Nurbekov 2008). The introduction of cereal or legume crops into the existing cropping systems in Central Asia as a second crop after wheat and barley harvest could be a promising alternative for increasing total grain production. The evidence from Central Asia indicates that CA practices are suitable for the existing major cropping systems. Research results from all Central Asian countries have shown that CA is suitable for the heterogeneous local conditions; and can provide similar or higher crop yields while saving considerable production resources, including fuel, seeds, water, agrochemicals and labour (Nurbekov et al., 2013). CA also can combat land degradation in the region through application of no-till, crop residue retention and crop diversification. So, the maintenance of significant amounts of soil coverage by residues reduces wind and water erosion, increases water infiltration for soil storage and for reduced crop water stress, improves soil quality and increases organic matter, and sequesters atmospheric carbon. Therefore, the benefits are obvious to the scientist, the environmentalist, and many others, but not necessarily to the farmer! CA, and especially the residue management component, must be packaged into easy to adopt technology transfer schemes.

EXPERIMENTAL APPROACH

The main objective of the experiment reported here was to study the effects of different conventional tillage systems and CA system on productivity of double-cropping (cereal followed by mung bean) in irrigated conditions of Uzbekistan and Tajikistan. Tillage treatments include conventional tillage or ploughing (CT), minimum tillage with a chisel harrow (MTC), minimum tillage with a disk harrow (MTD), and no-till CA (NT), respectively. The experiment was laid out in randomized complete block design. Plot size was 200 m2 (25×8 m). Field observations were recorded on plant

height, grains per spike and yield. The experiments were conducted for two seasons Tajikistan 2014-2015. Biometrical analysis of winter wheat was done according to the methods developed by State Variety Testing Commission of Agricultural Crops (SVTCAC, 1970). The data was statistically analyzed using GenStat program 18 edition. To estimate economic returns of tested tillage methods, cost benefit analysis was done.

RESULTS AND DISCUSSION

As figure 1 presents, no-till was advantageous to crop yields and it demonstrated advantages in terms of conservation of energy and labour resources. As fuel for producing agricultural products has become expensive for farmers in Uzbekistan, farmers have already started to employ alternative ways of decreasing fuel consumption. No-till addresses the challenge in the country. The lowest fuel consumption (5.9 l ha-1) was obtained with no-till mung bean crop, which was 47.7 litres lower than with conventional mung bean crop. Fuel consumption per ha was 53.6, 33.6 and 5.9 and 36.8, 25.4 and 5.9 litres under full tillage, minimum tillage and no-till, in Uzbekistan and Tajikistan respectively.

The crop was harvested for yield to determine the effects of tillage systems on mung bean yield. It appears that mung bean tend to yield more where wheat was grown in no-till situation. Grain yield was significantly affected by tillage method and across the two years. Maximum grain yield of 1.94 t ha-1 was recorded with no-till mung bean crop in Uzbekistan while minimum grain yield (1.26 t ha-1) was recorded with conventional mung bean crop in Tajikistan (Figure 2). The no-till mung bean crop provided 330 kg ha-1 (20.5%) yield advantage compared to the conventional mung bean crop which was significantly different in Uzbekistan. The average yield advantage in no-till mung bean crop with minimum tillage was 160 kg ha-1 (9.9 %) more than the control conventional tillage treatment in Uzbekistan.

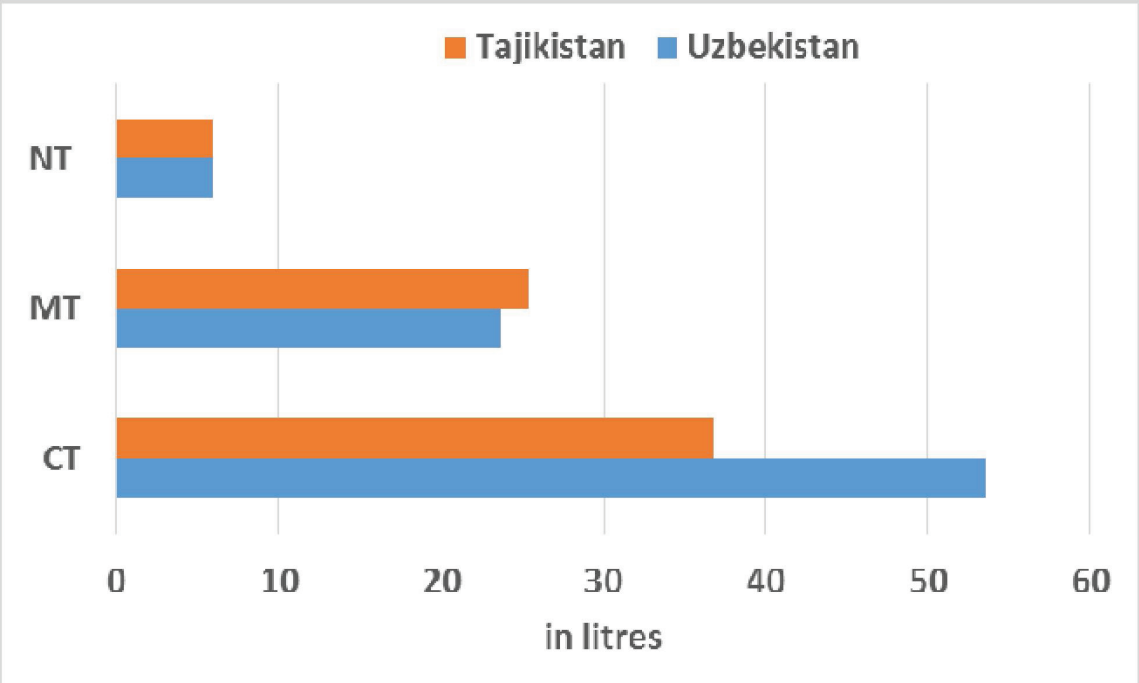

Figure 1. Effect of tillage method on productivity of double-cropped mung bean after winter wheat harvest in Uzbekistan and Tajikistan (2013-2014).

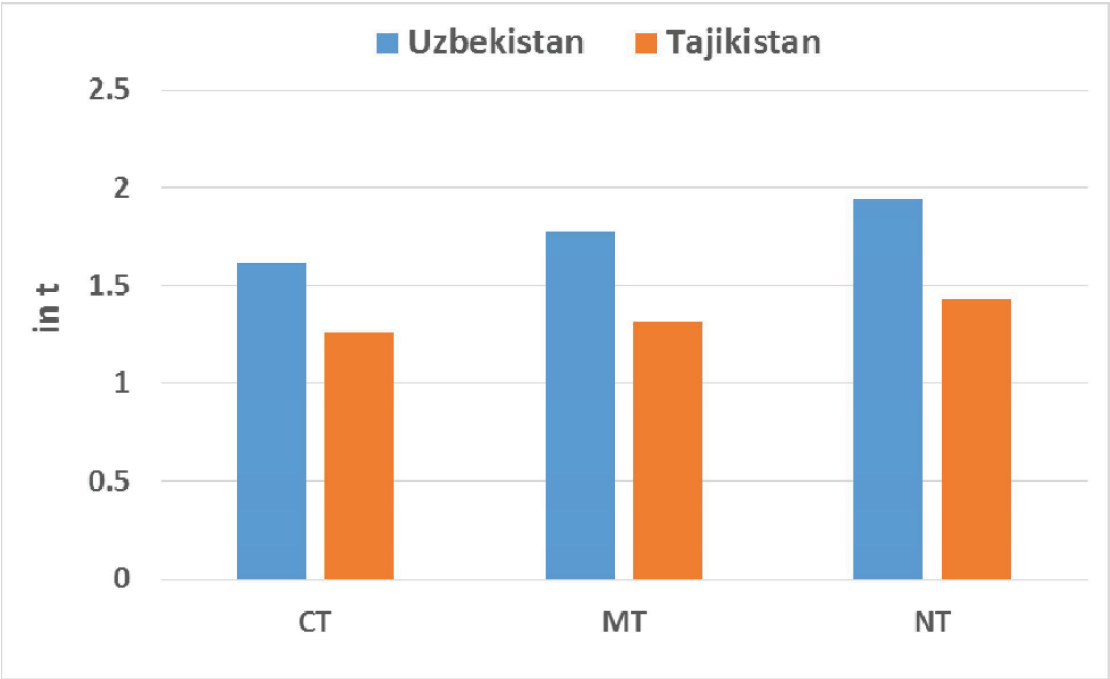

Figure 2. Effect of tillage methods on productivity of mung bean in Central Asia (2013-2014).

The reason for the differences in the mung bean grain yields between conventional tillage crop and no-till crop is not fully clear yet, but we hypothesize that improved soil moisture content under the no-till CA system could have been a cause of yield increase in the no-till mung bean crop.

The results presented from this experiment with double-cropped mung bean cultivation indicate that tillage reduction for surface irrigated production systems reverberate in the same positive way in terms of production profitability and sustainability of total grain production. It should be mentioned here that retention of crop residues in the NT CA system will be essential to ensure that the required enrichment of critical levels of the chemical, physical and biological soil parameters, that are crucial to ensure long-term production sustainability, can be achieved. Under the prevailing scenario of challenges arising from: increasing fuel and purchased input prices and decreasing per capita crop land, from salinization of irrigated lands, drought and heat problems, and from low priority given to fodder production and preservation, CA-based double cropping can help to reduce the effect of the mentioned challenges in the years ahead. In addition, land use efficiency will be increased with double cropping of no-till CA mung bean after wheat or barley crop harvest.

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INTEGRATED NUTRIENT MANAGEMENT CAN SUSTAIN CONSERVATION AGRICULTURE IN SOUTHERN AFRICA

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ABSTRACT

As the proportion of growers using no-tillage cropping reaches a high plateau, there has been increasing adoption of practices aimed at controlling weed seed set through pre-harvest herbicide applications (crop topping) or capture and destruction in the harvest process such as narrow windrow burning and to a lesser extent chaff carts (Figure 1). Narrow windrow burning, a practice that involves burning at least half of the crop residue (Walsh and Newman 2007), is shown to be one of the most rapidly adopted non-herbicide weed management practices in Australia, and is already being used by a majority of growers in several districts. Other innovative practices with emerging adoption levels include chaff tramlining where crop residue containing weed seeds is delivered from the harvester to traffic lines, and harvest weed seed destruction using mills fitted to the harvester that crush weed seeds to avoid the need to kill seeds in a separate process (usually burning).

INTRODUCTION

Traditional agricultural systems have potential to deteriorate soil quality (Dou et al., 2014) and escalate soil erosion and its associated consequences (Lal, 2003). The world face a severe threat to food security because of an increase in soil erosion (Pimentel and Burgess, 2013). Since about 99.7% of human food comes from the land, preserving cropland and conserving soil fertility should be of the highest importance to human welfare (Pimentel and Burgess 2013). In addition, climate projections show that most parts of the world will become hotter and drier (Solh and van Ginkel 2014). Thus, limited rainfall and drought are expected to be a more common phenomenon especially in the semi-arid tropics regions of southern Africa. The change in rainfall patterns due to change in climate also pose a major threat to food security (Mupangwa et al. 2008). Moisture conservation, soil quality enhancement and minimizing of soil erosion are therefore key focus areas in sustaining southern African agricultural systems that are dominantly rain-fed. Conservation agriculture (CA) which, is based on minimum soil disturbance, surface protection with plant residues as mulch and crop rotation was reported to have potential address the soil and water constraints faced by smallholder farmers in semi-arid regions (Mupangwa et al. 2008). In addition, CA allows early planting, because land preparation is simplified and can be done prior to the first effective rains (Haggblade and Tembo 2003). Thus, CA may effectively use most of the rainfall, reducing the threat of crop failure when below average rainfalls are received (Baudron et al. 2012). Due to numerous advantages CA gives, its adoption in southern Africa is likely to alleviate the current challenges faced by agriculture in the region. This paper reviewed the application of CA in southern African. Data was collected in studies conducted under southern African region. Only studies that compared CA with conventional tillage (CT) and/or other principles of CA were included.

RESULTS AND DISCUSSION

The main findings were that application of CA enhanced soil quality, increase soil moisture, reduced erosion by more than 50% and increased crop yields by up to 56% compared to CT (Table 1). Soil quality is a strong contributing factor of agronomic yield. Thus, CA has potential to increase farmer's returns (Ngwira et al., 2012), serving as a strategy to deal with hunger and improve farmers' livelihoods. However, the adoption of all three principles of CA by smallholder farmers remains a big challenge because biomass generation is generally low due to poor soil fertility and smallholder farmers' use of crop residues to feed their livestock (Giller et al., 2009; Vanlauwe et al., 2014). The use of mineral fertilizer to increase biomass under CA in southern African region was proposed before (Nyamangara et al., 2013, Vanlauwe et al., 2014). However, the prohibitive cost of mineral fertilizer makes fertilization an unviable option for smallholder farmers who are generally classified as poorly resourced. Instead, animal manure can serve as a low nutrients input for smallholder famers with livestock. Manure contains both macro and micro nutrients that a required by plants (Araji et al., 2001). The use of manure was reported to improve yields (Dordas et al., 2008), give same yields as mineral fertilizer (Basso and Ritchie, 2005) and improve soil quality (Parham et al., 2002).

Table 1. Conservation agriculture (CA) enhancing and contribution.

	General finds	Reference
Soil organic carbon (SOC)	SOC was found to be high under CA than CT by at least 9.4 %	Nyamadzawo et al. (2009), Thierfelder and Wall (2012)
Aggregate stability	Soils under CA had higher aggregate stability (>45%) than those under CT	Thierfelder and Wall (2010) , Thierfelder and Wall (2012)
Infiltration	CA increased steady infiltration rate by up to 331% compared to CT	Ngwira et al. (2012), Thierfelder and Wall (2012), Thierfelder et al. (2013), TerAvest et al. (2015)
Soil water content	Soil water content was at least 13% in CA than in CT	Araya and Stroosnijder (2010), Thierfelder et al. (2013), TerAvest et al. (2015)
Erosion	The CA practices reduced soil loss by more than 40 % compared to CT	Munodawafa and Zhou (2008), Araya and Stroosnijder (2010), Mchunu et al. (2011),
Yields	Crop yields were found to be at least 20% and higher under CA than in CT	Munodawafa and Zhou (2008), Thierfelder and Wall (2010), Ngwira et al. (2012)
economic benefit	CA was reported to increase returns by more than 42.7% compared to CT	Ngwira et al. (2012), Nyamangara et al. (2014)

The review concludes that for CA to be effective in the southern Africa, it needs to be coupled with integrated nutrient management. This is envisaged to promote the generation of enough biomass for both livestock feed and residue retention, and allow nutrient cycling. Thus, the integration of livestock is imperative to the success of integarated nutrient management in southern Africa CA systems. Furthermore, local field experiments on integrated nutrient management under CA are crucial to come up with a system that does not compromise environmental quality or increase greenhouse gas emission while generating enough biomass to feed livestock and for residue retention.

ACKNOWLEDGMENT

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MICROSTRUCTURE OF PAMPEAN SOILS CULTIVATED UNDER NO-TILL. THE BATTLE BETWEEN BIOLOGY AND MACHINES

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ABSTRACT

No-till cultivation (NT) modifies various physical, chemical and biological soil properties in comparison to both natural and ploughed soils. These modifications are related to changes in the organization of solid components and are traduced on soil morphology. This contribution synthesizes numerous works carried out using micromorphological and micromorphometric techniques to characterize the microstructure of the surface horizon of different Mollisols of the northern Pampa cultivated under NT. The studied cases covered soils with different cropping sequences, in different sectors within the plots and at different times during the agricultural cycle. Comparative studies were also carried out with ploughed soils and non-cultivated soils. Results obtained show that under NT a typical microstructure develops, characterized by a marked anisotropy resulting in the differentiation of thin microhorizons in the first centimeters of the A horizon. These microhorizons may have different degrees of development, different morphology of aggregates, as well as different type, proportion and orientation of pores. Based on these variants, four NT microstructural models have been distinguished, which are highly variable and dynamic in time and space. These studies clearly show that the microstructure of the surface horizon of soils under NT is the synthetic and dynamic result of two opposing forces: the mechanical pressures arising from machinery traffic on the one hand, and biological activity on the other. The compression produced by the traffic leads to the development of the laminar and densified models. On the contrary, the increase of the biological activity and particularly of the soil fauna leads to a destruction of the structures derived from mechanical stresses, giving rise to the biodisturbed and biobuilded models according to the intensity of those biological actions. Particularly relevant were studies comparing situations with greater intensification and rotation with cereals, versus situations with predominance of soybean in the agricultural cycles. In spite of the increase of machinery traffic in intensified plots, a greater activity of the fauna has shown to counteract effectively the compressive effect produced by traffic. These results suggest that it is possible to improve soil properties and to achieve the sustainability of the system by integrating NT with management practices promoting the increase of biological activity.

INTRODUCTION

No-till cultivation (NT) modifies various physical, chemical and biological soil properties in comparison to both natural and ploughed soils. It has been mentioned for a long time that the first and often most obvious change in the soil when no-till is introduced is its grater consolidation and compaction. In no-tilled pampean soils many authors also indicate a higher bulk density and mechanical resistance in comparison with plow tillage and reduced tillage. Correlatively, total porosity is usually lower under NT, but similar or higher total porosities in NT compared to tilled soils have also been reported (Álvarez et al., 2009; Álvarez and Steinbach, 2009). Those modifications on physical parameters are related to changes in the organization of solid components which are traduced on soil morphology. Thus, field macrostructure of upper horizons of no-tilled soils have been described by means of different procedures (Sasal et al., 2006; Álvarez et al., 2009; 2014; Kraemer et al., 2017). In most cases, compacted and massive areas alternating with visible zones of platy structures varying in continuity, thickness and conformation have been reported. Several mechanisms have been proposed to explain the common appearance of plates under NT: previous compaction of subjacent soil layers, soybean monoculture or high soybean frequency on the crop sequence (Sasal, 2016) and machinery traffic (Morrás et al. 2004; 2012; Álvarez et al. 2014).

On the other hand, some studies have evidenced significant increments in the number and diversity of soil fauna in relation with the number of years under NT (Ríos de Saluso et al., 2001). In a pampean Mollisol affected by different degrees of degradation, Morrás et al. (2001) found a fast increment of density and diversity of meso- and macrofaune in NT sites in comparison with plowed sites. Moreover, clear faunal differences were observed among different plots according to the degree of degradation inherited from their previous history under conventional tillage. Recent research in no-tilled pampean soils have shown differences on soil fauna according to the quality of management: higher density and diversity of macrofaune were found in those treatments with a higher proportion of cereals in the agricultural sequence, with more abundant residue cover, with higher soil humidity and relatively less agrochemicals use (Domínguez, 2012).

Although modifications on soil structure and on soil fauna in the upper horizon of NT soils are evident and have been widely recorded, the promoting factors are not completely understood, the relationship between soil architecture and soil biology and their consequences on soil behavior were scarcely considered, and their consequences on the sustainability and on the success of the NT system are not still addressed. According to the type of objects considered (aggregates, pores and soil fauna) and their sizes, microscopic methods applied on undisturbed samples are the most appropriate tools for their study. This contribution synthesizes numerous works carried out on the surface horizon of different Mollisols of the northern Pampa cultivated under NT, with the aim to characterize their microstructure, to identify the factors implied in its formation and evolution, and to understand soil physical properties and water dynamics under this system of cultivation.

MATERIALS AND METHODS

Thin sections of undisturbed samples from the A horizon of different Mollisols from the Pampa region (Argentina) cultivated under NT were studied by optical microscopy following the micromorphologic and micromorphometric procedures (Loaiza et al., 2015). Macrostructure descriptions in the field and morphological analysis of single aggregates by optical and electronic microscopy were also performed. In addition, numerous physical, chemical, biological and mineralogical

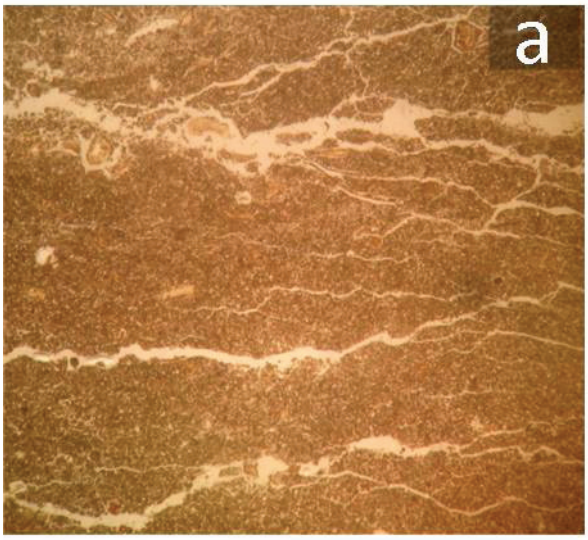
parameters were also studied by different methods. The studied cases covered soils with different cropping sequences, in different sectors within the plots and at different times during the agricultural cycle. Comparative studies were also carried out with plowed soils and non-cultivated soils.

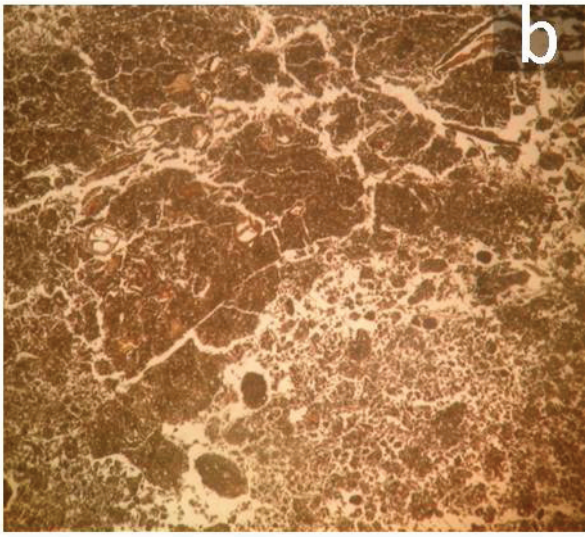
RESULTS AND DISCUSSION

Results obtained show that under NT a typical microstructure develops, characterized by a marked anisotropy resulting in the differentiation of three thin microhorizons in the first centimeters of the A horizon. These microhorizons may have different degrees of development, different morphology of aggregates, as well as different type, proportion and orientation of pores. Based on these variants, four NT microstructural models have been distinguished: platy (P), densified (D), bio-disturbed (BD) and bio-builded (BB), which are highly variable and dynamic in time and space (Morrás et al., 2004; 2012; Bonel et al., 2005; Kraemer and Morrás, 2017).

These studies clearly show that the microstructure of the surface horizon of soils under NT is the synthetic and dynamic result of two opposing forces: the mechanical pressures arising from machinery traffic on the one hand, and biological activity on the other. The compression produced by the traffic leads to the development of the P and D microstructural models (Figure 1-a, c, e). On the contrary, the increase of the biological activity and particularly of the soil fauna leads to disturbation or destruction of the structures derived from mechanical stresses, giving rise to the BD and BB models according to the intensity of those biological actions (Figure 1-b, d, f).

Particularly relevant were studies comparing situations with greater intensification and rotation with cereals, versus situations with predominance of soybean in the agricultural cycles. In spite of the increase of machinery traffic in intensified plots, a greater activity of the fauna promoted by a more continuous occupation of the soil with different crops, has shown to counteract effectively the compressive effect produced by traffic. These results suggest that it is possible to improve soil properties and to achieve the sustainability of the system by integrating NT with management practices promoting the increase of biological activity.





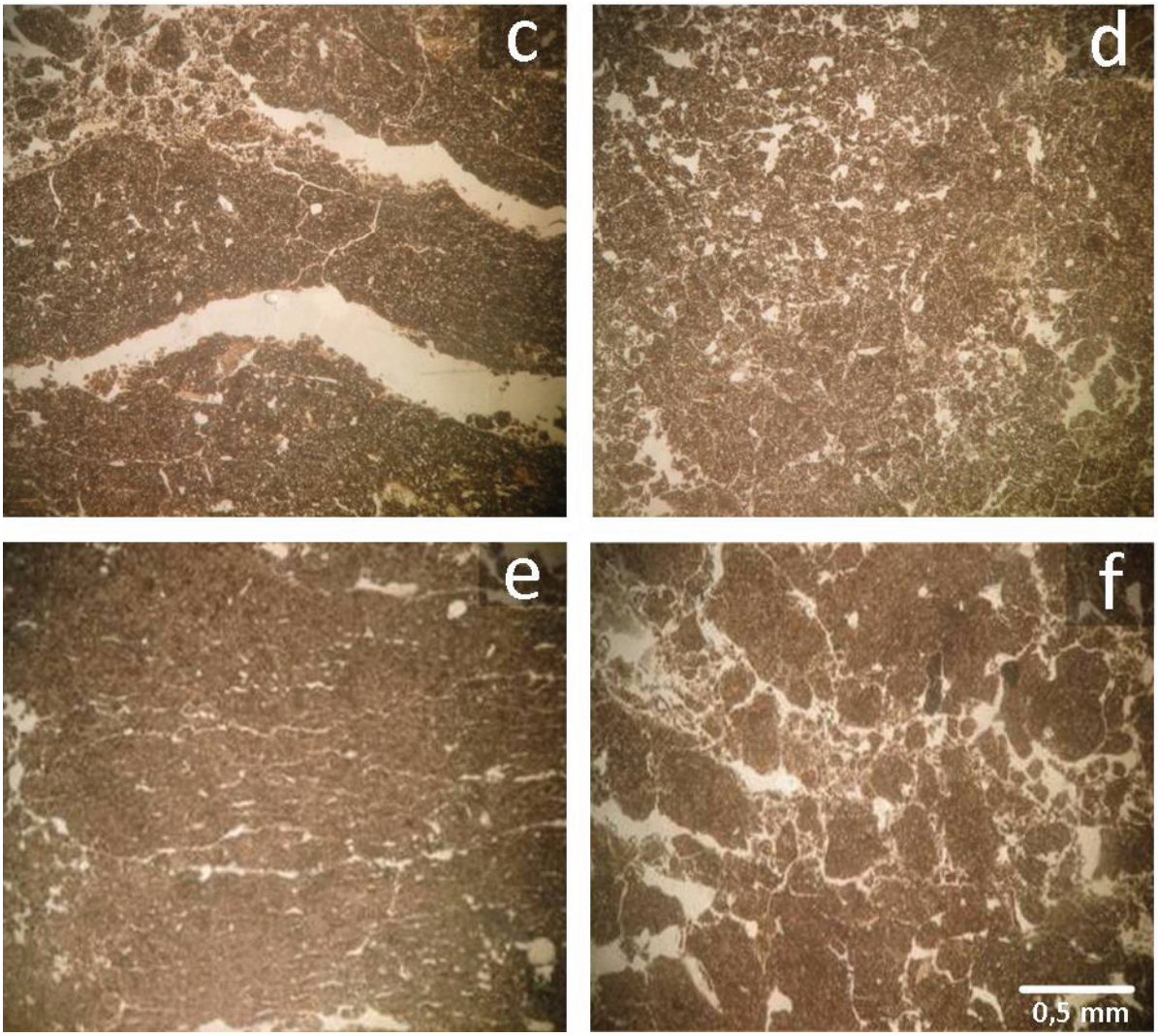


Figure 1. Some examples of platy microstructures (horizontal platy aggregates and planar voids) derived from mechanical stresses and crumb microstructures (rounded aggregates and compound packing voids) resulting from biological disturbance and biobuilding in soils under NT. No-tilled Mollisols from different areas in the Pampean region (Argentina). Soil samples obtained between 0 -6 cm depth. a) and b): Typic Argiudoll from Chañar Ladeado, Santa Fe province. c) and d): Typic Argiudoll from Chivilcoy, Buenos Aires province. e) and f): Typic Argiudoll from Monte Buey, Cordoba province.

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MITIGATION OF CLIMATE CHANGE THROUGH CONSERVATION AGRICULTURE IN EUROPE

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ABSTRACT

Agriculture and climate change are closely related. In this communication, the European Conservation Agriculture Federation (ECAF) presents how the European agricultural sector can respond to climate change through Conservation Agriculture (CA). It is based on the outcomes and the realization of several European (LIFE) public-funded projects based on the assessment of CA performance in Europe, and on a literature review on the topic. In terms of contribution, approximately 10% of greenhouse gases (GHGs) globally emitted come from the European Union (EU). Within the GHGs emitted in Europe, around 10% derive from agriculture. In order to reduce these emissions the 21st meeting of the Conference of the Parties (COP21) and the 11th meeting of the Conference of the Parties serving as the meeting of the Parties to the *Kyoto Protocol* (CMP) was held at the end of 2015 in Paris. It concluded with the adoption of a historic agreement to combat climate change and promote measures and investments for a low-carbon, resilient and sustainable future, the so-called Paris Agreement. Scientific studies, carried out in different European biogeographic regions and countries, agree that the less soil is tilled, the more carbon is sequestered and stored in it. These studies show that, during several years of Conservation Agriculture, it is possible to sequester large amounts of CO_2 per hectare and year in soils, when compared to systems based on soil tillage. In relation to conventional tillage systems the implementation of CA in EU-28 countries in both annual and perennial crops could result in an annual sequestration of almost 190 millions of tons CO_2 as soil organic carbon. The amount of CO_2 sequestered into the soil through the application of the CA would contribute significantly to reach the targets committed in Paris Agreement by 2030. Considering accepted European emission reduction targets, carbon sequestration that could take place on farmland under Conservation Agriculture would amount to 22% of reductions committed in all diffuse emission sectors by 2030, which corresponds to 10% of total annual diffuse emissions. This would allow for some flexibility in the reduction of emissions in other sectors such as housing or transport.

KEYWORDS: climate change mitigation, Conservation Agriculture, Best Management Practices, SOC, no-till, groundcovers.

BACKGROUND

Agriculture and climate change are closely related. In terms of contribution, approximately 10% of greenhouse gases (GHGs) globally emitted come from the European Union (EU). Within the GHGs emitted in Europe, around 10% derive from agriculture. In this short communication, the European Conservation Agriculture Federation (ECAF) presents how the European agricultural sector can respond to climate change through Conservation Agriculture (CA). It is based on the outcomes of several public-funded European LIFE projects on the assessment of CA performance in Europe, and on a literature review on the topic. The full paper (González-Sánchez et al., 2017) can be downloaded from ECAF's website (www.ecaf.org).

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Today, in order to achieve sustainability in agriculture a multidimensional approach is essential to attain a balance, or best compromise, between preservation and improvement of the environment, social equity and economic viability, and therefore improve the welfare of society. It is widely recognized that this can only be achieved if natural resources are maintained or even improved, i.e. used responsibly and efficiently. Not only in agriculture, soil is a key resource as it mediates a wide range of ecosystem services both provisioning, regulating and supporting services. To this end, soil quality, and in particular the amount of organic carbon stored in it are essential. Scientific studies carried out in different agro-ecological regions and countries agree that the less soil is tilled, the more carbon is sequestered and stored in it. Plants absorb carbon dioxide from the air and transform it through the process of photosynthesis into organic carbon. This organic carbon becomes the source for soil organic matter, contributing thus to an enhanced soil fertility and to an improved productive capacity. On the other hand, any action aimed at saving energy and fuel, such as reducing the number of tillage operations, optimizing the use of agricultural inputs and proper execution of operations, directly reduces emissions of greenhouse gases. Therefore, a sustainable agricultural system that responds to these requirements is of particular importance: Conservation Agriculture.

DESCRIPTION

Different studies in Europe show that during several years of application of CA principles it is possible to sequester large amounts of CO_2 per hectare and year in both annual and permanent crops, when compared to tillage-based cropping systems. Average sequestration rates per biogeographical region in Europe are summarized in Table 1.

Based on these assumptions the estimation for EU-28 countries of the potential soil organic carbon (SOC) sequestration through the adoption of CA in annual crops when compared to conventional tillage systems is given in Figure 1 for the different biogeographical regions in Europe.

In relation to CA in permanent crops (groundcovers), there are no official data for Europe as a whole. Due to that, the data on the current adoption of this practice derive from reports of the European national associations of Conservation Agriculture. Although scientific data for carbon sequestration are only available for the Mediterranean biogeographic region (except France), we present a calculation of the C sequestration potential in permanent crops for EU-28 in Figure 2, based on a considered conservative annual sequestration rate of 0.4 t ha-1yr-1 (Table 1).

In order to quantify the CO_2 emission reduction achievable through the sequestration of organic C in the soil and not released through the microbiological oxidation processes of organic matter, we are using the ratio of 3.7 tons of CO_2 that are generated from 1 ton of organic C. Therefore, taking into account the increase in soil organic matter (SOM) observed in CA systems (both annual crops and groundcovers in permanent crops) in comparison to the management systems based on conventional tillage, it is possible to calculate the total CO_2 emission offset potential through the implementation of CA in Europe (Table 2). The amount of CO_2 sequestered in the soil through the application of the CA, would reach the targets committed by 2030 in the Paris Agreement (UN, 2017) with greater ease. Considering overall European figures, carbon sequestration that could take place on farm land under Conservation Agriculture would help achieve around 22% of the necessary reductions in the non-ETS sectors by 2030, and almost 10% of the total emissions still allowed in the non-ETS sectors. This achievement would give the signing member countries some margin in the emission reduction in other sectors such as housing or transport.

Table 1. Average carbon sequestration rates in annual and permanent crops by biogeographical region.

		Biogeographical region			
Crop type		**Atlantic**	**Boreal**	**Continental**	**Mediterranean**
Annual	**Increase of soil organic carbon (t ha-1 yr-1)**	0.32	0.02	0.42	0.81
Permanent		0.40	ND	0.40	1.30

* estimation; ** not defined

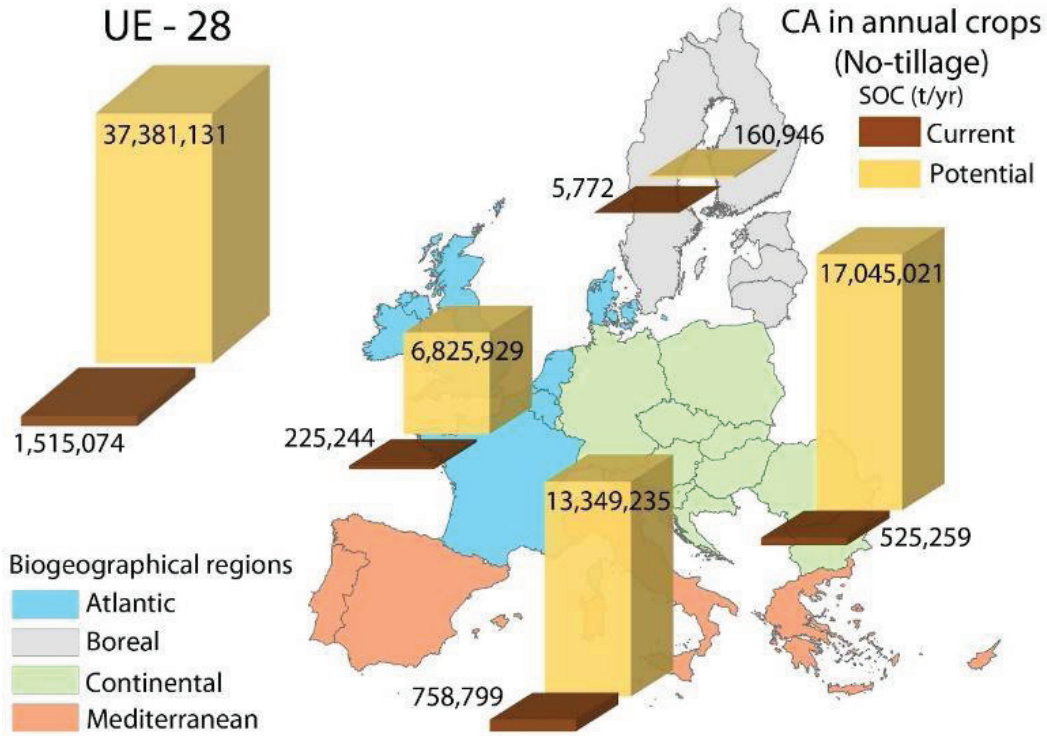

Figure 1. Current and potential SOC fixed by CA in annual crops compared to systems based on conventional soil tillage in EU-28 and for the different biogeographical regions in Europe.

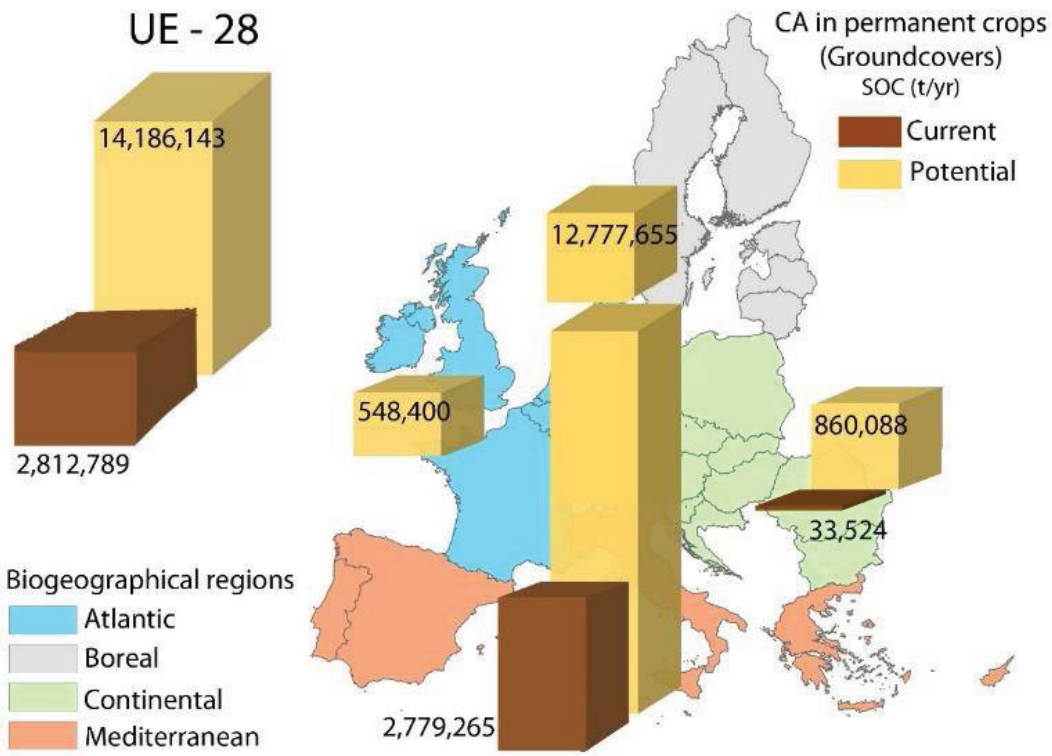

Figure 2. Current and potential SOC fixed by groundcovers compared to systems based on soil tillage in EU-28 and in the different biogeographical regions.

Table 2. Current and potential fixation of CO_2 in Europe.

	Biogeographical region	Current CO_2 fixation through CA (t yr^{-1})	Total Potential CO_2 fixation through CA (t yr^{-1})	Remaining Potential for CO_2 fixation through CA (Potential - current) (t yr^{-1})
Austria	Continental	43,731	2,019,403	1,975,672
Belgium	Atlantic	320	782,291	781,971
Bulgaria	Continental	25,470	5,145,996	5,120,526
Croatia	Continental	28,619	1,432,719	1,404,101
Cyprus	Mediterranean	803	341,213	340,410
Czech Republic	Continental	63,010	3,752,510	3,689,499
Denmark	Atlantic	2,959	2,632,794	2,629,835
Estonia	Boreal	3,090	42,435	39,345
Finland	Boreal	14,667	140,265	125,599
France	Atlantic	220,000	14,358,615	14,138,615
Germany	Continental	232,617	17,723,982	17,491,365
Greece	Mediterranean	2,309,258	9,729,155	7,419,897
Hungary	Continental	103,051	5,809,954	5,706,902
Ireland	Atlantic	2,367	1,186,900	1,184,533
Italy	Mediterranean	1,322,806	26,374,586	25,051,780
Latvia	Boreal	832	80,788	79,956
Lithuania	Boreal	1,414	156,173	154,759
Luxembourg	Continental	679	96,532	95,853
Malta	Mediterranean	0	23,611	23,611
Netherlands	Atlantic	8,700	874,935	866,234
Poland	Continental	603,650	15,391,891	14,788,241
Portugal	Mediterranean	205,142	6,382,238	6,177,096
Romania	Continental	901,191	11,916,910	11,015,719
Slovakia	Continental	43,024	2,052,459	2,009,435
Slovenia	Continental	3,828	309,713	305,885
Spain	Mediterranean	9,134,893	52,947,794	43,812,901
Sweden	Boreal	1,160	170,474	169,314
United Kingdom	Atlantic	591,548	7,203,670	6,612,122
Total Europe		**15,868,829**	**189,080,005**	**173,211,176**

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PEANUT POD YIELD AND SOIL COMPACTION IN BRAZILIAN CONSERVATION AGRICULTURE

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ABSTRACT

In Brazil the cultivated area with peanut is approximately 120.000 hectares and approximately 80% are concentrated in Sao Paulo State, mainly as crop rotation to renew sugarcane crop. Recently, there has been increasing the adoption of green harvested sugarcane system, which represents almost 75% of 9,2 million hectares. After harvesting a great amount of straw is deposited over soil surface, thus the adoption of conservation agriculture principles (legume breaks, minimum tillage, trash retention and when it is possible to use controlled traffic) are desirable in order to reduce the costs, to diminish the soil erosion and to maintain the good stalk yields. Peanut farmers are resistant to adopt the no-till under sugarcane straw, although there are a lot of scientific results In this context, two trials were carried out in a commercial fields located at Pitangueiras city (Red Latosol with high clay content) and Planalto city (Red-Yellow Latosol with high sand content), both in Sao Paulo State, Brazil. According to randomized block experimental design, three treatments were installed; conventional tillage, reduced tillage (Rip Strip®) and no-tillage. Agronomic characteristics were evaluated from 30 days after planting to the harvest at the beginning of April. The soil cone index was evaluated before installing the tillage and after harvesting of peanut using a digital penetrometer model PNT-2000® (DLG Company). The pod yield was three times and 26% lower in the no-tillage and Rip Strip, respectively, for clay soil, but no difference was observed in the Rip Strip in comparison with conventional for sand soil. On the other hand, the pod loss after digging was 7 % lower in conservation agriculture. The highest soil strength for both soils was verified from 0,10 to 0,30 m depth. Rip Strip it seem to be a good strategy to diminish the soil compaction in the row of peanut crop and can reduce the variability of seedling emergence, consequently a good pattern of plant population.

BACKGROUND

In Brazil the sugarcane crop is cultivated in almost 9.2 million hectares, which 60% of plantations are concentrated in Sao Paulo state. The government of Sao Paulo State has mandated (Act # 47,700 of March 1st, 2003, regulates the law # 11,241 of September 19th, 2002) that in flat (less than 12% of slope) sugarcane production areas feasible for mechanical harvest, the use of fire to reduce biomass before harvesting must be banished completely up to 2021, but recently this deadline was anticipated to 2017. Due to this social pressure, nowadays the majority of fields are harvested without burning (around 95 %), then a great amount of straw (average 15 Mg of dry matter per hectare each year) is deposited over the soil surface. In this condition is desired the adoption of reduced or no-tillage in order to diminish the problems with soil erosion and to reduce the costs. In 1997 farmers started to develop planter machines to sow soybean under sugarcane straw in order to save time and cash and is today a successful case. On the other hand, peanut farmers are resistant to adopt the no-till under sugarcane, although there are some results about the possibility to grow this legume in conservation agriculture. Peanut farmers mention three reasons to continue use conventional tillage: soil compaction, lower yield and problems with digging.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

In Brazil the cultivated area with peanut is approximately 120.000 hectares, which 80% are concentrated in São Paulo State, mainly as crop rotation to renew sugarcane crop. Recently, there has been increasing the adoption of green harvested sugarcane system, which represents almost 95% of 6,0 million hectares. Due the great amount of straw, peanut farmer need to spend more time and money to prepare the soil and the costs increase almost three times in comparison with burning harvest system. Normally to incorporate 15 Mg ha-1 of sugarcane trash, peanut farmers use seven tillage operations. As a consequence of intensive conventional tillage, the soil erosion is common and this situation difficult the relationship between land owner and the peanut farmers (90% are partner and pay US$ 350 per ha). The principles of Conservation Agriculture (CA) are very important to develop a sustainable peanut crop system. While in United States the percentage of land area under no-tillage or any kind of conservation tillage represented 25,3% of total cultivated with peanut (Mulvaney et al., 2017), in Brazil there few examples of commercial fields. For Brazilian crop systems the researches started in 2000 and there are results that shows increase in pod yield and a reduction in terms of pod loss after digging Soil compaction is one important reason to explain the reduction of pod yield. Even with new planter machine, the quality of peanut crop is not so good in terms of plant population (initial stand), than farmers have still searched a way to sow under straw without failures. Recently was imported from USA a strip tillage system called Rip Strip®. Scientific results show benefits of strip tillage for peanut in terms of thrips infestation, pod yield and profit (Siri-Prieto et al., 2009)

EXPERIMENTAL APPROACH

Considering this context, four trial were carried out in a commercial fields located at Pitangueiras city (Red Latosol, high clay texture) and Planalto city (Red-Yellow Latosol, sand texture) during growing season 2015/16, and Novo Horizonte city (Yellow Latosol, sand texture) and Assis city (Red-Yellow Latosol, medium texture) in 2016/17. All this places are located in different peanut crop regions in Sao Paulo State. According to randomized block experimental design, three treatments were installed; conventional tillage (moldboard plowing followed by two applications of disk harrowing),

reduced tillage (Rip Strip® after spraying the area with 3.6 kg a.i. ha-1 of glypfosate), amd no-tillage (crop residues on the soil surface after spraying of glyphosate). In both places (Pitangueiras and Assis cities) the peanut genotype was a runner type IAC-OL3 and for the others (Planalto and Novo Horizonte cities) was grown the runner variety IAC-503. It was used a vacuum planter calibrated to establish 166.000 plants ha-1 in paired row 90 cm apart with a large coulter followed by a double disc opener. Agronomic characteristics were evaluated from 30 days after planting to the harvest at the beginning of April. The soil strength was evaluated before installing the tillage and after harvesting of peanut using a digital penetrometer model PNT-2000 (DLG Company). After digging and mechanical harvesting, the same procedure was done to evaluate the pod loss in 2 m2 of soil surface.

RESULTS AND DISCUSSION

For clay soil conditions (Table 1), it was verified that the pod yield in no-tillage was in average 4000 and 2500 kg ha-1 lower than conventional and reduced tillage, respectively. On the other hand, for sand soil, no significant difference between conventional and reduced tillage was observed for pod yield. It's interesting to emphasize that the pod yield determined by samples has showed higher production in no-tillage for sand soil, but was lower for total area harvested. The plant failure (gaps) in the rows was 0,18%, 2.52% and 21.3 % at conventional, Rip Strip and No-Tillage, respectively. According to Siri-Prieto et al. (2009), in general, peanut response to conservation tillage has been variable in the last 20 yr due to issues such as weed control, diseases, hardpan, pod digging, and weather conditions. Maybe for the present research, the most important factor was the reduction in the plant population, due to the great amount of straw the seedling needs more time to emergence. The other important factor is the soil compaction, mainly in rotation with sugarcane, in which the traffic during the harvest is intensive. When it comes to soil compaction, in the Figure 1 and 2 are showed the soil strength for both soils in two different measurements. In sand soil, when the measurement was done with good soil water content, the value of soil strength is higher in the no-tillage, but the opposite result it was verified during a dry period. For clay soil, despite of the higher soil moisture, the soil strength is higher in the conservation tillage in comparison with conventional. The literature showed that the majority of crops have problem with vegetative and root growth when soil strength is higher than 2,5 MPa or a soil bulk density is higher than 1,4 g dm-3 (Caranache, 1990). The use of Rip Strip® reduced tillage, it seems to be an acceptable option to reduce the soil compaction in the peanut row and to keep the straw in a good level to avoid soil erosion.

Table 1. Pod yield in different soil managements for two peanut genotypes and years. Different letters compare means (Tukey 5%) between soil management treatments.

Soil Managements	Pod Yield (kg ha $^{-1}$)			
	IAC-OL3		IAC-503	
	2015/16	2016/17	2015/16	2016/17
Conventional	6046 a	5468 a	3834 (4881)	4965 a
Rip Strip	4514 b	5587 a	3089 (4848)	3545 b
No-Tillage	2054 c	4825 b	4445 (4750)	3682 b
F-probability	52,7 **	12.7 **	---	17.7 **
L.S.D (Tukey 5%)	1046	387.6	---	624.6
CV %	17,5	11,4	---	28,9

When it comes to soil compaction, in the Figure 1 and 2 are showed the soil strength for both soils in two different measurements. In sand soil, when the measurement was done with good soil water content, the value of soil strength is higher in the no-tillage, but the opposite result it was verified during a dry period. For clay soil, despite of the higher soil moisture, the soil strength is higher in the conservation tillage in comparison with conventional. The literature showed that the majority of crops have problem with vegetative and root growth when soil strength is higher than 2,5 MPa or a soil bulk density is higher than 1,4 g dm-3 (Caranache, 1990). The use of Rip Strip® reduced tillage, it seems to be an acceptable option to reduce the soil compaction in the peanut row and to keep the straw in a good level to avoid soil erosion.

Figure 1. Soil strength (MPa) measured in a sand soil at the beginning and in the middle of cycle of peanut crop, cultivated in Planalto city, Sao Paulo State. Means came from 30 replications.

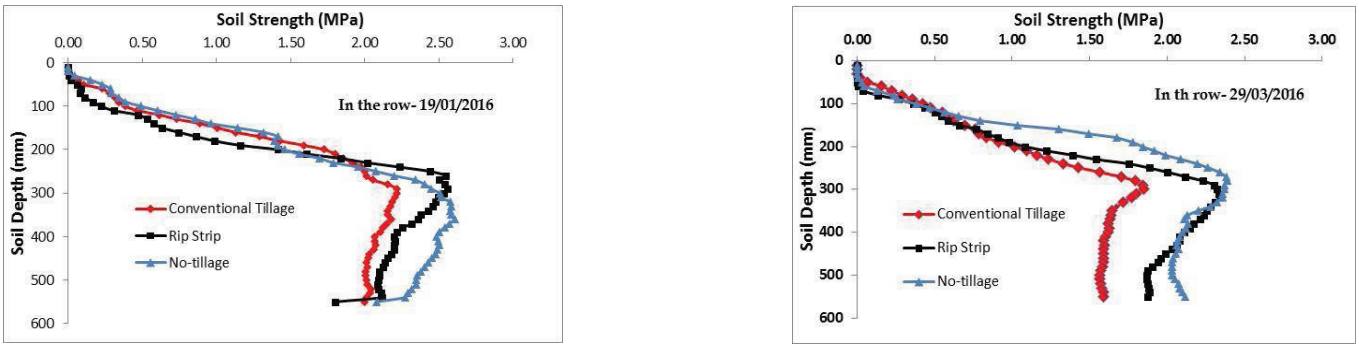

Figure 2. Soil strength (MPa) measured in a sand soil at the beginning and in the middle of cycle of peanut crop, cultivated in Pitangueiras city, Sao Paulo State. Means came from 60 replications.

In conclusion, the pod yield was three times and 26% lower in no-tillage and Rip Strip®, respectively, for clay soil, but no difference was observed in reduced tillage in comparison with conventional tillage for sand soil in both years, except in Novo Horizonte city in order to reduction in the plant population for conservation agriculture. On the other hand, the pod loss after digging was 7% lower in conservation agriculture systems. The number of failures in the row was almost 10 and 100 times higher than conventional and reduced tillage, respectively. The higher soil strength (2,5 MPa) was verified from 0,10 to 0,30 m depth. Rip Strip® can reduce the soil compaction in the row of peanut and can help to improve the seedling emergence, consequently a good pattern of plant population.

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PRODUCTIVE AND ENVIRONMENTAL FRIENDLY FUTURE CEREAL SYSTEMS THROUGH INNOVATIVE AGRONOMIC PRACTICES IN SOUTH ASIA

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ABSTRACT

South Asian countries will have to double their food production by 2050 while using resources more efficiently and minimizing environmental problems. Transformative management approaches and technology solutions will be required in the major grain-producing areas that provide the basis for future food and nutrition security. This study was conducted in four locations representing major food production systems of densely populated regions of South Asia. Novel production-scale research platforms were established to assess and optimize three futuristic cropping systems and management scenarios (S2, S3, S4) in comparison with current management (S1). With best agronomic management practices (BMPs), including conservation agriculture (CA) and cropping system diversification, the productivity of rice- and wheat-based cropping systems of South Asia increased substantially, whereas the global warming potential intensity (GWPi) decreased. Positive economic returns and less use of water, labor, nitrogen, and fossil fuel energy per unit food produced were achieved. In comparison with S1, S4, in which BMPs, CA and crop diversification were implemented in the most integrated manner, achieved 54% higher grain energy yield with a 104% increase in economic returns, 35% lower total water input, and a 43% lower GWPi. Conservation agriculture practices were most suitable for intensifying as well as diversifying wheat–rice rotations, but less so for rice–rice systems. This finding also highlights the need for characterizing areas suitable for CA and subsequent technology targeting. A comprehensive baseline dataset generated in this study will allow the prediction of extending benefits to a larger scale.

Keywords: best management practices, cereal productivity, cereals systems, conservation agriculture, crop diversification, global warming potential, rice-based cropping system, South Asia

DESCRIPTION

South Asia has a total population of 1.6 billion, of which about 540 million people are poor and hungry and one-third are malnourished. It is estimated that demand for food and nonfood commodities is likely to increase by at least 60% globally between 2010 and 2050, with many developing countries including those in South Asia having to double their food production. Future food production will be limited on a global scale by the availability of land, water, and energy therefore, decoupling future agricultural growth from the unsustainable use of these resources for increasing food production has become one of the cornerstones for a new sustainable development agenda. Agriculture in the Indo-Gangetic Plains (IGP) in South Asia is predominantly centered on the intensively irrigated rice–wheat systems with associated productivity and sustainability problems. During the last few years, several component technologies of conservation agriculture (CA) such as reduced or zero tillage, drill seeding, crop residue retention, and crop rotation have been evaluated in cereal systems. Zero-till wheat has been adopted on a significant area in the rice–wheat system in the northwestern IGP with positive impacts on wheat yield, profitability, and resource-use efficiency. A recent meta-analysis of global data reported either no gains or losses of grain yields of various crops with either full CA or with some components of CA. However, while yield advantages are not always possible to achieve with CA practices alone over the short term, gains in input use efficiency and economic benefits are attainable. Although the benefits of CA components are likely to be most when combined with other BMPs, this aspect largely remains unexplored. It is also uncertain to what extent future CA-based cereal systems in South Asia can be optimized to be more productive as well as meet many other requirements in terms of sustainable resource use and environmental impact.

To meet this challenge, promotion and adoption of cropping systems that integrated BMPs and CA components are essential from an agronomic viewpoint. Hence, four cropping systems management scenarios (S1, S2, S3, and S4) were conceptualized with a vision to design and evaluate future trajectories for intensifying and diversifying cereal-based cropping systems that are highly productive, achieve optimal resource-use efficiency, are economically viable, and are characterized by low global warming potential intensity (GWPi). Four novel production- scale research platforms were established to represent a combination of distinctly different agro-ecological conditions and major food production systems of densely populated regions of South Asia. A suite of performance indicators related to grain energy and economic outputs, various inputs (water, labor, nitrogen, photo- synthetically active solar radiation, and fossil fuel energy), and greenhouse gas (GHG) and global warming potential (GWP) were quantified, and the data were subjected to mixed model analysis and biplot analysis.

With best agronomic management practices (BMPs), including conservation agriculture (CA) and cropping system diversification, the productivity of rice- and wheat-based cropping systems of South Asia increased substantially, whereas the global warming potential intensity (GWPi) decreased. Positive economic returns and less use of water, labor, nitrogen, and fossil fuel energy per unit food produced were achieved. In comparison with S1, S4, in which BMPs, CA and crop diversification were implemented in the most integrated manner, achieved 54% higher grain energy yield with a 104% increase in economic returns, 35% lower total water input, and a 43% lower GWPi. Conservation agriculture practices were most suitable for intensifying as well as diversifying wheat–rice rotations, but less so for rice–rice systems. This finding also highlights the need for characterizing areas suitable for CA and subsequent technology targeting. A comprehensive baseline dataset generated in this study will allow the prediction of extending benefits to a larger scale.

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SMALLHOLDER FARMER INNOVATION AND CONTEXTS IN MAIZE-BASED CONSERVATION AGRICULTURE SYSTEMS IN CENTRAL MALAWI

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ABSTRACT

The increased threat of food insecurity, climate variability and change requires more sustainable ways of agriculture intensification in African smallholder farming systems (Pretty, Toulmin & Williams, 2011). Ample evidence confirms that maize-based conservation agriculture (CA) systems in sub-Saharan Africa lead to increased soil health and yield enhancement compared to conventional tillage-based agriculture systems yet their overall uptake remain low. On the other hand, an array of studies on challenges and solutions to CA systems in the region are principally on the views of scientists and often neglecting the views of CA farmers themselves yet uptake of CA in the Americas, where extent of adoption is far much higher than Africa (i.e. South America is 60% while Africa is 0.8%), was led by innovative farmers. Therefore, this study worked to capture farmer views by assessing farmer innovation and contexts during implementation of maize-based CA systems in Malawi, a southern African country with protracted food insecurity issues perpetrated by climate change and degraded soils. A survey involving interviews with 226 CA farmers was deployed and triangulated with key informants comprising extension workers and policy makers. The study showed that about 58% of smallholder farmers did not adapt CA practices to their circumstances largely because they were strictly following recommendations from change agents. The major challenge noted was competition for crop residues due to mice hunters, fires and grazing livestock. Local by-laws initiated by the communities have started to privatise the crop residues and its grazing. Despite farmers revealing wealth of local CA innovations, extension workers did not document and share them, thus, neglecting more than half of the potential solutions by the farmers. Despite presence of conducive policies and harmonisation efforts by the Government to support CA, the current relationship between CA farmers and stakeholders remains linear and does not recognise the importance of farmer contribution in the agricultural innovation system. Thus, non-linear interaction must be facilitated and enhanced to reap all benefits from innovation systems.

BACKGROUND

The increased threat of food insecurity, climate variability and change requires more sustainable ways of agriculture intensification in African smallholder farming systems (Pretty, Toulmin & Williams, 2011).

Conservation agriculture (CA) adapts to the negative effects of climate change (Thierfelder et al., 2017), may sequester soil carbon if systems are diversified (Powlson et al. 2016), reduces to a certain extent the emission of greenhouse gases (Kimaro et al. 2016), and halts soil degradation while improving agriculture productivity and income (Barungi & Maonga, 2011; Thierfelder et al., 2013; Reicosky, 2015; Mupangwa et al., 2016; Thierfelder et al., 2016). CA is not only associated with the climate-smart agriculture (CSA) framework but also sustainable production intensification (Lal, 2015; Kassie et al., 2015; Ward et al., 2016). Empirical evidence confirms that maize-based conservation agriculture (CA) systems in sub-Saharan Africa lead to increased soil health and yield enhancement compared to conventional tillage-based agriculture systems yet their overall uptake remain low (Bunderson et al., 2007; Derpsch et al., 2010; Ngwira et al., 2011; Thierfelder & Wall, 2011; Ngwira et al., 2012a; Kaczan et al., 2013; Thierfelder et al., 2013; Wall et al., 2013; Ngwira et al., 2014a; Ngwira et al., 2014b; Kassam et al., 2014; Thierfelder et al., 2015b). In 2014, Africa had only 1.2 million ha under CA, about 0.8% of global total area under CA and 0.9% of total arable land on the continent, and Malawi in particular, had 70 000 ha under CA in 2014, representing 2.8% of its total arable land (Kassam et al., 2014) (Kassam et al., 2014).

Many studies on challenges and solutions to CA systems in the region are principally on the views of scientists with little views of CA farmers themselves yet uptake of CA in the Americas, where extent of adoption is far much higher than Africa (i.e. South America is 60% of total arable land), was led by innovative farmers. Therefore, the underlying objective of the study was to assess farmer innovation and contexts during adoption and implementation of maize-based CA systems in central Malawi. Specific to this study was: a) to find out the proportion of farmers that modify CA practices within defined CA principles during the adoption process; b) to establish perceptions of farmers on the extent of benefit from the modification of the CA system practices; c) to identify CA challenges and innovations/solutions developed by the farmers against them; d) to identify pathways for sharing the local CA innovations; and e) to assess the environment for supporting development and nurturing of farmer CA innovations.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

There is recognition that as much as CA principles are universal in their application, the implementation of the actual technologies are site and farmer-circumstance specific requiring more innovative ways of promotion than the linear extension approach used to disseminate component technologies such as crop varieties (Ekboir, 2002; Wall, 2007; Thierfelder et al., 2016). Moreover, CA is knowledge-intensive hence it requires capacity in problem-solving amongst farmers, extension agents, researchers and other stakeholders (Wall, 2007). Ignoring farmer voices on innovations for coping with CA challenges could be one of the reasons for the seemingly low adoption in the Africa and other lagging parts of the world (Bragdon & Smith, 2015). Therefore, the results from the study demonstrate how significant farmer innovations are in making the CA work in their farming circumstances, thus challenging CA scientists and practitioners to pragmatically integrate innovative farmers in the agricultural innovation systems. The study would encourage practitioners to initiate innovation platforms that put CA farmer innovators central to the CA agenda.

METHODOLOGY

The study was founded on the agricultural innovation system, which recognises farmers as innovators beside scientists. A survey involving interviews with 226 CA farmers was deployed and triangulated with key informants comprising extension workers and policy makers.

RESULTS AND DISCUSSION

The study showed that about 58% of smallholder farmers did not adapt CA practices to their circumstances largely because they were strictly following recommendations from change agents. About 67% of those that modified the practices claimed that it was 'very beneficial' to their farming system, perceiving enhanced yields and reduced farming cost, among others. Farmers are heterogeneous and so are their farming environments hence the call for CA practices to be site and circumstantial specific is critical (Thierfelder et al., 2016; Dougill et al., 2017). Thus, the finding informs that more work needs to be done to encourage farmers to innovate as conceived in the agricultural innovation system (Spielman, 2005; Thierfelder & Wall, 2011).

The majority of farmers (85%) indicated to face challenges with CA. The challenges mostly mentioned were: a) burning and destruction of mulching materials by mice hunters (75% of farmers); b) livestock grazing on and destruction of mulch (55.5%); inadequate amounts of mulching material available (20.2%); g) theft of maize stalks which are used as fuel for cooking (15.4%); and h) CA activities are laborious and costly (13.5%). On the other hand, experts knew less than what farmers reported. The majority of communities in SSA have free access to utilisation of residues for grazing and other purposes (Valbuena et al., 2012; Mupangwa & Thierfelder, 2014). The combined effects of low agricultural production, high population growth and decrease of communal resources lead to dependency on crop residues for not only livestock but also many household activities such as cooking and construction (Valbuena et al., 2012).

Solutions to such challenges were also reported. The most mentioned solution (44.7%) was the privatisation of the mulch through by-laws by the local authorities (e.g. chiefs) whereby every community member is to respect the CA farmers' field groundcover. The by-laws illegalise: a) the fire outbreaks caused by mice hunters or general bush fires; b) cricket hunters; c) theft of mulch; and d) grazing one's livestock on other people's CA farms. Such solutions were said to be shared in the following forums: field day (31.7%); farmer group/club (27.9%); agriculture show (26.9%); and farmer field school (12.5%). These methods, with an exception of farmer field school, are linear and do not conform to interactive and participatory extension methods as envisaged in the agricultural innovation system. Despite farmers revealing wealth of local CA innovations, extension workers did not document and share them, thus, neglecting more than half of the potential solutions by the farmers. The reason for not documenting them was that the solutions were locked in the extension workers' minds as they perceived they should not be shared before being scientifically proven.

The study further revealed that extension workers positively react to farmer-driven innovations and tend to encourage them, despite, as already indicated, not documenting the innovations for sharing with other stakeholders particularly scientists. The by-laws provide the major institution at community levels protecting the CA. Two major milestones on the national CA environment are the formation of National Conservation Agriculture Task Force (NCATF) and the guidelines for CA implementation. The NCATF aims to advocate and influence agricultural and other policies related to conservation agriculture and facilitate capacity building. Currently, NCATF effectiveness may not be confirmed especially with frequent meetings being impeded by funding challenges such that some stakeholders recently complained of meeting only once since its re-launch in 2007 (Dougill et al., 2017). The CA guidelines just launched at the end of year 2016, have come at a right time when CA messages in the field were lacking harmonisation.

In conclusion, the results show that despite some farmers being CA innovators, and having presence of conducive policies and harmonisation efforts by the Government to support CA, the current relationship between CA farmers and stakeholders remains linear and does not recognise the importance of farmer contribution in the agricultural innovation system. CA scientists and experts are in fore front, while CA farmers are passively following. This could be the likely reason why CA adoption is very low

in Africa and other lagging regions of the world. Thus, non-linear interaction must be facilitated and enhanced to reap all benefits from innovation systems. An example of how farmer innovators could be engaged is through innovation platforms such as learning centres and farmer field schools.

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SOIL MANAGEMENT QUALIFICATION UNDER NO-TILL SYSTEM IN CENTER-SOUTHERN BRAZIL

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ABSTRACT

No-tillage (NT) system comprises a set of technological processes aimed at exploring farming systems while promoting soil conservation management. Its main principles are: leaving soil undisturbed except for seeding in the drills or rows, the maintenance of permanent soil cover, the diversification of crops by rotation or crop consortium, the adoption of joined harvesting-seeding process to reduce the time gap between operations. Although the NT system was developed to reduce erosion and to promote soil quality, there are several inadequate practices that have been applied in areas where cropping is misnamed as "No-tillage" system, e.g., the use of monoculture, the terraces' misuse or elimination, the absence of contour plowing and others that are incompatible with the conservation principles and that lead to losses in soil and water quality and in local biodiversity. In order to improve the soil management in NT areas, a network research program coordinated by Embrapa Soils and supported by Itaipu Binacional has been studying no-tillage in twelve watersheds of six regions in Center-Southern Brazil since 2014. The network is developing indicators to assess soil management and its environmental effects at property and watershed scales. The program includes: participatory processes of self-evaluation, adjustment and certification by farmers; monitoring farming systems and small watersheds parameters (soil and plant) in twelve locations; long term experiments in six study-sites; and technology transfer in reference areas for training in NT systems. As preliminary results, the selection of monitoring watersheds has been carried out and the communication process has promoted effective participation of farmers in Paranapanema-SP, Londrina-PR, Toledo-PR, Maracaju-MS, Rio Verde-GO and Passo Fundo-RS. In addition, the establishment of local and international institutions network started up actions to improve soil management though no-tillage system.The monitoring approach adopts complementary methods to assess the farming system: IQP which is the No Tillage Participatory Quality Index developed by the Brazilian Federation of No-Till Farms and Irrigation (FEBRAPDP); DRES (Rapid Diagnostic of Soil Structure) to asses management structural quality in areas under NT; and Beta (β) index to classify watershed management based on hydrometeorological data, turbidity time series and sedimentary data set from monitored watersheds.

BACKGROUND

The no-tillage (NT) preconizes soil management without disturbing the soil through tillage while keeping soil cover with undisturbed crop residues and diversified cropping system involving annuals and perennials in rotation, sequence and/or associations. The NT has been adopted rapidly along extensive areas of Center-Southern Brazil due to initial advantages such as the erosion control. Nevertheless, several inadequate practices to tropical and subtropical regions have been applied in farming systems, such as the use of monoculture, the terraces' misuse or elimination, the absence of contour plowing and others that are incompatible with the conservation principles and that lead to losses in soil and water quality and in local biodiversity.

In contrast, we recommend the No-tillage system (NTS) developed in Brazil, which comprises a set of technological processes aimed at maximizing biodiversity, photosynthetic activity, the functions of active roots and soil cover, in order to improve economical production of diversified crops and environmental quality.

In order to study the soil management quality and environmental impacts in No-tillage areas, the project called "Improvement of land management in the Center-Southern Brazil – Research Network SoloVivo" has been carried out in twelve small watersheds.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

This network is developing indicators to assess soil and water quality management and its environmental effects at small watershed scales. The research includes participatory processes of self-evaluation, adjustment and certification by farmers; monitoring farming systems, and quality parameters for soil, water, crops and management; long term experiments in six study-sites; and formation of reference areas for training in NTS.

The project aims at acknowledging farmers who obtain good yields with soil and water conservation and generate environmental services to society. As preliminary results, the communication process has promoted effective participation of farmers in the selection of small watersheds and in the whole monitoring process. In addition, the establishment of partnership with local and national institutions increased the network and started up actions to improve soil management while seeking the full use of NTS. The monitoring approach adopts complementary methods to assess the farming system: No Tillage Participatory Index (IQP); Rapid Diagnostic of Soil Structure (DRES); the Environmental Performance Indicator (β) and other indicators under development.

DESCRIPTION

The IQP based in Roloff et al. (2011) was developed initially in the surrounding areas of Itaipu reservoir and it is currently under further development and validation in other regions of Center-Southern Brazil. The index is formed by eight indicators of soil management, which have been weighted according to regional farmers agreement in the sub-basin of Western Parana state. The IQP indicators are: rotation intensity; rotation diversity; straw cover persistence; tillage frequency or absence; adequate terracing; conservation practices evaluation; balanced nutrition; farmer commitment (time of no-tillage system). The indicators are evaluated by scores from 0,25 (the worst score) to 1 (the best one). The indicators scores are weighted by factors chosen together with farmers

in order to calculate the index value, i.e., IQP value is the sum of all indicators' values multiplied by its respective weighting factor. This final value should vary from 0 to 10, where the scores 10 to 8,51 mean "very good", scores from 8,5 to 6,51 are "good", from 6,5 to 4,5 they are "regular" and the scores lower than 4,5 mean "low" quality according to Roloff et al.(2011).

According to Ralisch et al (2017), the DRES was developed to assess a visual soil structural quality within the 25cm-depth surface soil layer sampled from small trenches. The soil samples are evaluated according to these main criteria: 1. Degradation features or soil layer structure conservation after initial handling, and 2. Attributed scores based on proportion of different sized aggregates. During the handling, the evaluation comprises the aggregate size, format and disruption; the disruption faces' format, orientation and roughness; root system distribution and aspect; and biological activity evidences. The soil samples should be collected from different plots of the property, according to the land use history, soil classes and soil texture. Due to variations of these characteristics, one to three layers may be identified in the surface soil samples. Scores for structural quality (Qe) should be attributed to each layer, and the scores vary from 1 (totally degraded structure, Figure 1a) to 6 (the best structure condition, Figure 1b).

The sample structural quality (IQEA) is calculated using all layers' scores of one sample (Qe), and the average IQEA of all samples in a plot is called the index of soil structural quality (IQES) for plot area (Ralisch et al., 2017).

The DRES can support decision making of farmers in order to improve soil structural quality and avoid inadequate practices, such as soil scarification that increases the cropping costs and leads to yield losses.

Figure 1. Samples of soil surface layer separated by DRES show **(1a)** a totally degraded structure and **(1b)** the best structure condition with preservation of earthworms.

The SoloVivo network also works in the development of an index to classify the watershed environmental performance (β), according to the proposal of D'Agostini (1999). Based on hydrometeorological data, turbidity time series and sedimentary data set from monitored watersheds, the β index will be used to evaluate the environmental performance from the relationship between the soil management quality and erosive potential.

The objective of developing this index is the proposal of theoretical and methodological approach to subsidize conservation policies and initiatives aimed at improving environmental performance of land use and soil and water management in the watershed.

These methodologies have been developed in the network environment to be applied together with farmers in order to support their decision making on soil management practices of Conservation Agriculture.

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SOIL QUALITY AND EARTHWORM POPULATION: A CORRELATION WITH THE NO-TILL QUALITY INDEX (IQP)

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ABSTRACT

Sustainable management in agriculture is fundamental to the conservation of soil and water resources. The No-Till System (NTS), when performed following its quality principles, in addition to improving soil physical and chemical characteristics, provides an adequate habitat for the development of soil animals, including earthworms. These organisms can contribute to ecosystem processes and can be used as indicators of soil quality. In this context, the aim of the present study was to validate the No-Till Participatory Quality Index (IQP), by measuring soil quality parameters (physical and chemical properties and land use history), and correlate these with earthworm populations as soil quality bioindicators. Earthworm populations were sampled at 40 farms with NTS in Western Paraná (Brazil), where IQP had been applied resulting in four quality categories: low (n=2), regular (n=11), good (n=24) and very good (n=3). Earthworms were handsorted from five 20 x 20 cm width x 20 cm depth monoliths per farm, using an adaptation of the Tropical Soil Biology and Fertility method. Earthworm were preserved in absolute alcohol, for subsequent counting, weighing and identification. Soil samples for chemical and physical analyses were also collected. There were few significant ($p < 0,05$) correlations between IQP values and soil attributes (negative: humidity and sand; positive: clay and organic matter). Although most farms had good or very good IQP, few adopted more variable crop rotations (n=5) and many of them (n=21) had soil disturbance (subsoiling), and therefore were could not be considered strictly NTS. Hence, the IQP is not consistent with the reality of the sampled farms and its calculation requires adjustment. Significant correlations were found between earthworm populations with some chemical and physical soil properties (negative: soil disturbance and water flow over the contours; positive: silt, aluminium and adequate contour lines), land use history, IQP and its indicators. Mean total earthworm abundance ranged from 0 to 715 ind m-2 and richness from 0 to 5 species. Earthworm abundance, richness and percentage of native and exotic species, were important in separating farms under NTS. However, most farms (40 and 52,5% of total) had only moderate earthworm abundance and species richness levels, demonstrating the need for management improvements in the areas of NTS to enhance earthworm populations and their contribution to ecosystem services.

Keywords: soil properties; validation; indicators; earthworms.

INTRODUCTION

The No-Till System (NTS), when performed following its principles of quality, in addition to improving soil physical and chemical characteristics, provides an adequate habitat for the development of soil animals, including earthworms.

Inadequate soil management in the western region of Paraná state, Brazil has resulted in erosion and silting of rivers and lakes. In this context, Itaipu Binacional, together with the Brazilian Federation of No-Till and Irrigation, made the Participative Quality Index of No-Till (IQP), which was developed to evaluate the quality of the NTS System practiced by farmers in the region.

The aim of the present study was to validate the IQP by correlating it with soil quality attributes (physical, chemical and biological) and history of the sites, as well as to evaluate the potential of earthworms as bioindicators in sites under NTS in western region of Paraná state (Paraná River Basin 3), Brazil.

EXPERIMENTAL APPROACH

A total of 40 sites were sampled, part of the IQP platform, which has four categories of grades: low (< 4.50), regular (> 4.51 to < 6.50), good (> 6.51 to < 8.50) and very good (> 8.50). In each site were sampled five points, totalizing 200 samples. The earthworms were sampled using the adapted Tropical Soil Biology and Fertility (TBSF) method, according to Bartz et al. (2013), generation data of earthworm abundance (ind m-2), earthworm biomass (gr m-2), species richness (number) and percentage of native and exotic species (%). In the same sample points, were taken 500 grams of soil of each monolith for routine fertility analysis and granulometry. A soil ring was removed near the monolith to determine the density, moisture and total, macro and micro porosity. The resistance to penetration measuring was also performed. It was carried out the survey of the history of the sites and the values of the indicators that compose the IQP. These information is available accessing the Itaipu PTI No-Till platform and these data were used to establish correlations with the IQP and measured soil variables (chemical, physical and biological). The total data (55 variables) were submitted to Pearson correlations and Principal Component Analysis (PCA), considering a significance of up to 10%.

RESULTS AND DISCUSSION

According to the grade received at the IQP, most sites fell into the "good" grade category (24 sites). The correlations between the index and the physical and chemical attributes were significant for the few evaluated parameters. However, the sites classified as "very good" were associated with the organic matter, pH, number of crops and age of No-Till. On the other hand, the "regular" sites were mainly associated with the planting history of the sites. There was no grouping of areas classified as "good", so these were not associated with specific attributes (Figure 1).

The average abundance of earthworms in the 40 sampled sites ranged from 0 to 715 ind m-2 and the average biomass varied between 0 and 8.1 g m-2. The total richness of earthworm species ranged from 0 to 6 species. There was a predominance (more than 50%) of native species in 3 sites and of exotic species in 24 sites.

Pearson's correlations of biological attributes with soil physical and chemical, historical of the sites and IQP indicators were significant at 10% for the few attributes measured and depending on the biological attribute measured. However, the ACP with all the data (soil biological, physical and chemical attributes, historical of the site and IQP indicators) (Figure 2) showed a significant correlation and grouped the 40 sites. The earthworm abundance, biomass and species richness along with the less intensive land use parameters (such as smaller site size, higher soil cover, crop rotation, number

of crop cultivations, number of cover crops) had the largest number of associated sites (33 sites). According to Brown et al. (2007), agricultural management practices such as crop rotation, use of cover crops, No-Till, soil drainage, among others, increase the earthworms populations (abundance and specie richness). The ACP also showed a correlation between earthworm populations and soil chemical attributes. The activity of the earthworms in the soil affects the its characteristics, as changes in pH and release of nutrients, making them available to the plants, as well also affecting the mineralization of organic matter (FRAGOSO et al., 1997).

Two sites, that have the highest earthworm abundance, are among the few sites that use forage turnip or grasses (other than oats or wheat) in the rotation. Turnip has a high capacity of nutrient recycling, and promotes a greater protective cover of the soil, besides having a pivoting root that helps in the decompression of the soil (CALEGARI, 2006). This ensures protection and higher diversity of organic matter for the earthworms. The site that presented the highest earthworm abundance is the one that presents the higher rotation diversity, besides not practicing the soil preparation (subsoiling, common in the region). This indicates that the benefits offered by the variety of planted crops have a direct influence on the earthworms populations.

CONCLUSION

Most sites have IQP classified as "good" (24 sites), but the attributes measured in this study show that the No-Till System is not being practiced properly. This leads to a reflection on the need for improvements in the soil management, as well as the need for more studies, covering a higher number of sites, for the validation of IQP. The biological variables (earthworm abundance, biomass, species richness and percentage of native and exotic species) had significant correlations and were important variables for the practices linked to the principles of the No-Till System, which guarantee the conservation and quality of the system.

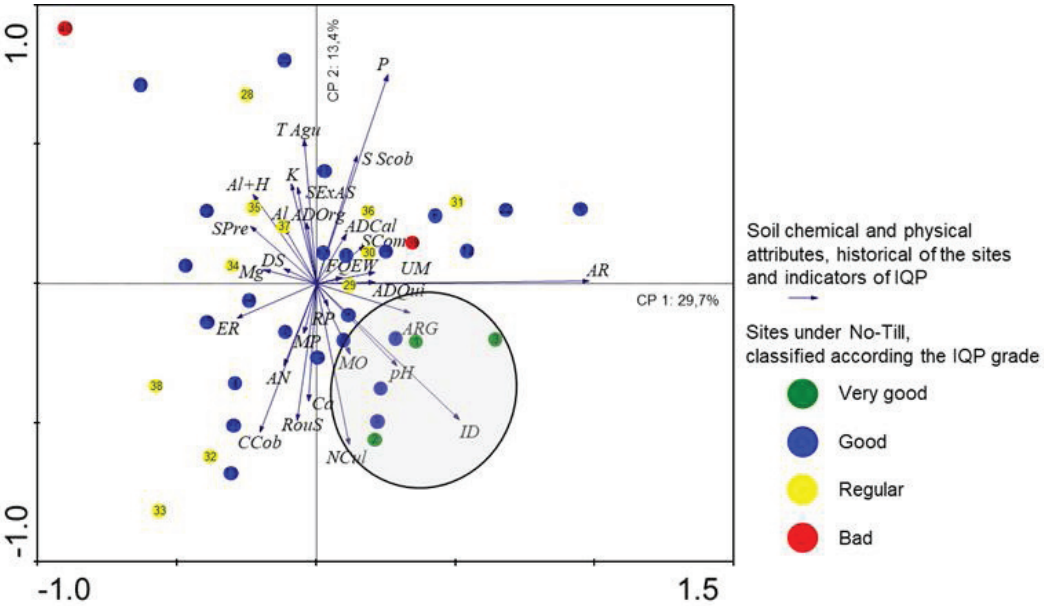

Figure 1. Principal Components Analysis between soil physical and chemical attributes, historical of the site and IQP of the 40 sites under No-Till in the western region of Paraná state, Brazil. (**Physical attributes:** RP – resitance do penetration; UM - % humidity; DS – soil density; MP – macroporosity; ARG - % clay. **Chemical attributes:** MO - % organic matter; K (Potassium); P (Phosphorus); Ca (Calcium); Mg (Magnesium); Al (Aluminium); pH; Al+H (exchangeable Aluminium). **Historical of the sites:** AR - size of the site (ha); TAgu - n° of times see water passing over terracing; SExAS - soil exposure after seeding; SCom - soil compaction; SPre - soil preparation, SScob - n° month without live crop (averageof the last 4 years); AN - animal grazing; ADCal – use of limestone; ADOrg - use of organic fertilizing; ADQui - use of chemical fertilizing, FQEw - have seen earthworms; NCul - number of planted crops (average of the last 3 years); RouS - crop rotation or succession; CCob - n° of cover crops)

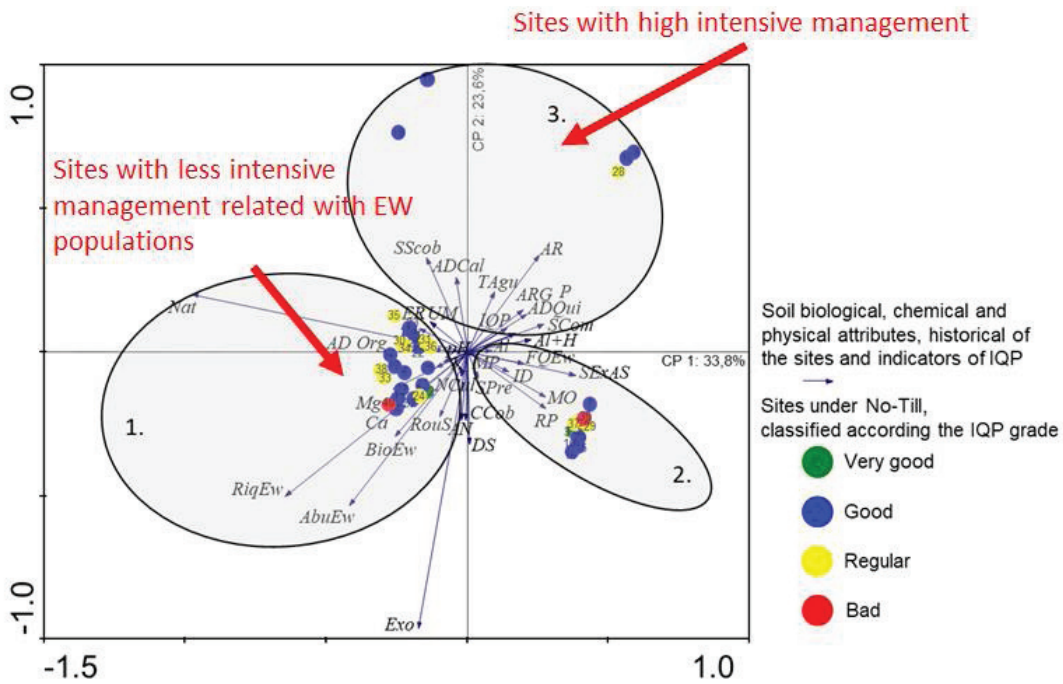

Figure 2. Principal Components Analysis between soil biological, physical and chemical attributes, historical of the site and the IQP indicators of the 40 sites under No-Till in the western region of Paraná state, Brazil. (**Physical attributes: RP** – resitance do penetration; UM - % humidity; DS – soil density; MP – macroporosity; ARG - % clay. **Chemical attributes:** MO - % organic matter; K (Potassium); P (Phosphorus); Ca (Calcium); Mg (Magnesium); Al (Aluminium); pH; Al+H (exchangeable Aluminium). **Biological attributes:** AbuEw - earthworm abundance, BioEw - earthworm biomass; RiqEw – earthworm species richness; Nat - % of native species; Exo - % exotic species; **Historical of the sites:** AR - size of the site (ha); TAgu - n° of times see water passing over terracing; SExAS - soil exposure after seeding; SCom - soil compaction; SPre - soil preparation, SScob - n° month without live crop (averageof the last 4 years); AN - animal grazing; ADCal – use of limestone; ADOrg - use of organic fertilizing; ADQui - use of chemical fertilizing, FQEw - have seen earthworms; NCul - number of planted crops (average of the last 3 years); RouS - crop rotation or succession; CCob - n° of cover crops)

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THE FARM IN NUMBERS – BENCHMARKING AS A TOOL FOR IMPROVED PERFORMANCE IN CONSERVATION AGRICULTURE/ZERO TILLAGE SYSTEMS IN TROPICAL BRAZIL

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ABSTRACT

This system, developed over a ten year period, allows farmers to self-evaluate against regional/local top performances and averages. A group of 20 farmers in Goiás state was surveyed; they practice a soybeans/maize annual succession under Zero Tillage/Conservation Agriculture. The 69 indicators cover: general farm information (rainfall, area, location, top and average yields), machinery performance, soil nutrient status, efficiency of nutrient use, crop production practices, input use and management practices. These indicators represent a management guide to pinpoint the areas which most require management attention or specialised consulting, as a means to improve overall performance, i.e. reducing the gap to the top performance; a below-average figure indicates the need for urgent action. The evolution of efficiency and yields over time can also be measured against a year 0 base or against regional statistics. Examples of these indicators (range in brackets) are: investment in horsepower/ha (30.83 – 76.00), kg of soybeans per kg of P2O5 applied (4.65 - 27.43), ha/yr/planter row (11.53 – 71.38), ha/yr per foot of combine head, small grains (13 - 47) or maize and cotton/row (15.00 – 57.11), ha cultivated per farm employee (11.53 – 71.38), number of crops planted annually (2-4). From the variability indicated, potential for improvement is high in many instances. O total of 53% of farmers practiced biological controls for insect pests and Sunn Hemp (Crotalaria spp.) or Buckwheat (Fagopyrum esculentum) for nematode control and 100% of farmers returned used chemical containers for re-cycling, The nutrient efficiency indicators do confound yield effect between nutrients but are consistent and considered useful farmer guides. A statistical analysis is in progess and would be included in the case of an oral presentation. Acknowledgements : Farmer Group GAPES, Rio Verde-GO, NGO Solidaridad/Dutch IDH fund, Goiás state Soybean Farmers' Association, Xecape Rural, crop consultants, Rio Verde-GO and Cooperativa Agropecuaria do Distrito Federal.

BACKGROUND

Due to its diffuse nature, the agricultural sector in Brazil has lagged behind industry in the application of modern management tools and benchmarking is an example (Landers , 2007). The 19th century Scottish physicist, Lord Kelvin declared the simple truthe that "If you can not measure it, you can not improve it." The best definition of agricultural benchmarking could be "A systematic process to generate condinuous improvement by comparing farm performance in a series of indicators with the top performer and the regional average in each category". This system, called "The Farm in Numbers" has been developed by the principal author since 2002.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

This tool allows farmers to self-evaluate against regional/local top performers and averages. A group of 20 farmers in Goiás state was surveyed; they practice a soybeans/maize annual succession under Zero Tillage/Conservation Agriculture (ZT/CA). The 70 indicators represent a management guide to pinpoint the areas which most require management attention or specialised consulting, as a means to improve overall performance, i.e. reducing the gap to the top performance; a below-average figure indicates the need for urgent action. The evolution of indicators over time can also be measured against a year 0 base, or against regional statistics. The individual farm figures are kept anonymous in order to maintain farmer confidence in the exercise.

EXPERIMENTAL APPROACH

As this tool is aimed at farmers, their managers and crop consultants, a simple empirical method was chosen to compare farm data with the best regional datum for each of the indicators and regional averages. In this case, the group average was taken as the regional average. The indicators cover: general farm information (rainfall, area, location, top and average yields), machinery performance, soil nutrient status, efficiency of nutrient and irrigation water use, employee performance, crop production practices, input use (including the "Periculosity Index``) and other management practices. The nutrient indicators do confound yield effect between nutrients, but are consistent and considered useful farmer guides. As the volume of data per farm is quite large, here we give examples of some of the more important indicators. The specialised Periculosity Index is the subject of a separate submission accepted at this congress.

RESULTS AND DISCUSSION

Examples of these indicators (range in brackets) are: farm horsepower/ha (30.83 – 76.00), where ZT/CA adoption initially showed a 44% reduction in hp/ha (Landers, Ed. 1994) but present levels may be high due to high horsepower tractors only used for planting; kg of soybeans per kg of P2O5 applied (4.65 - 27.43) shows considerable room for improvement by monitoring leaf P levels and improving soil biological activity to solubilize P fixed in the soil; ha/yr/planter row (11.53 – 71.38) reflects the level of investment in planter capacity, with incremental returns usually accruing from earlier planting and planting in the correct window for each variety; ha/yr per foot of combine head, small grains (13 - 47) or maize and cotton/row (15.00 – 57.11), this is a management decision

depending on the returns to earlier harvesting, which are high for seed production and harvesting in irrigated areas (to maximise the cropping intensity) and the extent to which harvesting is contracted (into the farm or outside the farm with own equipment), second crop maize after soybeans is left in the field to dry down to 14% moisture at harvest, in the winter dry season; hectares cultivated per farm employee (11.53 – 71.38) varies considerably with the farm enterprises and the level of mechanization; number of crops planted annually (2-4), only one farmer plants a cover crop on part of his area, the remainder stick with the soybean/maize succession, whose input costs are climbing. The planting of cover crops is widely seen only as a cost, with no tangible returns, where the lack of information on long term financial returns to this practice is the principal motive for non-adoption of a true pluri-annual rotation, as conceived in the three basic principles of Conservation Agriculture (Vaneph & Benites, 2001). A total of 53% of farmers practiced biological controls for insect pests; the use of biological agents is rapidly advancing in Brazil and the Periculosity Index will be important in registering the consequent reduction in the use of agricultural chemicals, which must be promulgated to consumers. Important to note is that 100% of farmers return used chemical containers for re-cycling, where the national campaign "Campo Limpo" has placed Brazil as world leader in this area.

In conclusion, from the variability indicated, potential for improvement is high in many instances and benchmarking is an effective tool ro provoke management analysis of low performance and thus contribute to overall efficiency and improved investment decisions.

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TOPPS PROJECT: CONSERVATION AGRICULTURE TO REDUCE WATER POLLUTION BY PESTICIDES

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ABSTRACT

TOPPS (Train Operators to Promote Best Practices and Sustainability) is a European stewardship project in partnership between public and private organizations, such as universities, research centers, consulting companies, and the European Crop Protection Association (ECPA). In the framework of the project, a Best Management Practices (BMP) guide to reduce runoff has been developed, aiming to provide advisors the knowledge needed to prevent water contamination. The project focuses on promoting those BMPs for the use of plant protection products (PPPs) in a sustainable way, in order to protect natural water resources. Runoff BMP's are divided into six categories: soil management; cropping practices; vegetative buffers; retention structures; correct use of PPP; and irrigation. BMPs related to Conservation Agriculture are the core in the soil management and cropping practice chapters. Minimum soil disturbance practices are recommended, together with crop rotations, among many other BMPs, as a key to prevent pollution risks by runoff. Several factors influence the risk of runoff and erosion, i.e., type of soil, climate, landscape, but farmers cannot control those parameters. However, any farmer can improve soil management practices and shift to Conservation Agriculture. TOPPS BMPs help farmers to maintain a good soil structure and increase the water infiltration into the soil profile, and consequently reduce runoff (up to 70%) and erosion (up to 95%). In order to disseminate the BMPs among farmers and advisors, a number of training activities have been carried out. The aim of training days is showing how to diagnose the risk of contamination by pesticides in farms, and also to give guidance on how to choose the best option among the BMPs proposed by TOPPs. To date, more than 1500 people have been trained in Spain. A survey distributed after each training shows that the 73% of the attendees identify the lack of soil cover as the main cause of contamination by runoff. Farmers consider Conservation Agriculture principles (no-tillage, permanent groundcover, and crop rotation) to be the most effective agricultural practices to prevent runoff and erosion.
More information at: http://www.topps-life.org/ (ENG) and http://proyectotopps.es/ (ES)

Keywords: Runoff, Erosion, Best Management Practices, soil conservation.

BACKGROUND

Most of our human activities leave traces in the water (traffic, medicine, industry, human waste etc).

Agricultural activities contribute to water pollution through entries of plant nutrients (mainly Nitrogen and Phosphate) and Plant Protection Products (PPP). Indeed, the contamination of surface waters by plant protection products is a problem in certain areas. In Europe, Directive 2000/60/EC of the European Parliament and of the Council established a framework for Community action in the field of water policy. It obliges the EU's Member States to take the necessary measures to prevent the pollution of water. These measures require adaptation of farms to meet the requirements laid down by the new legislation, and it is therefore necessary for the farmer to acquire habits aimed at the implementation of best management practices.

Active ingredients of plant protection products may reach the surface waters mainly through runoff (McDonald et al, 2000). Beyond the problems generated in the farms, runoff and erosion produce the contamination of the waters from a physical point of view, since channels/dams that receive the flows of runoff present excessively turbid waters and generate ecological problems where the deposition of the sediments takes place. From the chemical point of view, both runoff water and sediments are transmitters of active ingredients, which are transported to the riverbeds, which might lead to contamination.

TOPPS actions comprise:

- Develop Best Management Practices (BMPs) to reduce the risk of pesticides (PPPs - Plant Protection Products) entering water in Europe.
- Develop information and tools for risk diagnosis and provide materials to be used for presentations and training courses to support dissemination of BMPs.
- Dissemination of BMPs through trainings and demonstrations, workshops and presentations for farmers, advisers and stakeholders.

The expected outputs are to:

- Create increasing awareness of the need to protect water from PPP contamination, while simultaneously providing practical information on how it can be done.
- Inform operators and stakeholders about the correct use of PPPs and how to improve equipment and infrastructure.
- Increase acceptance of the need to implement risk reduction measures.

TOPPS is operating in 12 European countries. The core countries are ES, IT, FR, BE, DE, PL; whereas the extension countries are RO, HU, SK, GR, PT, NL. The authors of the contribution to the 7WCCA are from the "Runoff" Spanish (ES) partner.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Runoff is considered the main diffuse source entry route contributing about 30 to 35% to the surface water pollution by PPP. Runoff and erosion are natural processes influenced mainly by the climate and weather conditions (intensive rain), soil characteristics and the landscape, but agriculture also influences the runoff risk through soil tillage practices, cropping pattern, size of fields and others.

Soil management directly influences the water infiltration capacity in the soil and, therefore, affects runoff and erosion. Improving soil structure, increasing soil porosity and reducing compaction favors increased retention and storage of water, reducing pollution risks due to erosion and erosion. Conservation Agriculture in annual crops (no-tillage/direct seeding) reaches higher levels of rainwater infiltration than conventional tillage (Zhang et al, 2007), and also increases the volume of macropores and organic matter, which retains agrochemicals and favor its degradation (Sadeghi et Isensse, 1997), thus reducing the risk

of pesticide loss through runoff (Holland, 2004). In addition, CA improves the capacity of reducing runoff and erosion over the years (Maetens et al, 2012). So the application of CA represents a viable alternative for improving the quality water in European agriculture (Soane, 2012). Besides, the implementation of field infrastructures, such as safety bands and water retention elements, have also contributed to the reduction of runoff and the transfer of sediments and PPP (Maetens et al, 2012; Syversen and Bechmann, 2004).

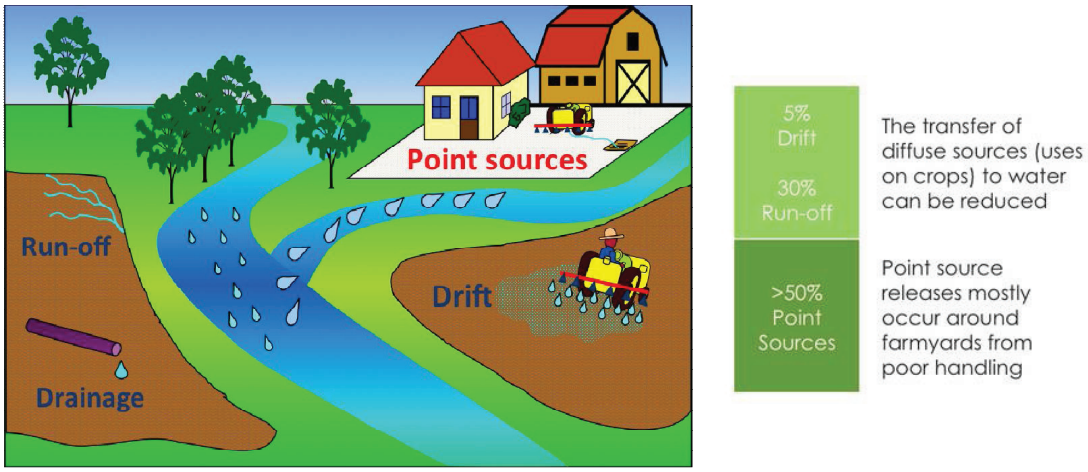

Figure 1. Entry routes of PPP to surface water (Source: TOPPs project http://www.topps-life.org)

DESCRIPTION

TOPPS have released many technical documents in several languages, which are all available in the project's website http://www.topps-life.org/. A manual of best management practices (BMPs) for the reduction of water pollution by PPP from runoff and erosion has been developed. The guide is divided into categories in order to provide advisers and technicians the best options on the basis of mitigation. The key categories are: soil management, where CA is essential; crop practices; vegetative buffers; retention structures; proper use of plant protection products; and optimization of irrigation.

To disseminate the aforementioned measures, a number of theoretical-practical trainings throughout the Europe. In Spain, since the beginning of the project in 2012 more than 40 courses and field days have been organized. In total, more than 4000 farmers and technicians have been able to learn firsthand the benefits of Conservation Agriculture and other BMPs.

After the theoretical-practical days, a survey was sent to attendees about their perception of the causes of pollution caused by runoff and erosion, and the most appropriate measures to take. The 73% identify conventional agriculture, that leaves the soil without residues, as main driver to runoff. In addition, respondents felt that the maintenance of land cover through Conservation Agriculture (no tillage+residues+crop rotations) the most effective and easiest agricultural practices to implement for preventing runoff.

Table 1. Best management practices to Reduce Water Pollution by Runoff and Erosion.

Soil management	• Reduce tillage intensity • Manage tramlines • Prepare rough seedbed • Establish in-field bunds	• Manage surface soil compaction • Manage subsoil compaction • Do contour tilling/disking • Increase organic matter
Cropping practices	• Use Crop rotation • Do strip cropping • Enlarge headlands	• Use annual cover crops • Use perennial cover crops • Double sowing

Vegetative buffers	• Use in-field buffers • Establish talweg buffers • Use riparian buffers • Use edge-of-field buffers	• Manage field access areas • Establish hedges • Establish/maintain woodlands
Retention structures	• Use edge-of-field bunds • Establish veget. ditches	• Establish artificial wetlands/ponds • Build fascines
Adapted use of pesticides & fertilizer	• Adapt application timing • Optimize seasonal timing	• Adapt product and rate selection
Optimized irrigation	• Adapt irrigation technique	• Optimize irrigation timing and rate

CONCLUSION

The application of Best Management Practices, especially those based on Conservation Agriculture, directly affect the control of water quality. Adequate knowledge of the soils combined with an efficient use of available tools would result in a more responsible use of plant protection products. The establishment of BMPs will lead to an improvement in the quality of the water, and a step forward towards sustainability in agriculture.

ACKNOWLEDGEMENTS

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VERSATILE MULTI-CROP PLANTER FOR SMALLHOLDERS' CONSERVATION AGRICULTURE IN ASIA AND AFRICA

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ABSTRACT

Small farm and field sizes are unsuitable for 4-wheel tractors (4WT) in many parts of Asia and Africa. The wide choice of seeders used with 4WT for mechanized planting is not available for 2-wheel tractors (2WT), the predominant form of farm power in S. Asia. Smallholders grows three or more crops in a year and over a 5-year cycle due to changing profitability of crops cultivate 4-6 crops with diverse seed sizes, seed rate, row spacing, fertilizer rates, seeding depth etc. Hence, service providers seeking all-year-round business need seeders with versatility to justify the investment cost. Other criteria that need to be satisfied by potential purchasers of a planter for 2WT including low price; earning capacity; flexible and quick adjustments in the field for seed/fertilizer rate, row spacing, seed size, planting depth; durable and reliable in operation, and; light weight with minimal vibrations. The Versatile Multi-crop Planter (VMP) was designed to meet the above criteria and has successfully established a diverse range of crops in Bangladesh. The field capacity of VMP was 0.07 ha hr-1 for strip planting (SP) which was 57% higher than for conventional tillage (CT). Land preparation cost by VMP was decreased by up to 75% for single pass planting compared to CT. It has the capacity to sow many crops from small jute seed up to maize. The VMP weighs 152 kg and ex-factory price is US$900. Fuel consumption was highest for CT (33.1 l ha-1) and lowest in SP mode (5.83 l hr-1) by VMP. The maximum cost (US$ 41.47 ha-1) for crop establishment was incurred by CT while the lowest (US$ 10.27 ha-1) was for SP. Local manufacturer started commercialization and established a network with 7,000 farmers. The 2016 sales of 100 VMP have resulted >1,500 hectares of planting in Bangladesh. The 2WT-based VMP is a unique multi-functional planter with capability for seed and fertilizer application at variable rates, depths and row spacing. The VMP could be used to develop CA practices across a wide range of cropping systems by smallholder farmers in Bangladesh, and other regions of South and Southeast Asia and Africa.

BACKGROUND

Mechanization is spreading in Asia and Africa due to growing cropping intensity as well as the non-availability and higher cost of labour. Small field sizes and low incomes restrict the purchase and utility of 4-wheel tractors (4WT) in many parts of Asia and Africa. The wide range of 4WT options for mechanized planting are not available to those regions where 2-wheel tractors (2WT) are the predominant form of mechanized tillage (Baker et al., 2007). The large numbers of 2WT operating in Asia (Haque et al., 2016) and increasingly in Africa for soil tillage are evidence of considerable interest amongst small farmers in mechanized tillage. However, extensive full rotary tillage and puddling of soil, often practiced more than six times per year in rice-based cropping in Asia, is not favorable to maintain of soil organic matter and soil structure. In South Asia, where cropping intensity is high, due to changing profitability of crops smallholders cultivate 4-6 crops over a 2-3 years cycle with diverse seed sizes, seed rate, row spacing, fertilizer rates, seeding depth etc. Hence a planter for such diverse cropping systems needs to have multi-functional capabilities. Small contractors providing planting services (Local Service Providers [LSP]) need to be able to hire out their planter for business all-year-round to justify the investment. There are a number of other criteria and challenges that would need to be satisfied by potential purchasers of a planter including low purchase price; sufficient earning capacity; flexible set up in the field with capability to be modified quickly for different seed rate, fertilizer rate, row spacing, seed size, planting depth; durable and reliable in operation, and; light weight with minimal vibrations.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Initial research and development of 2WT-operated planters which started in Bangladesh in 1995 was reported in Haque et al. (2013). To date, most of the planters developed cannot satisfy the minimum soil disturbance criteria of CA; and none of the present planters for 2WT are capable of planting in all crop establishment modes. Hence the LSPs and farmers are reluctant to purchase a planter that can only be used for a narrow selection of crops at a particular time of the year. The challenge is to design a multi-function planter capable of handling many crops and planting methods etc. The rapid developments in minimum soil disturbance planting for CA using 4WT have largely by-passed the 2WT (Baker et al., 2007). In principle, the similar components can be used on planters for 2WT as for 4WT but on a smaller and lighter scale. However, the challenge remains to design such planters and demonstrate their effectiveness, reliability, and durability at a price that allows ready adoption in the target market. The challenge is to design a multi-function planter capable of handling many crops and planting methods etc. The VMP planter meets the above criteria and has successfully established a diverse range of crops in Bangladesh (Haque et al., 2018; Bell et al., 2017).

EXPERIMENTAL APPROACH

The research and development of the 2WT-based VMP was carried out under a project (LWR-2010-080) funded by the Australian Centre for International Agricultural Research (ACIAR). The main functional parts of the VMP were: rotary shaft with attached blades; vertical disk-type seed box, fluted-type fertilizer box; the toolbar frame; depth controller-cum-press roller; driving

seat for transportation; furrow opener, etc. (Figure 1). Haque et al. (2018) reported the detailed fabrication of the VMP. The VMP was powered by 8.95 to 11.9 kW Dongfeng (Figure 1), or Saifeng 2WT but could be used with any other 2WT with similar power rating and hitching arrangement. The Dongfeng or Saifeng 2WT have different but suitable hitching points to attach with the VMP. The VMP has designed with capability for seeding and fertilizing in lines for: 1) Single-pass shallow-tillage (SPST); 2) strip planting (SP); 3) zero tillage (ZT); 4) bed planting (BP) (for single-pass new bed-making or re-shaping of permanent beds together with simultaneous planting and fertilizer application); and 5) conventional tillage (CT) using full rotary tillage following broadcast seeding and fertilizer spreading. On-station and on-farm replicated trials were conducted with different tillage options and seed calibration to assess effective field capacity, fuel consumption, crop establishment and yield; and the data were analyzed by MSTAT-C. A typical example of performance is shown in Table 1 from a clay soil of the High Barind Tract, Rajshahi, Bangladesh, 2010-11, but details of performance evaluations of VMP with major crops are elaborated in Bell et al. (2017) and Haque et al. (2018).

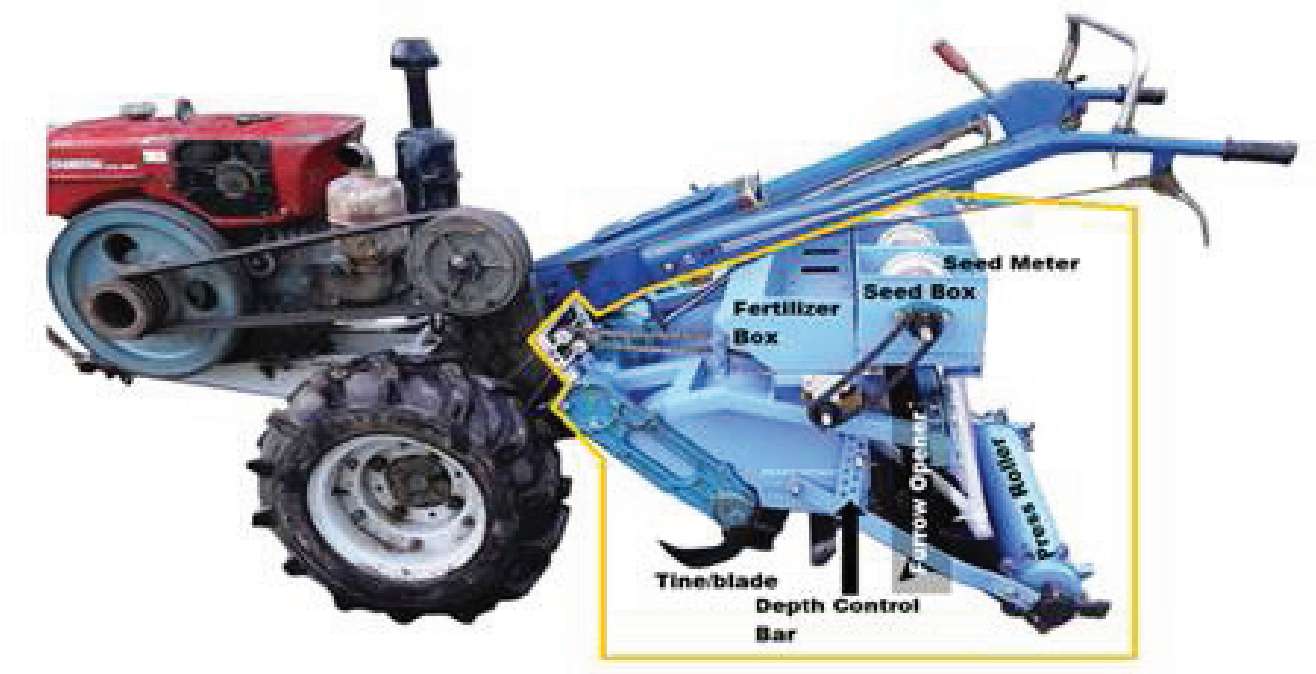

Figure 1. A Versatile Multi-crop Planter (VMP, inside of the yellow box area) attached with 2-wheel tractor.

RESULT AND DISCUSSION

The field operating capacity of the VMP was 0.07 ha hr-1 for SP which was 57 % higher than for CT (Table 1). Land preparation cost by VMP was decreased by up to 75 % for single pass planting compared to CT. The VMP was capable of sowing many crops from small jute (Corchorus olitorius) seed (2 g-1000 seeds) up to maize (Zea mays) (160 g-1000 seed). The VMP weighs 152 kg and ex-factory price is US$1000. Significant variation was observed on field capacity when operated for CT, SPST, SP, ZT and BP: 0.03, 0.07, 0.07, 0.06 and 0.05 ha hr-1, respectively.

Table 1. Effect of tillage mode by the VMP on fuel consumption, field capacity, labour requirement and cost of land preparation and seeding of lentil (Lens culinaris Medikus), chickpea (Cicer arietinum L), mung bean (Vigna radiata L. R. Wilczek) and black gram (Vigna mungo) in clay soil at High Barind Tract, Rajshahi, Bangladesh, 2010-11. Table adapted from Haque et al. (2016).

Tillage type	Field capacity (ha hr^{-1})	Fuel consumption (l ha^{-1})	Labour requirement, (person-hr ha^{-1})	Land preparation and seeding[a] cost (US$ ha^{-1})
Conventional tillage (CT)	0.03c	33.1a	48.1a	41.5a
Single pass shallow tillage (SPST)	0.07a	20.6c (38)	15.4c (68)	19.8d (52)
Strip planting (SP)	0.07a	5.83e (82)	15.3c (68)	10.3d (75)
Zero tillage (ST)	0.06ab	16.6d (50)	17.3c (64)	18.1c (23)
Bed planting (BP)	0.05b	28.9b (13)	23.9b (51)	28.8b (13)
LS	**	**	**	**

Values in parentheses indicate the percent saving over CT (4 tillage passes). Values in a column, followed by a common letter are not significantly different at P<0.01 by Duncan's Multiple Range Test. [a]Considering variable costs for labour (land preparation @Taka 30 and seeding @Taka 20/ha); diesel fuel (@Taka 45/l). 1 US$ = 80 Taka

The fuel consumption was highest for CT (33.1 l ha-1) and lowest in SP (5.83 l hr-1) by VMP. Seed sowing in SPST, SP, ZT and BP by VMP saved 38, 82, 50 and 13 % diesel fuel over CT (Table 1). The maximum cost (US$ 41.47 ha-1) of land preparation and seeding was incurred in case of CT system and the lowest (US$ 10.27 ha-1) for SP. Compared to CT, planting by SPST, SP, ZT, and BP systems lowered costs by 52, 75, 23, and 13 %, respectively. The VMP with a vertical plate seed meter placed 96 % of maize plants 180 to 260 mm apart (mean 205 mm; SE ± 3.9 mm) with a single-pass operation. Indeed, the spacing between plants was more consistent than maize planted by hand in well-prepared land after four tillage operations (data not shown here).

Based on feedback from operators who found seed rate calibration difficult, seven vertical meters for different seed size have been developed to regulate the seed rate without further calibration. Also, to optimize the price, minimize the weight, and balance the weight, substantial improvement was made on VMP during 2015 and 2016. Significant improvements were made on the shank of the furrow opener to increase its strength, and the seed-boot and fertilizer-orifice of the furrow opener were modified to minimize seed and fertilizer contact. Since 2010, a total of 205 units of different models of VMP have been manufactured and sold locally and 43 units exported to 9 Asian and African countries.

During 2012 to 2015, 2016, and 2017, a total of 6, 18, 50 VMPs were monitored closely to collect performance data. Total area coverage of the monitored VMPs were 39, 70, 150, 246, and 943 ha; and service was provided to 187, 523, 1115, 1014, and 3772 farmers during 2012-13, 2013-14, 2014-15, 2015-16, and 2016-17. The VMP is a unique multi-functional and multi-crop planter powered by 12-16 hp 2WT with capability for seed and fertilizer application at variable rates, depth and row spacing using SPST, SP, ZT, BP, and CT. By using the VMP, the establishment costs for various crops in different tillage systems were significantly reduced compared to CT. Hence the potential for application of minimum tillage planters with these 2WTs is extensive. Planters such as VMP could be used to develop CA practices across a wide range of cropping systems used by smallholder farmers in Asia and Africa.

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SIMPLE ABSTRACTS

POSTER PRESENTATIONS

Conservation Agriculture and Climate Change (variation, adaptation, and mitigation)

ADOPCIÓN DE LAS TERRAZAS COMO TECNOLOGÍA PARA EL CONTROL DE LA EROSIÓN HÍDRICA EN ENTRE RÍOS

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Degradation of productive land by water erosion has been a relatively known issue for many years and of great economic importance due to its impact on current and future production. Entre Ríos province presents a wavy landscape, with high intensity rains and soils susceptible to erosion due to the presence of dense subsurface horizons that limit water infiltration. Because of this, excesses of runoff water are produced causing erosion of the slopes, even in the case of conservation tillage systems. Since 1967, with the implementation of the Agreement between the Food and Agriculture Organization of the United Nations (FAO) and the National Institute of Agricultural Technology (INTA), investigations have been conducted to determine the local factors included in the Universal Soil Loss Equation. Major achievements in generation and adoption of soil conservation technologies are attributed to the continuous interaction of state policies oriented to research, experimentation, extension, and promotion. The objective of this work was to evaluate the current terraced agricultural land area of the province, after more than 40 years of implementation of this technology. The results showed that there is a clear predominance of terraces adoption in the southwestern sector of the province. This may be due to longer agricultural use history of this region and to the wider extension and diffusion efforts of this practice. However, with the implementation of no-till system in the middle ninety's, the agricultural frontier expanded to the south-central region of the province. Nowadays, Paraná and Diamante departments count with more than 25% of their agricultural area systematized with terraces, while Victoria, Nogoyá, Gualeguay, Uruguay, Tala, and La Paz just have between 10 and 20%. Total systematized area with terraces is about 420,000 ha, which represents 21% of the agricultural area of Entre Ríos province. Evacuation terraces are the best option to control soil degradation in soils susceptible to water erosion, but their insufficient adoption evidences the need to promote and educate about the great importance of soil resource conservation.

AGROBIODIVERSITY ENHANCEMENT TO TACKLE CLIMATE CHANGE CHALLENGES IN NORTHERN ITALY

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Fostering agrobiodiversity can have a key role in enhancing the resilience of rural land to the impact of climate change. Number of crop species cultivated, extent of land cover over the year with living plants and soil biodiversity (e.g. occurrence of earthworms and microartropodes, biological activity) point out a positive effect in maintaining soil functions and increasing the long-term sustainability of cropping systems. These indicators were assessed comparing Conservation (CA) and Conventional (CV) Agriculture practices in 20 farms representative of pedoclimatic conditions and cropping systems occurring in the Po plain and the bordering foothill landscapes in Northern Italy, where agriculture is very intensive. To this purpose data on crop rotations, including cover crops and intercropping practices, were collected in the farms for three years (2014-2016) and a soil sampling was carried out in the 2014 and 2016 after the harvest of summer crop, providing three replications per plot, in order to evaluate the earthworms abundance and the QBS-ar index based on presence/absence of microartropodes. Results achieved in the survey indicate an higher performance with CA compared to CV, further increased when all the conservative principles (e.g. crop rotation, cover crops, no-till) are applied. Farmers applying CA are pushed to get more diversified crop rotations, with plants of more species and botanic families cultivated; moreover, the introduction of double cropping and cover crops allows a longer cover of soils during the year, leading to favourable condition for organisms living in the agroecosystems. Less disturbance of soils enhances presence and activity of soil fauna, contributing also to improve water infiltrability, incorporation of organic carbon into the soil, regulating nutrient cycle and availability for plant uptake. However, soil biodiversity indicators (earthworms and QBS-ar index) appeared strongly influenced by soil conditions (water content, temperature) at the moment of sampling. Evidences achieved in this study support CA can actually help to tackle climate change in Northern Italy, providing an important contribution to adaptation challenges.

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CHANGE OF SOIL USE AND WATER BALANCE IN SOUTHERN CORDOBA (ARGENTINA)

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In the last three decades, over the southeast region of Córdoba (Argentina) took place an important change in the use of soil causing a significant environmental deterioration. Our objective was evaluate the impact of soil use change in the regional water balance in the southeast region of Cordoba. The water balance was calculated as the difference of annual precipitation and weighted crop water use. The precipitation was obtained from National Weather Service database for Laboulaye station. The water use was estimated with area of crops, nature grasslands and pastures (official reports); crops average yield (official reports) and grassland and pasture production (local literature data), and water use efficiency (local experiments). The water balance was analyzed in a 30 years period and correlated with the variation of the water table depth in Laboulaye. The Laboulaye historical precipitation shows increasing values in the last 50 years, with higher frequency of years with more than 1000 mm (2 every 10 years). In 1986/87, 75% of the soil area was covered with pastures, and a low proportion with annual crops (maize, sorghum, wheat), resulting in water use of 1000 mm ha-1. In the last decades, the area with pastures was replaced mainly with soybean and maize causing a reduction of water use down to 600 mm ha-1. The number of positive water balance years is similar to negative water balance years, however, the amount of water excess is higher than the water deficit, increasing water storage and causing water table elevation (R2 0.67, $p<0.001$). In summary, the change of soil use in the southeast region of Córdoba (Argentina) caused a reduction in water use. This situation added to precipitation frequently higher than average, resulted in water excesses that increased water table levels and vulnerability of the region to waterlogging and flooding events.

CONSERVATION AGRICULTURE IN TIMES OF CLIMATE CHANGE: WHAT BENEFITS CAN WE EXPECT FOR SMALLHOLDER FARMERS IN SOUTHERN AFRICA?

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Conservation Agriculture (CA) for smallholders has been promoted in southern Africa since the early 2000s to counter declining soil fertility, improve food and nutrition security and to reduce the negative impacts of climate variability and change. Results from long-term research show that CA systems adapt well to a variable climate through increased infiltration, moisture retention and the possibility to plant early. This has positive co-benefits on resilience and the ability of farmers to deal with climate-related stress (e.g. in season dry-spells, erratic rainfalls, and heat stress). The mitigation effects of CA on increased carbon sequestration and reduced greenhouse gas emission are more uncertain due to the specific environmental conditions (long dry season, limited biomass growth on sandy soils) and socio-economic circumstances of smallholder farmers in this region. Diversification with intercrops, shrubs and tree-based elements will lead to improved biomass production and greater carbon sequestration which will extend its mitigation benefit. Productivity and profitability increases of more than 100% have been measured across different CA farming systems in Malawi, Zambia and Zimbabwe. However, yield benefits accrue only after 2-5 cropping season depending on soil type, climatic conditions and the specific CA systems applied. Based on these results, conservation agriculture can be labelled as climate-smart and should be promoted for its high adaptation and productivity benefits. More research is needed to better understand what drives mitigation in this area. CA systems in southern Africa are seen to be most suitable in areas where farm labour and draft power is limited; where delayed planting results in a pronounced yield decline; where crop yields are significantly affected by available soil moisture; and where severe soil erosion threaten the short- to medium-term productivity of existing farmland.

DEGRADATION IN SOILS OF THE FAMILY AGRICULTURE UNDER THE CATTLE SYSTEM - CROPS WITH DROUGHT EPISODES. PROVINCE OF MALLECO, CHILE

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In order to know the characteristics of the soils used by family agriculture in dry lands, 30 sites with different soil uses (Los Sauces commune, Lat. 37º56'S and Long. 72º39'W) were analyzed naturalized prairie, crop rotation and meadow planted. The topography is composed by terraces and with slopes. The area is under the orographic shade of the coastal mountain range with rainfall less than 800 mm. Soil physical quality indicators were evaluated: Resistance to penetration RP (kPa), organic matter (%OM), texture (USDA), bulk density (BD g cm-3) and unsaturated hydraulic conductivity (Ks), field capacity (% FC), permanent wilting point (% PMP) and total porosity (TP). The predominant soils belong to the alfisol order classified as Fine, kaolinitic, mesic, Ultic Palexeralfs and Fine, mixed, mesic, Rhodic Kanhapludalf. Its texture is sandy loam and loam sandy loam. The% of range useful water for plants (RU) (% RU=FC-PWP) was of 7.22% and the OM content of 3.05% decreasing in depth. Ks (cm hr-1) close to zero indicates the formation of impermeable surface layers in the winter season that causes water runoff and low vertical infiltration. Compaction was detected (RP>2000 kPa) in sown pastures, natural pasture and crop rotation. There were no differences between land uses. Soil BD was high (BD≥1.45 g cm-3). TP of the soil is variable, decreasing to a critical level when there are clay layers (≤30%). The other correspond to ultisols soils (very fine, mixed, isomesic, Rhodic Paleudults) clay loam with 10.3% of RU and 2.3% OM, with compaction in pastoral slopes. Inceptisols (fine, mixed, mesic, Fluventic Dystrudepts) clay loam with 9.1% of useful water and 6.3% of OM, with sites compacted superficially and sub-surface. The soil of the dry zone presents low water retention capacity, low OM levels and surface and sub-surface compaction. Given these conditions, critical drought episodes are likely to be recurrent and constantly affect these the productive system of rural communities. It is highly convenient concretely integrate into their productive systems practices that promote the formation of permanent vegetation cover, soil aggregation, increased OM and vertical water infiltration of rain in the soil.

Keywords: Alfisol, degraded soils, physical quality, compaction soils.

EFFECT OF LAND USE CHANGE ON SOIL CARBON STOCKS AND STRUCTURAL STABILITY IN THE SOUTH AMERICAN CHACO

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In the Argentine sub-humid Chaco since the end of the '70 there has been an advance of the agricultural frontier over the native forest. Loss of forest reduces carbon stocks in vegetation and causes significant losses of soil organic carbon (SOC), one of the elements that contribute to the union of the elementary particles of the soil to form aggregates. The objective of this study was to determine the SOC stock up to 1-meter deep, determine its fractions in the surface soil layers and determine the structural stability (SS) through the Le Bissonnais method under different land uses: agricultural under no-tillage (less than 10 years and more than 20 years under agriculture), pasture and forest in the Chaco Subhumid region. The OC contents up to 1 m deep expressed in equivalent mass were as follows: forest (119.3 Mg ha-1)> pasture (87.9 Mg ha-1)> agricultural (71.9 and 77.3 Mg ha-1). The most sensitive OC fraction was the coarse fraction (2000 µm -212 µm) in both studied depths (0-5 cm, 5-20 cm). Resistant carbon (<53 µm) was the main organic matter fraction for all the studied situations except for the forest. The weighted average diameter (WMD) is higher for forest and pasture (1.67 mm). Agricultural soils have a WMD of 0.76 mm, 54% less than the pristine situation and pasture. The SS is directly related to the coarse particulate fraction of the organic carbon (r = 0.60 p = <0.01) and the total carbon (r = 0.48 p <0.01). The stock of SOC, its quality, its distribution in the profile and SS were sensitive to the change of land use in the studied region. The conversion of the Chaco forest to crops was associated with the decrease of OC up to the meter deep, SOC labile fractions and SS that make soil more susceptible to erosion. The loss of such important ecosystem services that help to mitigate global warming and the loss of SS could be reduced by appropriate management practices, one of which may be the incorporation of pastures of warm-season grasses.

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FOLLOW UP OF THE STATUS OF THE WORLD'S SOIL RESOURCES REPORT 2015 - GLOBAL MANAGEMENT OF SOIL ORGANIC MATTER (SOM)

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Soil organic matter (SOM) declines have been identified as a main threat for soil quality, so that increasing SOM levels represents a major part of the solution to various environmental concerns related to climate change and food production. The impact of different initiatives, practices and actions undertaken by different stakeholders involved in SOM management was assessed on the basis of reviewing recent scientific literature (focus on review articles) and responses to a stock template. Main drivers of SOM inputs and storage in soil are soil texture and clay percentage, soil type, climate and vegetation residues. Different authors found about 2.0 Mg C ha-1 as a minimum annual C input to maintain critical soil functions and/or stop further soil C losses. Field practices to reduce soil disturbance (zero tillage and others) may increase SOM content and improve topsoil quality, but their potential to mitigate climate change may be overestimated. Practices aiming to increase soil carbon stock including crop rotations, cover crops, afforestation and manuring, among others, generally have positive impact on SOM. Up to 2.2 Pg C (1 Pg = 1015 g) may be sequestered above- and belowground over 50 years in agroforestry systems, with largest carbon sequestration after croplands and with conifer species planted. Land use change to biofuel feedstock production impacts on SOC is highly dependent on the specific land transition, with overall 6–14% SOC gains after cropland conversions and carbon losses of 9-35% after of grassland or forest to corn (without residue removal) or poplar caused significant carbon loss. There is a need to be more realistic about both the benefits and disadvantages of these practices on climate change mitigation. Different land policies implemented at global, national or regional scale have demonstrated their potential to recover SOC and stop soil degradation.

Keywords: soil organic matter, soil carbon stocks, C drivers, zero tillage, climate change mitigation, crop rotations, afforestation, land policies.

IMPACT OF CROP RESIDUES LOCALIZATION ON ORGANIC CARBON SEQUESTRATION:EXPERIMENTATION AND MODELING

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The absence of tillage in conservation agricultural system (CA) changes the patterns of crop residues input,localization and decomposition in different the soil layers. The principal goal of this study is to determine the organic carbon flux in CA(wheat residues in surface) compared to inversion tillage system (IT) (wheat residues incorporated into soil) under laboratory controlled conditions. Particulate organic matter, C-CO2 and resistant organic carbon were monitored during three months of incubation at 28°C. The Roth-C model (www.rothamsted.ac.uk) was used to simulate the long-term evolution of different organic pools for data obtained during incubation. The results showed a larger (+26%) amount of the particulate organic matter in CA compared to IT system. The C-CO2 evolved from soil under CA was 20% lesser then the amount of organic carbon mineralized in IT system. The Roth-C model, optimized with the curve of C-CO2 measured during incubations, allows us to obtaina good simulation of labile and resistant soil organic carbon pool evolution with aRMSE ranged between 9 and 17%. On the other hand, the Roth-C model was used also to predict the evolution of organic carbon in soil in two long experimentations located in Northern Tunisia with some success. Some modification in the Roth-C parameters is needed to validate the use of this model in the context of CA where there are a huge change of crop residues localization and decomposition compared with the traditional practices with tillage.

NITROUS OXIDE EMISSIONS FROM NATRACUOLL SOILS WITH BOVINE EXCRETA AND ITS RELATIONSHIP WITH EDAPHIC AND CLIMATE VARIABLES IN WINTER SEASON.

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One of the most important environmental impacts generated by the livestock sector is the emission of greenhouse gases (GHGs), mainly nitrous oxide (N2O) and methane (CH4). The main source of nitrous oxide (N2O) is the excreta of grazing cattle. Given the relevance of this GHG, the aim of this research was to evaluate the N2O emissions from the soil in winter season with addition of feces and urine, and its relation with some climatic and edaphic variables. Samples of N2O were measured by using the closed static chamber method. In addition, edaphic and climatic variables were analyzed. The N2O emissions were concentrated when soil temperature was in the range of 8.1 and 10.2 ° C, air temperature between 4.2 ° C and 12.1 ° C, 60 and 80% of the water-filled pore space (WFPS). There was not correlation among the soil N2O emission and the measured soil chemical parameters. Since soil nitrates, soluble carbon and WFPS were not limiting factors, the soil temperature seems to drive the N2O emission from soil in winter season when temperatures are very low. The urine increased the N2O emission from soils. However, feces application did not affect the N2O fluxes. Despite the increases in this GHG when urine was added to soils, the N2O emission levels were generally low for all treatments, probably due to a predominance of very low temperatures during the duration of the experiment.

ORGANIC CARBON CONTENT IN AGGREGATES OF SOILS IN THE WEST PATAGONIA IN THE SOUTHERN CHILE

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Aggregates are defined as physically stable organometallic complexes that on the basis of their arrangement make up the soil structure, this structure, in turn, is susceptible to be modified according to grade of human intervention. It was analyzed the content of organic carbon (OC) in macroaggregates (Σ≥0.25 mm Ø) and microaggregates (Σ <0.25 mm Ø) in a soil classified as Andisol (franc, mean, mesic Typic Hapludands) in fluvioglacial terraces and slopes of the Chilean Patagonia (45º43'S, 72º07'W, 288 masl) with 5 extensive grazing land uses : terrace in degraded natural pasture (TD), terrace in well-kept planted pasture (TP), silvopasture (SP), degraded natural pasture on a hill site (DP), and well-kept planted pasture on a hill site (PP) at depths of 5, 10 and 20 cm.
The results indicate differences ($p \leq 0.05$) between OC content between treatments and depths. OC storage in the soil is high. 0-20 cm depth SP stored 247.38 t ha -1 followed by DP (245.7 t ha -1); TP (227.4 t ha -1); PP (221.6 t ha-1) and TD (174.9 t ha -1), respectively. The total aggregation in the soils is high (> 85%), predominantly the presence of macroaggregates, mainly in SP (78%), followed by the sequence: TP>TD>DP (62, 62 and 58%). The percentage of OC (0-20 cm) in the macroaggregates was higher in SP (8.6±1.8), followed by DP (7.75±1.2), PP (7.43±1.2), TD (7.07±3) and TP (4.75±0.8). In microaggregates the percentage of OC was higher in DP (9.55±1.9), followed by PP (8.13±2.2), TP (8.05±1.2), TD (7.75±4.4) and SP (6.79±1.5). Microaggregates are more stable structures because they contain more chemical bonds and constitute the basis of macroaggregates in the hierarchical ordering. There is a tendency to greater %OC in microaggregates soil both treatments and depth, except the SP, where by the action of soil organisms (microrrizic activity associated with Nothofagus pumillio, exudates, polysaccharides presence and binders) occurs a higher % OC in macroaggregates. TP, on the other hand, %OC is significantly higher in microaggregates, which is attributed in origin to the disturbance suffered the soil when sowing and crack the macroaggregates.

Key words: Organic Carbon, Patagonia, silvopasture, macroaggregates, microaggregates.

PROJECT LIFE+ CLIMAGRI: BEST AGRICULTURAL PRACTICES FOR CLIMATE CHANGE: INTEGRATING STRATEGIES FOR MITIGATION AND ADAPTATION

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The project LIFE+ ClimAgri (Best agricultural practices for Climate Change: Integrating strategies for mitigation and adaptation, LIFE13 ENV/ES/000541) presents a holistic approach to the climate change concerns for the agricultural sector, more specifically for the irrigated regions of the Mediterranean Basin. Through improved farming practices based on Conservation Agriculture, LIFE+ ClimAgri addresses the mitigation of climate change in the geographical area of study, and also favor the adaptation of crops to the future agro climatic scenario, which is likely to happen due to the expected climatic variations in the southern regions of Europe (increase of temperatures, increase of extreme weather events and reduction of rainfall). To this end, the project has implemented adaptation and mitigation measures in irrigated crops, based on a decalogue of Best Management Practices (BMPs), including the three principles of CA: Minimum soil disturbance, maintenance of permanent soil cover, and crop rotations. The project is being developed at two different scales: BMPs effectiveness is being verified at pilot scale both in the present climatic conditions -in several demonstration farms- and in the expected future climatic conditions, through their simulation in a greenhouse under controlled conditions; at global scale, in order to guarantee the replicability of the proposed set of BMPs, the project has established a European network of 12 demonstrative farms in Mediterranean countries (Portugal, Spain, Italy and Greece) to test these BMPs in regions with similar climatic conditions. Preliminary results in pilot farms show that the implementation of the set of BMPs in maize (Zea Mays) saves around 20% of energy consumption and increases around 30% the carbon sequestration in soils with respect to the conventional farming practices. Additionally, in the framework of this project, a GIS platform has been developed. The GIS is a tool available at project's website (www.climagri.eu) that enables the calculation of a set of 25 indicators that can help farmers evaluate the performance of the current BMPs, and eventually suggest new ones.

Keywords: climate change mitigation and adaptation, Conservation Agriculture, Best Management Practices, GIS.

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STRUCTURAL STABILITY IN SOILS OF THE ANDES MOUNTAIN IN THE ARAUCANIA REGION IN THE SOUTH OF CHILE

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The Andean range of the region of La Araucanía, in Chile, presents an increasing process of degradation of soils and desertification product, among other factors, to the grazing of goats of extensive way. To this process are added projections of upward climatic variability between 300 and 500 meters of the zero isotherm. This will cause the replacement of snow by rainfall. This aspect will have an unintended impact since snowfall is a factor in the constant supply of water in the grasslands of low sectors in spring - summer. In 2015/16, physical quality indicators were determined in soils classified as Dystrudepts (Inceptisol). The sites are located in the Lonquimay commune (Lat. 38°37'38 "S; Long.71°05'26" W) between 850 and 1.350 meters above sea level, on north and north-west exposure slopes at an average altitude of 1.190 meters, in the altitudinal fringe of isotherm variability. Three land uses were investigated: extensive degraded natural pasture (DP), alfalfa pasture (AP), ñirre forest (Nothofagus antartica) under grazing (FG), and three depths (0-5, 5- 15 and 15-25 cm). Aggregate stability (%), organic matter (OM), aggregate stability as a Mean Weight Diameter (MWD) with the wet sieving method, Bulk Density (BD g cm-3) and Porosity (%) were determined. Sandy soils (FG 52% and AP 57% sand) and sand-fine loam (DP 72% sand) with variable OM contents in FG (11%), AP (7 %) and DP (4.6 %) predominate; with low moisture available (≤10%). Total porosity is 60%. Although there were significant differences ($p \leq 0.05$) in soil aggregate stability between FG (0.25 mm), DP (0.24 mm) and AP (0.2 mm) all values were ≤0.4 mm of MWD classified as aggregates with low structural stability (very unstable). It is concluded that in this sector of the Andean mountain of the Araucanía Region the soils present high structural fragility and increasing degradation processes, which under the current conditions of intensive grazing and probable incidence of adverse and irregular climatic events such as intense rainfall will induce erosive that will further increase the degradation condition.

Keywords: Araucanía, Lonquimay, soil, aggregation, MWD.

THE POTENTIAL OF SOC FIXATION IN SPAIN TROUGH OF APPLICATION OF CONSERVATION AGRICULTURE

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The evident global climate change requires the implementation of measures to reduce greenhouse gas (GHG) emissions and minimize their concentrations in the atmosphere. Among the latter, carbon sequestration through management changes in agriculture has gained great relevance after the latest conferences about climate (Paris and Marrakech), therefore introducing agriculture into the "4 per 1000 Initiative, Soils for Food Security and Climate". Its objective is to mitigate GHG levels through an annual increase of 4 per 1000 (0.4%) each year of organic carbon in all soils of the planet. A part of the CO2 that crops are able to fix from the atmosphere through photosynthesis accumulates carbon in the soil as organic (SOC). It is extremely important to increase the coefficient of SOC fixation in soils through management practices, such as conservation agriculture (CA). In general, studies about the potential effect of CA on SOC at the national level, explain its implementation as an all or nothing, or, by percentages with certain subjectivity, not estimating an evolution associated with the decisions that, ultimately, farmers themselves make. This report presents the potential of SOC fixation in Spain, depending on the future application of CA. This potential has been calculated on the basis of the expected evolution, over the next 10 years, if agri-environmental aid was established for its implementation, similar to those currently available for organic farming. Therefore, potential sequestration level was calculated as accurately as possible in case of wider application of the CA. The information obtained will help national institutions to make decisions regarding climate change and, specifically, with regard to the actions which should be taken to reduce GHG emission to which Spain has committed by signing the Paris Agreement.

Keywords: climate change mitigation, Conservation Agriculture, Best Management Practices, SOC, no-till, groundcovers.

Conservation Agriculture and Innovative Adoption (education and learning systems)

ADOPTION AND IMPACT OF RESOURCE CONSERVATION TECHNOLOGIES IN WHEAT PRODUCTION – EVIDENCE FROM HARYANA FOR UPSCALING

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Resource conservation technologies (RCTs) are primarily pro-sustainable that focus on resource savings by minimum tillage and offer better livelihood to farmers. An attempt has been made to track the adoption and impact of RCTs in Kaithal district of Haryana during 2014-15 in nine villages with 120 purposively selected farmers who have adopted either of the three RCTs viz; zero tillage, rotary tillage and laser land leveller or in combination. Adoption pattern revealed that 69.92% of the farmers had adopted zero tillage, 51.22% adopted rotary tillage, 67.48% adopted laser land leveller, 22.76% adopted zero tillage+rotary tillage, 47.15% adopted zero tillage+laser land leveller, 33.33% adopted rotary tillage+laser land leveller and 13.01% adopted zero tillage+ rotary tillage+ laser land leveller. Regarding the impact of zero tillage technology, a majority of the farmers (77.91%) told that there was saving of time in sowing as compared to conventional tillage. Further, around 80 % told that there was an increase in broader leaf weeds under zero tillage and reduction in narrow leaf weed population (80.23%), and 76.74% of them reported reduction in overall weed population. All the farmers agreed that there was cost saving under zero tillage technology. Most of them (91.86%) harvested more yield (100-200Kg/ha) as compared to conventional tillage. A large number of farmers (61.63%) observed longer crop duration (4-7 days), increased soil fertility (51.16%), increased organic carbon in the soil (54.65%) and increased moisture retention capacity of soil (50%) and less lodging (87.21%) against conventional tillage. All the farmers agreed that there was time saving under rotary tillage in wheat sowing. A majority of them (68.25%) reported decrease in the cost of cultivation, more yield (41.27%), increased soil fertility (86.96%), increase in organic carbon content of soil (57.14%), increase in moisture retention capacity of soil (52.33%), avoidance of terminal heat (85.71%) and increase in lodging (46.03%). Due to adoption of laser land leveller, farmers (45.78%) could save time in field preparation, 2-3% increase in cultivable area, less time required to irrigate the crop, 30-40% water saving, more yield (96.39%) and less lodging (95.18%). Clearly, the study indicates the economic and environmental advantage of the RCTs warranting policy formulations for mass adoption across intense cropping system areas.

ECONOMIC AND SOCIAL ASPECTS OF CONSERVATION AGRICULTURE ADOPTION IN UZBEKISTAN

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Land degradation problems are becoming the main factor for agricultural development in Uzbekistan. Conservation Agriculture (CA) adoptions are proposed to reduce land degradation processes and improve soil quality. The implementation of the resource saving technology is, however, not so easy going. The old traditions of crops growing cannot be replaced quick. A strong push, like providing economic and social benefits, can change the opinions of farmers in their activities. This research was conducted in order to find out the positive and negative sides of the CA technology from different aspects (economic and social). The objectives of this study were (1) to study the costs and benefits of conventional technology according the government instruction and real farmers' activities with the results of adoption conservation agriculture technology, (2) to interview the farmers who are already using CA technology and Conventional technology and analyze the soil conservation policy in Uzbekistan. The partial budget methods used for the assessment of the technologies showed that by adopting conservation agriculture technology farmers can reduce 45% of fuel and 20% of labour costs while increasing the cotton and wheat production by 6% and 8%, respectively, in the first years of implementation. The survey conducted for 32 farmers concluded that conventional farmers are willing to implement new technologies and conservation agriculture can satisfy the preferences of farmers to use new resource saving technology. The research of incentives of soil conservation in Uzbekistan presented that the national policy and programs are more based on developments, regulations, penalties and incentives on land reclamation and bonitet where not many specific focused programs on soil conservation with special fund for farmers support for it. The establishment of soil conservation fund and including the CA technology into the state program will open the possibilities for enhanced technological development in Uzbekistan. The adoption of conservation agriculture practices in Uzbekistan can provide sustainable agriculture which is going to improve the economic, social life in the rural areas of Uzbekistan.

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INTENSIFICATION OF CONSERVATION AGRICULTURE BASED IN NO-TILL SYSTEM IN WEST AFRICA THROUGH THE ADEQUATION OF SMALL MACHINE

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The objective of this study was to promote the No-Till System (NTS) through the basic mechanization power on farms of the countries of West Africa. The methodology consisted of taking the Senegal as a study model and then spreading this experience to other countries. Our choice is the southern zone of the Arachidier Basin, because it is very erosive zone and characterized by a high adoption of animal traction, where each farm has at least one seeder and one draft animal and large amount of information on water erosion and anti-erosion management techniques. In this area, handicrafts are very developed. The artisans were grouped in labor unions and supported by NGOs and by projects involved in the promotion of crafts. Among 108 farms and 90 artisans selected, questionnaires on socio-demographic characteristics were applied. Posteriorly, the principal component analysis based on the constraints and the opportunities of the implementation of the NTS made it possible to carry out a hierarchical ascending classification allowed to differentiate the types of farms. The results showed that for farms types 1 and 4 had more resources than the other two types, 2 and 3. These last, had a greater propensity to adopt the NTS. For artisans, the results show that artisans of types 2 and 3 had more experience and more sophisticated equipment in the manufacture of seed drill than type 1, that they are competent to adapt the seeders to the NTS. These results allow to work with the pilot actors who are more adapted to receive the proposed technology of NTS, before to extend to others, with the aim of promoting conservationist agriculture. This approach is possible to be reproduced in the other regions of West Africa that have the same characteristics as the South of the Arachidier Basin in Senegal.

LONG-TERM ASSESSMENT OF CONVENTIONAL AND NO-TILL MANAGEMENT ON WINTER WHEAT UNDER DRYLAND CONDITIONS IN CENTRAL TURKEY

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Wheat production in Turkey is often conducted using excessive tillage under water stressed environments. Increasing No-till area around the world have attracted the attention of many stakeholders in Turkish agriculture. Main reason of interest in No-till management is the reduction of production costs resulting from elimination of soil tillage as well as the soil degradation. However, in order to successfully apply No-till technology, it is necessary to manage the fields in accordance with the local conditions and by adhering to the general principles of conservation agriculture (CA). CA is the collective umbrella terms commonly given to no-till which refers to direct planting into the residues and stubble of a previous crop or fallow, without any previous tillage or soil disturbance. For instance, rotation with diverse crops is one of the three principles of CA. For this purpose, studies initiated in 2001, the development of a suitable No-till planter for local conditions was emphasized and field trials started with the machine which had sufficient functionality. The first results showed that No-till was a feasible method, but showed that proper crop rotations were absolutely necessary. Conventional and No-till methods have been tested in chickpeas, lentil, safflower, vetch, continuous wheat and fallow fields since 2011. According to the results obtained, the yield of wheat after fallow was significantly 70% percent higher than wheat following other crops. There was a significant interaction of planting methods and rotational crops effect on wheat yields. While wheat yield (2,51 t ha-1) was higher after vetch under conventional cultivation, wheat yields after lentil (2,81 t ha-1) and chickpea (2,78 t ha-1) was better under No-till. The time of soil cultivation in traditional planting and the weed pressure in No-till management were the causes for these results. It was also determined that direct cultivation is a more economical way of production and improves soil properties. However, in order to get better yields under No-till management has to be done as early as possible according to the conditions with proper crop rotations and a good no-till drill.

PROMOTING SMALLHOLDER ADOPTION OF CONSERVATION AGRICULTURE THROUGH MECHANIZATION SERVICES

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The importance of conservation agriculture (CA) is discussed in the context of producing food for a growing population while, at the same time, conserving and improving the natural resource base – sustainable crop production intensification. CA requires mechanization and the necessary equipment may be beyond the reach of the majority of smallholder farmers, especially in sub-Saharan Africa. A logical solution to this situation is to provide CA mechanization services from private sector entrepreneurs. These will be well-equipped with appropriate CA equipment and will usually benefit from specific training on the technical aspects of CA machinery operation, and on the business skills needed to run a profitable venture. The technical skills to be reinforced include: equipment selection, calibration of planters, seeders and sprayers, field operation, maintenance and repair. Business skills needed include: market research and feasibility studies, business planning, calculation of operational costs, partial budgets, break-even points and cash flows. The case is made for local manufacture to reduce the costs of machinery acquisition and to encourage local adaptation. Start-up costs are discussed together with the options of obtaining finance. Guidelines for marketing and managing the mechanization service provision business are developed. These include the importance of contracts, work planning, regular maintenance schedules, and record keeping. Finally the most appropriate vehicle for delivering the training and sustaining support is considered. Formal training courses are a good starting point but can be expensive to organize and execute. Individual counselling from extension sources is a viable option when the quality of the service is high enough. Study groups of involved entrepreneurs should be encouraged and supported to overcome the problems which will inevitably arise in new business ventures.

QUALITATIVE EXPLORATION OF THE FUNCTIONALITY OF FARMER-TO-FARMER EXTENSION MECHANISMS FOR DISSEMINATION OF CONSERVATION AGRICULTURE IN AFRICA

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African governments and development organisations have strongly embraced farmer-to-farmer extension systems in the promotion of Conservation Agriculture (CA) to African smallholder farmers. Limited resources for extension services to serve large and sparsely populated end users have driven this embrace, whereby local communication networks can be leveraged to quickly deliver information. However, there has been little detailed investigation of the functionality of such systems, particularly beyond the lead farmers who spearhead local information delivery efforts. We conducted semi-structured interviews with 325 key informants (including farmers at all levels of CA implementation and various non-farm actors) in six countries in eastern and southern Africa to qualitatively explore the perceived effectiveness of farmer-to-farmer extension systems in delivering information widely on CA. These informants ranged from farmers at various stages of CA utilisation (non-exposed, non-trial assessment, trial assessment and different utilisations) as well as non-farm actors (extension, community leadership, policy and researchers). Whilst there was an acknowledgement of lack of resources for extension activities and hence the movement to farmer led extension mechanisms, key themes emerged in relation to coverage and a perceived lack of access to extension services. The subsidisation of lead farmers discouraged investment in CA activities for some farmers and also raised the risk of a culture of financial dependency. There were assertions that such mechanisms potentially led to creating inequality and perceptions of favouritism towards lead farmers who often did not extent information beyond their existing social networks. Overall, a broad range of issues were identified with the functionality of farmer-to-farmer extension systems that other studies may have overlooked due to a focus on lead and follow farmers. Hence, this study provides unique insights into the functionality of current extension systems and issues to be addressed in information delivery systems to facilitate the wider adoption of CA.

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SOIL STRUCTURE QUALITY AND THE PARTICIPATIVE QUALITY INDEX FOR THE NO-TILL SYSTEM (IQP)

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Due to the great difficulty in measuring the suitability and quality of the No-Till System (NTS), the Brazilian Federation of No-Till System and Irrigation (FEBRAPDP), In partnership with Itaipu Binacional and Itaipu Technological Pole, proposed a participatory methodology, the Participative Quality Index for the No-Till System (IQP). The IQP is composed of indicators that aim to evaluate the farm system management and to predict potential impacts. The project is based on a cycle of continuous improvement, proposing in a participatory way the self-evaluation of the farmer in relation to a conservationist and productive base. The soil structure is the main component of the soil capable of affecting it´s fertility, and it is directly affected by the soil management. A new methodology for rapid assessment of soil surface structure (Soil Structure Rapid Diagnosis – DRES) was proposed by Londrina State University (UEL), FEBRAPDP, Embrapa Soils, Embrapa Soybean, Embrapa Wheat and Embrapa Western Agriculture, with the support of Itaipu Binacional. The sample, taken as a monolith from 0 to 0.25 m, is separated into layers (when visually differentiated) and identified as to size of clods, signs of compaction and presence of roots. From the note attributed per layer, the sample note is calculated by means of a weighted average, allowing the qualification of the structure. The note varies between 6 and 1, being the highest reflex score of good structural quality, in which the structure resembles that of native, uncultivated soil. However, the lowest score reflecting poor structural quality and the need for diagnosis and adequacy of the management performed in the area. The criteria adopted for the determination of the quality of the structure are: size and shape of the aggregates, presence or not of compaction features or other modality of soil degradation, shape and orientation of cracks, roughness of rupture faces, rupture resistance, distribution and aspect of the root system and evidence of biological activity. IQP and DRES arise from the need to monitor agricultural areas and the sustainability of production systems. These methodologies, as applied tools, converge and facilitate the monitoring of the effects resulting from the soil management, allowing the identification of the need to adapt the systems.

Acknowledgments: to FEBRAPDP, Itaipu Binacional, Embrapa Solo Vivo Project and Londrina State University.

UREASE INHIBITOR NBPT ON AMMONIA VOLATILIZATION AND CROP PRODUCTIVITY: A META-ANALYSIS

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The urease inhibitor N-(n-butyl) thiophosphoric triamide (NBPT) slows urea hydrolysis, reduces NH3 volatilization loss, and enhances N availability to plants. Even though most studies have proved the potential of NBPT-treated urea to reduce NH3 loss, the benefits to increase crop yield have been less consistent, mainly because N is not always the limiting factor. A metaanalysis was carried out to evaluate the effect of soil properties (e.g., soil pH, soil texture, soil organic C [SOC]), N rate, and NBPT concentration on NH3 volatilization loss and crop yield when comparing urea with NBPT-treated urea. Regression analysis indicated cumulative NH3 loss of 31.0 and 14.8% of applied N for urea and NBPT-treated urea, respectively, a 52% reduction in NH3 loss by using the urease inhibitor. The use of NBPT delayed NH3 loss. It took 4.8 and 8.3 d for 50% of the total NH3 loss to occur for urea and NBPT-treated urea, respectively. The meta-analyses indicated that when compared with urea, NBPT-treated urea reduced NH3 volatilization loss across all soil pH classes, soil texture classes, SOC contents, N rates, and NBPT concentrations. The meta-analysis indicated an average crop yield increase of 5.3% for NBPT-treated urea compared with urea. This trend was observed for all classes of soil pH, SOC content, and N rate, but yield increases were limited in coarse-textured soils and NBPT rates >1060 mg kg–1.

Conservation Agriculture and Sustainable Intensification (production, profit, sustainability, food security)

ADVANCES IN THE STUDY OF THE MOVEMENT OF GLYPHOSATE, AMPA AND SEDIMENTS IN A TYPIC ARGIUDOLL IN A MICRO-BASIN OF THE ARRECIFES RIVER UNDER NO-TILLAGE

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In Argentina, the incorporation of transgenic crops (TC) and glyphosate together with no-tillage systems (NT) lead to a substantial change in agricultural production. The degradation of glyphosate is regulated by soil biological activity, where the main metabolite is AMPA (acid methyl phosphoric amino). The fate of both molecules in the environment depends on climatic conditions, edaphic variables and agricultural management. The reduction of structural stability (SS) and the occurrence of platy structures (PS) are frequent features in the undulated Pampas under NT. This frequency often increases in the crop sequences with high inclusion of soybean, which in turn, could influence the movement of glyphosate and AMPA and sediment yield. The objective of this study was to quantify the transport of glyphosate, AMPA and sediments by means of rainfall simulations (rainfall intensity: 60 mm h-1; plots of 0.25 m2) at two sampling dates (July and October) as well as the effects of both SS and PS. The production plot was located in a micro-basin belonging to the Arrecifes River on a Typic Argiudoll (Arroyo Dulce series). The sediment yield did not show significant differences between sampling dates ($p < 0.05$), and presented high variability in the replicates mainly due to the occurrence of PS. Moreover, PS presented a positive correlation ($P<0.05$) with runoff. In both dates, glyphosate and AMPA were detected; however their magnitude and location were very variable. For example in winter glyphosate was found in runoff whereas in spring it was detected only in soil. In those microplots where soil presented a greater continuity and thickness of PS the concentrations of AMPA were higher whereas the higher concentrations of glyphosate were registered under higher SS. PS may favour anaerobiosis conditions which would lead to a differential behavior of soil biological activity and in the infiltration/runoff status and thus glyphosate degradation. The results presented are exploratory and preliminary, and therefore more detailed studies are required in the long term to arrive to better interpretations of the effect of soil structure on glyphosate transport.

Keywords: runoff, transgenic crops, platy structures.

AGRICULTURE INTENSIFICATION EFFECTS ON MACRO AND MICRONUTRIENTS IN SOIL FRACTIONS WITH DIFFERENT LABILITY

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Sustainable intensification of agriculture can be defined as the process that uses environmental resources (water, solar radiation, nutrients) more intensively, maintaining or increasing crop yield per unit area and using chemical inputs in a rational way. The inclusion of cover crops during the winter season could be one sustainable strategy to increase crop intensification in sequences where soybean predominates, helping to maintain soil fertility and organic matter levels. The aim of this research was to evaluate the effects of 8 years of sustainable agriculture intensification on soil organic carbon, macro and micronutrients associated with granulometric fractions of different lability in a Typic Argiudoll of the Rolling Pampa, Argentina. A long term experiment was designed at INTA Oliveros to evaluate crop sequences with different intensity of soybean participation under no tillage system. The experiment included two crop sequences commonly used in this area: soybean– soybean (S-S) and maize - soybean - wheat / soybean (M-S-W/S) combined with the inclusion of wheat (Triticum aestivum L) as cover crop (CC) in winter. The intensification sequence index (ISI), that expresses the relative number of days of the year occupied by crops in a given crop sequence was 0.39, 0.69, 0.55 and 0.64 for S-S, S-CC-S, M-S-W/S and M-CC-S-W/S, respectively. Cropping intensity modified C, N, S, P, Ca and Mn only in the coarse particulate fraction (105–2000 µm) (Pcf). The carbon was 296.7 % larger in S-CC-S than in S-S and was positively correlated with the ISI (R2 0.63, $p<0.05$) suggesting that the ISI can be a good predictor of C inputs to the soil. N, P and S increased 4, 3 and 2 times, respectively, when comparing S-S with S-CC-S. Sequences that have more proportion of soybean showed an increase in Ca content. Mn in M-CC-S-W/S increased 43 % over the others. These results suggest recycling from fertilizer applied in previous crops in the rotation in case of P and S and/ or previous leguminous crop in case of soybean. Ca and Mn seems to be recycled from deeper layers since these nutrients were not added as fertilizer.

AGRONOMIC PERFORMANCE OF SOYBEAN CO-INOCULATED WITH RHIZOBIUM AND PLANT GROWTH-PROMOTING BACTERIA IN MATO GROSSO DO SUL - BRAZIL

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As the world demand for food grows, there is a necessity to increase production. However, conservationist techniques are needed for sustainable production. As a result, the use of nitrogen fixing bacteria (NDF) and plant growth promoters bacteria (PGPB) inoculated in commercial crops such as legumes and grasses has been increasing. Since this technic contributes to increased production while allowing a partial or even total reduction of chemical fertilizers, such as nitrogen fertilizer in soybean production, then reducing further soil contaminations. The aimed of this work was to evaluate the effects of co-inoculation of Bradyrhizobium and Azospirrilum bacteria on the development of the soybean crop on the season 2016/17. The experiment was conducted in a rural property located in the municipality of Vicentina - MS, Brazil. The soil classification is dark-red latosol (Oxisol), and the climate of the region, according to the Köppen climate classification, is tropical monsoon Am. The experiment consisted of three treatments that were arranged in randomized blocks design with eight replicates per treatment. The treatments consisted of seeds inoculated with Bradyrhizobium japonicum, Bradyrhizobium japonicum + Azospirillum brasilense and control. Soybean cultivar used was M 6410 IPRO that were sowed spaced at 0.45m between rows with a plant population of 270 thousand per hectare, and a fertilization of 200 kg/ha-1, NPK formula 02-20-18. The following traits were to evaluate: plant height at maturation, stem and root dry mass yield per plant, number of pods per plant, number of grains per pod, final plant population per hectare, one hundred grain weight and grain yield. The data were submitted to analysis of variance and averages compared by the Tukey's test ($p < 0.05$). According to the results, there was no statistical difference for the studied variables, therefore the inoculation with B. japonicum and co-inoculation with B. japonicum + A. brasiliense did not differ from the treatment without inoculation. Perhaps the seed treatment of fungicide and insecticide, and the low rainfall in the establishment of the culture provided the mortality of the bacteria, threatening the efficiency of the biological fixation of nitrogen.

Keywords: Bradyrhizobium japonicum, Azospirillum brasilense, BFN

Acknowledgements: EMBRAPA Western Agriculture, CAPES, UFGD.

ATTRIBUTES OF CHEMICALS AFTER SOLO YEARS CORN WITH BRACHIARIA RUZIZIENSIS INTERCROPPING, IN PONTA PORÃ, MS, BRAZIL

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In Brazilian central region, the base grain production is on the succession soybean and off-season maize. The winter corn with perennial forage intercropping produces high amounts of plant residues in no-tillage; as a result, it may increase the soil chemical properties. The aimed of this study was to evaluate the soil chemical properties after years of winter corn intercropping with Brachiaria ruziziensis. The experiment was conducted at the experimental field of EMBRAPA Western Agriculture in Ponta Porã, MS, 2016/2017 season crop, Dystroferric Red Latosol (Oxisol). The experimental design was a randomized block design with six treatments: T1 - single corn, T2 - Intercropping in 2011, T3 - Intercropping in 2011 to 2013, T4 - Intercropping in 2011 to 15, T5 - Intercropping in 2013 to 15, T6 - Intercropping in 2015, in four replications. Soil samples were collected during soybean flowering period, for chemical analysis macronutrients, micronutrients and soil moisture, in the layers 0.0 to 0.10 m and 0.10 to 0.20 m. The data were subjected to ANOVA and average were compared by Tukey's test at ($p<0.05$). The layer 0.10 - 0.20 m presented higher moisture (21.5%) relative than the layer of 0.0 - 0.10 m. All chemical attributes presented in the layer 0.0 to 0.10 m be greater than 0.10 - 0.20m, excepted Fe, as was more in the 0.10-0.20 layer. T4 show higher total carbon (29.3%) and organic matter (1.7 g kg-1) in soil, when compared to other treatments. It's possibly for the contribution of crop residues for corn intercropping with B. ruziziensis during the five years. The corn intercropped with B. ruziziensis does not changes the availability of nutrients but increases the soil organic matter and soil carbon content.

Keywords: soil compaction; tillage; crop rotation.

Acknowledgements: Embrapa Western Agriculture, CAPES, UFGD.

BIOMASS PRODUCTION OF WINTER ANNUAL CROPS AND THE EFFECTS IN SOYBEAN IN NO-TILLAGE SYSTEM

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The no-tillage is one of the most important soil conservationist technic. It contributes to enhance the chemical, physics and microbiological soil attributes. However, no-tillage system needs to preserve the soil surface continuously with vegetation cover and straw. Therefore, the aimed of this study was to evaluated the production of cover crop biomass of different winter crops and the productivity of soybean by two desiccation time. The experiment was conducted at Embrapa Western Agriculture located in the municipality of Dourados - MS, Brazil. The soil is classified as a Dystroferric Red Latosol (Oxisol), and the climate of the region, according to the Köppen climate classification, is tropical monsoon Am. The experiment was conducted in a factorial design 4 X 2 with three replicates in randomized blocks. Where the soybean crop was sowed after four winter crops (corn, corn intercropped with Brachiaria sp., Brachiaria ruziziensis and cowpea), and two intervals of dissection (30 days and 1 day before sowing). The desiccation were performed with Potassium Glyphosate at a dose of 2.00 kg ha-1 a.i. BRS 1003 IPRO soybean cultivar was sowed with 0.5m by rows as a population of 280 thousand plants per hectare, and inoculated with Bradyrhizobium japonicum. The fowling variables were evaluated: dry biomass productivity of the cultures at sowing time, soybean germination, plant height at maturation, and crop yield. The variables were not affected by the desiccation interval, and germination was not influenced by the biomass productivity. Corn intercropped, corn and B. ruziziensis showed the highest averages of dry biomass ($p<0.005$) 7786.00 kg ha-1, 7072.00 kg ha-1, and 6695.00 kg ha-1 , however cowpea dry biomass was the lowest 2841 kg ha-1. Averages of the soybean variables, as plant height and yield, did not differ after corn intercropped, corn and cowpea (0.73m, 0.71m and 0.74) and (2864.00 kg ha-1, 2699.00 kg ha-1 and 3045.00 kg ha-1) respectively. Concluding that the crops biomass of corn intercropped and corn provided nutrients to the system then increasing the crop yield.

Keywords: Straw production, corn intercropped with Brachiaria sp, dissection

Acknowledgements: EMBRAPA Western Agriculture CAPES, UFGD.

BLACK OAT ROOT GROWTH IN A TYPIC HAPLUDOX UNDER NO-TILL AS AFFECTED BY PHOSPHOGYPSUM AND NITROGEN RATES

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Phosphogypsum (CaSO4.2H2O) has been used in Brazilian agriculture to decrease aluminum (Al3+) toxicity and increase calcium (Ca2+) availability in the soil profile, producing better root growth for crops, especially in deeper layers, with beneficial effects on nutrient and water absorption. The aim of this work was to evaluate the root growth of black oat in function of phosphogypsum and nitrogen (N) rates. The experimental design was randomized blocks with split-plots, with phosphogypsum rates of 0 and 6 Mg ha-1 on the plots, and N (urea) rates on the split-plots: N0 = without N; N50 = 50 kg ha-1 of N; and N100 = 100 kg ha-1 of N. Acrylic tubes were installed soon after black oat was sown, on april 2016 (cv. IAPAR 61), perpendicularly to soil surface. At full bloom, using a root scanner (CI-600, CID Bio-Science), root images from 0-20, 20-40, 40-60 e 60-80 cm soil layers were acquired, then treated sith RootSnap!® software, to obtain the length, area, volume and mean diameter of the roots. Data were submitted to variance analysis, and means were compared by Tukey test (p<0,05). There was no interaction between phosphogypsum an N rates for any root parameter. No N effect was noticed for 0-20 e 20-40 cm on root growth, but the length, area and volume of the roots were increased by 6 Mg ha-1 of phosphogypsum. At 40-60 cm, the length and area of the roots were also increased by gypsum application, and in this layer the values of length and area of the roots were higher without N (N0) than with N application at N50 and N100 rates. At 60-80 cm, phosphogypsum application resulted in higher values of length and e area of the roots, and the N0 rate presented higher length area and volume of the roots in relation to N50 and N100. Phosphogypsum increased black oat root growth in all soil layers until 80 cm, and N fertilization decreased root growth in layers deeper than 40 cm.

Keywords: Calcium Sulphate, urea, minirhizotron.

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BRACHIARIA PRODUCTION IN SEED INOCULATION FORMS

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The use of nitrogen-fixing bacteria diazotrophic, especially bacteria Azospirillum brasilense, stands in the agricultural environment as a sustainable alternative in reducing nitrogen application in grasses. The objective was to evaluate the biomass culture in order to Brachiaria brizanta cv. BRS Paiaguás intercropped with corn and inoculated with A. brasilense and Bradyrhizobium japonicum, in istroferric Latosol and Distrofic Latosol. The experiment was established in a greenhouse not heated in 02/25/2016 in pots with 0.75 dm3 of soil. The Brachiaria was sown in five inoculation treatments; 1) with nitrogen and without inoculation, 2) Bradyrhizobium inoculation in the summer; 3) Azospirillum in the summer; 4) Bradyrhizobium and Azospirillum inoculation in the summer; 5) Bradyrhizobium and Azospirillum in the summer and Azospirillum in autumn winter. After 45 days the corn harvest, the forage collected. Data were subjected to ANOVA and means were compared by Tukey's test ($p<0,05$). The Brachiaria was more productivity in clay soil. There was a significant interaction between treatment and soil for the stems production per area and total dry mass, wherein higher values were observed when grown on con-inoculation (13.9 g plot-1), but without differ statistically from nitrogen fertilization (13.7 g plot-1). The co-inoculation in intercropped Brachiaria-corn in Distrofic Latosol is an efficient methodology to replace the nitrogen fertilization of the forage.

Keywords: Azospirillum brasilense; Bradyrhizobium japonicum; inoculation.

Acknowledgments: EMBRAPA Western Agriculture, CAPES, UFGD.

COMBINATION OF SOIL AND FOLIAR NITROGEN INCREASES NITROGEN USE EFFICIENCY IN CEREALS

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Sustainable nitrogen (N) fertilization remains a critical issue in conservation agriculture (CA). High N fertilization rates are exposed to losses - with strong environmental constrains. Moreover, N fertilization represents ca. 50% of the cost of cereals crops, and a high cost for the farmers, so increases in the N use efficiency (NUE) would provide reductions in the production cost of cereals and environmental benefits. Our objective was to evaluate the NUE in wheat and corn fertilization programs using combinations of soil and foliar N fertilizations. Wheat and corn experiments were carried out in in the Argentine Rolling Pampa (Argentinean corn-belt) under CA system during the 2016-2017 cropping season. Incremental rates of mineral fertilizer (urea) were applied to the soil on each crop, and later during the growing season treatments with and without foliar N fertilizer were combined. The NUE was calculated as the grain production per unit of N applied. In both crops, increases in yield were found at increments in nitrogen fertilization but with a significant decrease in NUE. On average, the use of foliar N fertilizers increased NUE by 66% and 26% in wheat and corn respectively, being higher at the lowest soil fertilization rate - 80% and 95% increase at 50 kg N-. Foliar N fertilizations allowed reductions by 50% of the soil N fertilizer without reductions in the yield on both crops. These promising results provide a baseline for new N fertilization strategies, combining soil and foliar fertilizations that increase NUE.

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CORN PRODUCTION AND SOIL PROTECTION IN MATO GROSSO DO SUL, BRAZIL

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In Brazilian tropical region, the predominant corn production is in the “late season” - autumn-winter - with soybean crop in succession. The work was carried out with the objective of characterizing the “late of season corn” in Mato Grosso do Sul State. From 2007 up to 2015, every two years, participatory rapid diagnosis (PRD) were done with technical assistants and spike samples were collected in representative fields. Direct sowing of corn is predominantly made in clay soils, on soybean straw, with higher proportion in March, but it is been anticipated to February, due to the early soybean harvest. The anticipation of sowing prevent productivity losses due to frost in the South region or drought all over the State. Sawing anticipation improves corn productivity by being cultivated in a period of higher temperature, insolation and humidity, but exposes the crop to pests and diseases. Fertilization was done mostly at sowing, according to soil analysis and harvest expectancy. The smaller doses were used mainly in small properties or in sandy soils, where the soil natural fertility is lower. Bt@ technology, with insecticide to seed treatment, was introduced in most corn crops but did not eliminate the need for insecticide applications. RR@ technology was introduced in some crops of the cereal and decreased weeds infestation but made it difficult to control corn plants in RR@ soybean in succession. The predominant corn line spacing was 0.90 m and has became 0.50 m for providing the best plant arrangement and higher productivity. Plant population increased from 48,000 to 54,400 plants per ha and productivity from 4,547 to 7,751 kg ha-1. The area with intercropping corn-Brachiaria ruziziensis in Mato Grosso do Sul was inexpressive in 2007 and increased to 34% in 2015, predominantly in the Center-South region of the State. Soil cover (above ground crop residue) was 32% in 2007 and rose to 44.2% in 2015. Corn-brachiaria intercropped is a system that increases soil cover.

Keywords: biomass, corn, intercropping, no-till.

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COVER CROPS: SHORT TERM EFFECTS ON SOIL ORGANIC MATTER FRACTIONS AND ASSOCIATED NUTRIENTS

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The inclusion of cover crops (CC) during the winter season could increase soil organic matter and associated nutrients, especially by increases in the more labile fractions. The aim of this research was to evaluate the short term effects of inclusion of Wheat (Triticum aestivum L.) and Vicia (Vicia sativa L.) as CC previous to Soybean and Maize, on soil organic carbon fractions and nutrients associated in a Typic Argiudoll of San Antonio de Areco, Bs. As. A physical fractionation of the soil was carried out, separating it into three fractions: coarse particulate (105 and 2000 µm), fine particulate (53 and 105 µm) and associated with clays (<53 µm), where the C, N and P contents were determined. The use of CC after a year increased the soil organic carbon, nitrogen and phosphorus only in the most labile organic fraction (coarse particulate fraction -CPf) in the first 5 cm soil depth. The coarse particulate fraction is especially sensitive to soil management in the short term, and therefore the increase of carbon and nutrients responds to the presence of stubble on the surface that causes an intense recycling of this element in the first centimeters of soil. The highest values on C and P in the CPf were observed with the inclusion of Vicia as cover crop, for both, Maize and Soybean, while the increases in N in the CPf by Vicia inclusion was only significant in Maize ($p < 0.05$). Under Soybean the relative increases with respect to fallow treatment in C, N and P in the CPf were 8, 33 and 58% with Vicia, and 3, 19 and 42% with Wheat as CC, respectively. Under Maize these increases were 50, 60 and 126% whit Vicia, and 20, 34 and 53% when CC was Wheat. The inclusion of Vicia as CC increased the C, N and P in the labile fraction to a greater extent than that obtained by the inclusion of Wheat. However, a longer period would be necessary to realize if the increase in carbon and nutrients in the more labile fraction concludes in a higher amount of stable organic matter.

DEVELOPING NITROGEN FERTILISER MANAGEMENT STRATEGIES FOR WHEAT UNDER CONSERVATION AGRICULTURE PRACTICES IN THE WESTERN CAPE, SOUTH AFRICA

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The adoption of conservation agriculture (CA) practices will influence the physical, chemical and biological properties of soils. It is expected that these changes will influence the amount of plant available nitrogen (N) to crops during the growing season. The aim of this study was to evaluate wheat N requirement and develop optimal N top-dress rates under CA practices.
Wheat (SST 056) was planted at a rate of 80 kg ha-1 at five different locations that differ in soil properties and climatic conditions. Cropping systems tested included wheat after canola, wheat after medics and wheat after lucerne. Nine sites were laid out in a randomised block design with eight treatments and four replications. The treatments comprised planting with 25 kg ha-1 N and different N rates (0, 25, 50, 75, 105, 135 and 165 kg N ha-1), applied as top-dressing. The control (C) treatment was planted without any N and received no further N. Yield was determined using a Winter Steiger plot harvester. Results indicated initial differences ($P < 0.05$) in yield with increasing top-dress rates until a plateau was reached and further increase in N rates had no effect ($P > 0.05$) on yield. Although yield varied between localities and cropping systems, results showed that maximum yields ($P > 0.05$) were achieved at N top-dress rates between 0 kg ha-1 and 50 kg ha-1. Nitrogen top-dress rates that achieved maximum yield in this study were lower than expected and lower than the general recommendations made to producers. Nitrogen fertiliser rate recommendations for wheat production under CA practices might need to be reassessed in order to ensure optimal yields and minimal environmental impacts.

Keywords: conservation agriculture, fertiliser, nitrogen, wheat

DIFFERENTIAL POROSITY STUDY UNDER A SOYBEAN-COVER CROPS-SOYBEAN SEQUENCE IN A TYPIC ARGIUDOLL OF THE NORTH OF THE PROVINCE OF BUENOS AIRES

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The soybean (Glicine max. L) is the main crop of Argentina by volume production, as by the planted area. It is known that soybean monoculture negatively impacts on soil quality and system sustainability, especially on Typical Argiudolls of North of Buenos Aires Province, which increase bulk density and the occurrence of platy structures and decreasing porosity. The objective of this study was to evaluate the differential porosity in a Soybean-winter Cover Crops (CC) - Soybean sequence, after ending the CC and after the soybean harvest. The yields of soybean were also evaluated. The experiment was carried out in "La Fe", a farm located near San Antonio de Areco, north of the Buenos Aires Province in 2013/2014. The treatment were 4 CC: Barley (Avena sativa), Vetch (Vicia sativa), Annual Ryegrass (Lolium multiflorum), Barley (Hordeum vulgare), Barley+Vetchand Control treatment without cover crop (traditional fallow), implanted with no tillage systems (NT) on soybean stubble. The ending of CC was performed with herbicide (glyphosate), in September (first sampling of porosity). The following soybean was planted in October and harvested in April (second sampling of porosity). Macro-, meso- and microporosity were analyzed in Richards Pressure Plate Extractors, for each treatment. It were observed changes in the pore size distribution after ending of CC. In this way, under CC it was increased the amount of mesopores and diminished the micropores ($P<0,05$). No significant differences ($P>0,05$) were observed in the amount of macropores between the different treatments. Total porosity evidenced a greater compaction under traditional fallow than under CC. At harvest, total porosity was significantly raised between 15% and 8% respect to control in the treatments were barley and ryegrass were implanted as CC. This substantial increase in porosity observed in barley and ryegrass is in correspondence with with the trend of increases in soybean yield under these CC predecessors.

Keywords: soybean monoculture, fallow, physical properties.

DIVERSITY OF THE SOIL MESOFAUNA IN INTEGRATED AGRICULTURAL PRODUCTION SYSTEMS (IPS)

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Integrated Agricultural Production System (IPS) are an important alternative for sustainable production, since these systems normally result in less soil disturbance and greater plant diversification. However, very little is known of the impact of IPS on soil mesofauna. These animals are related to soil chemical and physical properties and react quickly to environmental changes. Therefore, the objective of this study was to assess soil mesofauna populations and community composition (total number of individuals, relative abundance, average richness and Simpson, Shannon and Pielou diversity) in a long term IPS experiment at the Federal University of Paraná-UFPR agricultural experiment station in Pinhais, Paraná. The experimental design consisted of three blocks and four treatments: Annual crops (L), Pastures with livestock (P), Annual crops + Pastures (LP) and Annual crops + Pastures + Eucalyptus trees (LPF). The soil mesofauna were collected using Pitfall Traps and a modified Berlese-Tulgreen funnel (8 cm diam.) in n=6 samples per plot. Pitfall traps remained in the field for 3 days and funnels were kept under low-intensity light (40W) for 7 days. Soil samples (n=5) were taken for chemical fertility analysis (pH, C, N, Ca, Mg, K, P, CEC, Base saturation, H+Al), in order to relate these to the IPS treatments and mesofauna communities. A total of 2,745 individuals from 17 groups were collected in the traps, while 30,942 individuals from 13 groups were extracted in the funnels. Mesofauna abundance was higher in L and LP, probably due to the higher soil cover in these systems. For both collection methods, livestock production had a lower mean richness, likely due to increased compaction and decreased soil cover. Shannon diversity, Simpson dominance and Pielou uniformity resulted in similar trends using both collection methods, but the highest Shannon index occurred in the cropping areas, because these areas had higher taxonomic richness. Multivariate statistical analysis using soil fauna abundance and chemical parameters is underway and results will be presented in the poster.

Keywords: Pitfall, Berlese, edafic fauna, Integrated Agricultural.

DYNAMIC OF HERBICIDES WHEN APPLIED ON THE TOP OF SUGARCANE HARVEST RESIDUE AND UNDER DIFFERENT LENGTH OF DROUGHT STRESS CONDITIONS AFTER APPLICATION

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Leaching is the main form of transport in soil of nonvolatile molecules and water soluble. However, aspects related to water restrictions and crop residues present on the soil surface, such as straw sugarcane, may interfere with the dynamics of herbicides in the environment. This aspect is extremely relevant in the cane raw cultivation system because it is the application of herbicides in dry season, in which the product remains in the environment until occur the first rains and so it passes to have bioactivity in control plants weed. Therefore, this study aimed to study the soil of amicarbazone pre-emergence herbicides and tebuthiuron when applied directly to the soil and the straw sugarcane and later submitted to different periods of drought. For this, a leaching experiment was conducted by bioassay methods and followed the experimental design 2x2, with four replications, two dry periods and two amounts of straw, this factor has been adopted for the amicarbazone herbicides (1400 g ha-1) and tebuthiuron (900 g ha-1) individually. The herbicides were applied on top of the soil columns in the presence of 0 to 10 t ha-1 of straw, these treatments were submitted to two different dry periods (0 to 30 DAT). Subsequently, one was simulated 30 mm rain directly and individually on the pipes after the two dry periods, and then carried out the sowing Cucumis sativus (bioindicator). Phytotoxicity assessments were performed at 7, 10 and 15 DAS. At 15 DAS was also determined the dry weight, height and chlorophyll of the shoot. For leaching experiment, it was noted that most herbicidal phytotoxicity amicarbazone was in the 0-5 cm. And that drought decreased herbicide mobility in the environment. The straw reduced the leaching of this herbicide when associated with longer periods without rain. In leaching tebuthiuron the permanence of the product of the sugar cane straw for 30 DAT has the lowest leaching of that herbicide. Therefore, it is noted that the presence of the straw associated with different water stress periods environment can result in decreased mobility of herbicides in the environment used in the harvested crop of sugarcane mechanically.

EARTHWORM POPULATIONS AS SOIL QUALITY INDICATORS IN DIFFERENT LAND USE SYSTEMS IN SOUTHERN BRAZIL

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Natural ecosystems have been modified over the years by the adoption of different farming practices. The level of impact on soils and soil life of these human interventions is highly dependent on the management techniques adopted. Systems using perennial crops (e.g., orchards and pastures) generally have lower impact on soils. Earthworms are generally considered good indicators of soil fertility and have been extensively used as indicators of soil quality, because they are easy to see and collect and also represent the major part of the soil fauna biomass. The objective of the present work was to evaluate the impact of different land use systems on earthworm populations and soil chemical and physical attributes, and assess the role of earthworms as bioindicators of soil quality, particularly using the general index of soil quality (GISQ). We evaluated five systems: annual crops (C), perennial orchards (O), pastures (P), native grass (G) and native forests (F) with three replicates. All sites were located in Pelotas-RS at three agricultural experimental stations of Embrapa Clima Temperado. Earthworm populations were sampled using the standard TSBF/ISO handsorting method (n=6 per plot) and formalin (0.5%) extraction (n=3 per plot). Soil quality was measured using chemical (C, N, pH, Ca, Mg, K, P, CEC, H+Al, Base saturation) and physical attributes (bulk density, moisture, texture). Mean earthworm densities using handsorting were 330, 194, 39, 20 and 17 individuals m-2 in C, P, O, G and F, respectively. However, highest biomass was found in G (19.3 g m-2) with lower values in C (6.8 g m-2), P (6.7 g m-2) and F (3.2 g m-2), due to the small biomass of worms found in the agricultural systems. Formalin extraction was not efficient in collecting earthworm, generally resulting in very low abundance. Statistical analysis of the soil properties and GISQ calculation are still underway, and the results will be explored in the poster presentation.

Keywords: bioindicators, soil quality, soil management, agricultural systems

EFFECT OF CORN SEEDING RATE ON AGRONOMIC OPTIMUM NITROGEN RATE

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In Rio Cuarto region (Cordoba, Argentina) corn is the most sown crop. Most of the crop is grown in no tillage systems that improves soil structure and rise the organic matter as consequence of the less mineralization and the stubble. As consequence of this more nitrogen (N) fertilization is needed. There are different method to estimate N rates but none of them takes in account the interaction with N and seeding rate (SD). The aim of this research was to evaluate the interaction between dose of N and seeding rate. Four experiments were stablished during 2016/17 growing season in Rio Cuarto Region. A combination of four N rates (between 0 to 300 kg ha-1) and four seeding rates (between 30000 to 130000 seed ha-1) were tested. The Agronomical Optimum N Rate (AONR) was determined for each seeding rate. The criteria for the field selection included soybean as predecessor crop and at least 10 years of no tillage system. The experiments were harvested with yield monitor connected to a GPS. The data was analyzed with general models with spatial correlation. The results shown that there was significate interaction between N and SD ($p<0.0001$). The response to N and the AONR varied with SD in all sites. In site I AORN ranged from 115 to 147 kg N ha-1 for 40.000 and 90.000 seed ha-1, in site II the rage of rates were 159 and 187 kg N ha-1 for the mentioned rates. In sites III and IV the AORN ranged from 0 to 300 kg N ha-1 for the low and the high seeding rate evaluated respectively. N requirements increase while increasing seeding rate and the magnitude of the increase was related to the site productivity.

EFFECT OF INTEGRATED AGRICULTURAL PRODUCTION SYSTEMS ON SOIL MACROFAUNA COMMUNITIES

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Integrated agricultural Production Systems (IPS) have been used extensively for the recovery of degraded areas, since they include rotations of crops with pastoral and/or forestry systems that improve soil quality and decrease soil erosion. However, little is known of the impacts of IPS on soil fauna, and these organisms can be used as bioindicators of soil quality, since their communities are related to soil chemical and physical properties and because they react quickly to environmental changes. In the present study we evaluated the density and diversity of soil macrofauna in several types of IPS, installed in a long-term experiment at the Canguiri experimental Farm, belonging to the Federal University of Paraná – UFPR, located in Pinhais, Paraná. Four treatments were evaluated in three replicate blocks: Annual crops (L), Pastures with livestock (P), Annual crops + Pastures (LP) and Annual crops + Pastures + Eucalyptus trees (LPF). Soil macrofauna were collected using standard (TSBF/ISO) methodology by handsorting n=5 soil monoliths and by placing n=6 pitfall traps (3 days in the field) per plot, in September 2016. Soil samples were taken for chemical fertility analysis (pH, C, N, Ca, Mg, K, P, CEC, Base saturation, H+Al), in order to relate these to the IPS treatments and soil fauna communities. Detritivores (beetles, isopods) and ecosystem engineers (earthworms, ants) were influenced by LPF and LA systems respectively. The number of individuals trapped varied from 1 (Thysanopetra) to 216 (Diptera). LA had the highest abundance (889 Ind.Arm.day-1), while highest diversity was observed in blocks 1 and 3 in PE, with Shannon of 1.97 and 2.11, respectively. Using handsorting L (10,032 ind. m-2) and LPF (8,432 ind. m-2) had significantly higher density of soil fauna than the other systems. P had lower diversity (Shannon) than the other systems. Among the systems adopted, LPF proved to be more efficient in the restructuring the edaphic fauna. Multivariate statistical analysis using soil fauna abundance and chemical parameters is underway and results will be presented in the poster.

Keywords: Soil Management, Ecosystems, Ecosystem engineers.

EFFECT OF KEY PARAMETERS OF STRAW CHOPPING DEVICE ON QUALIFIED RATE, NON-UNIFORMITY AND POWER CONSUMPTION

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Mechanized straw returning to the field is a key component of conservation tillage in sustainable farming. The structural and movement parameters of straw chopping device have significant effects on qualified rate, non-uniformity, power consumption during the operation. sixteen types of straw chopping devices, including different key parameters (feeding speed, shell angle, distances of chopping and fixed blade), were compared using the field integrated testing system in harvested wheat field, and the effects of key parameters on qualified rate and power consumption under operating speed of 2000~3500r/min were analyzed using finite element model (FEM) . On the basis of orthogonal test, the influence of each factor on the qualified rate of wheat straw chopping, non-uniformity followed the order: feeding speed (significant)> shell angle> distances of blades; the qualified rate decreased with increasing feeding speed ( ) and distances of the blades ( ). The order of three factors' effects on power consumption was shell angle (significant) > feeding speed > distances of blade (not significant); the power consumption decreased with increasing shell angle ( ). The optimum performance parameters of straw chopping device were determined as follows: feeding speed 2500-3000r/min, shell angle 65°-70°, distances of chopping and fixed blade 8-10mm. The results showed that the qualified rate was 94.57%, non-uniformity was 11.12%, and power consumption was 5.23kw. Our results provided a reference for optimal design of the straw chopping device to generate more suitable soil environments, and promote the application of the light seeding quality and operating efficiency.

Keywords: straw chopping device; finite element analysis; qualified rate; non-uniformity; power consumption

EFFECT OF THE DIVERSIFICATION AND INTENSIFICATION OF CROP ROTATION ON SOIL MESOFAUNA IN NO-TILL SYSTEMS OF THE PAMPA REGION OF ARGENTINA

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In the Pampa region of Argentina, a group of farmers have implemented a field essay of diversification and intensification of crop rotations (DICR) under no till. It consists in increasing the amount of different crops per unit of time on the same area. Soil mesofauna, with a body diameter of 0.1 to 2 mm, is composed by mites (Acari) and springtails (Collembola), both sensible to changes in soil management. The present study aimed to analyze the effect of the DICR on the abundance of soil mesofauna. Eighteen sites were selected from three private farms near Pergamino city (Buenos Aires province) where a DICR essay was established 3 years before sampling, in a field with the same land use history and soil type. The treatments had different indexes of crop rotation calculated as: days of the year with plants/365 days, from 0,43 for typical crop rotation (wheat/soybean-corn-soybean) to 1 in pasture: typical rotation, high intensification with legume, high intensification with 100% grasses, and pasture. Two reference systems, a soybean monoculture and a natural environment were also studied. Five soil samples, 10 cm deep and 5 cm in diameter, were collected at each site, divided into litter and 0-5 cm. They were processed in the Berlese system to extract the organisms. The mites were identified in Oribatida, Mesostigmata, Prostigmata and Astigmata. Oribatid mites in the litter layer responded positively to the DICR in the three farms. In the mineral soil (0-5cm), they showed a positive response to DICR in two of the farms. Oribatids are functionaly important in soil because they are actively involved in the decomposition of crop organic residues and therefore fosters nutrient cycling. Mesostigmata showed a positive response to DICR only in litter, in two of the farms. Prostigmata and Collembola did not increase their abundance with DICR. We conclude that the DICR produces changes in soil biology after a rotation cycle of 3 years, increasing the abundance of some biological groups essential for the decomposition and cycling of soil nutrients.

EFFECT OF TILLAGE ON THE PRODUCTIVITY OF WINTER WHEAT UNDER RAINFED CONDITIONS IN UZBEKISTAN AND TAJIKISTAN

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Cox (1986) studied the effect of different methods of soil preparation and two different types of wheat varieties on wheat grain yields. No significant difference was observed between treatments. Touchton and Jonson (1982) conducted an experiment on the effect of three different methods of tillage (chisel, moldboard plow and no tillage) on the yields of wheat and soybean. Yield of soybean under chisel and no tillage were similar, but wheat yield under chisel plow was less than under moldboard plow. Taking this into account it was decided to study effect of tillage on productivity of no-till winter wheat in the rainfed conditions of Central Asia. The main objective of this ongoing trial is to study the effect of different tillage methods on the productivity of winter wheat in the rainfed conditions of Southern part of Central Asia. The study areas are located in the rainfed areas of Uzbekistan and Tajikistan. There were three different tillage options; conventional till (CT), minimum till with disking (MTD) and no-till (NT). Analysis of variance (ANOVA), using replicated trials in randomized complete block design, was used to study the relationship between tillage and location. All statistical analyses were performed with GenStat 18th edition. The study describes the first analysis of no-till systems research in Tajikistan and Uzbekistan under rainfed conditions, and shows that there is potential for introducing no-till practice in the region. Overall, the adoption of no-till cropping at farm level is dependent on the technology offering overall cost savings through reduced need for weed management and disease control (or different methods to do so) and/or the achievement of higher stable yields over the years.

EFFECTS OF INTENSIFICATION AND DIVERSIFICATION OF CROP ROTATION ON SOIL STRUCTURE AND ENZYMATIC ACTIVITIES AT SOIL AGGREGATES LEVEL

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No-till and crop rotation are basic components in conservation agriculture. In cooperation with the Project Chacra Pergamino – AAPRESID, our Lab has been able to show that diversification and intensification of crop rotations (DIRC) modified soil biochemistry and soil biology parameters according to management (see posters by Covelli et al, Bedano et al, Ferrari et al, in this Congress), just 4 years after change of DIRC in those soils. The objective of this piece of work was to look how this differential DIRC modified the soil structure at the micro aggregate level, and how enzymatic activities were distributed within the micro aggregates. Two contrasting crop rotations (Maize-Soybean-Wheat-Soybean / Maize-Wheat-Soybean-Vicia-) with different index of intensification of rotation (IIR) (0.61 and 0.97) were taken for analysis at the different micro aggregate fractions. Wet sieving performed soil fractionation, to get the fractions 2000-250, 250-63, 63-20, 20-2, < 2 m. Soil enzymatic activities were performed by fluorometric method using 4-MUB-X substrates. Cellobiohidrolase, Chitinase, -Glicosidase, -Glucuronidase, Phosphatase, Sulfatase, Acyl-estearase and Leucin-amino-peptidase (7-AMC method) were determined to get an enzymatic profile of soils and soil fractions. The proportions of soil micro aggregates were significantly modified according to soil managements, with low variations between replicates. The biggest fraction 2000-250 m was significantly enhanced by DIRC. When enzymatic parameters (Km, Vmax) were analyzed according to fractions and soil management, it was found that different iso-enzymes would be selected at different aggregate fraction. The distribution of enzymatic activities related to degradation of cellulose and chitin varied differentially between different fractions, while other enzymatic activities more related to intermediate metabolism and P or S cycles remain more or less constant between fractions. It is worth noting that cellulase and chitinase activities were found to be good markers of DIRC. Considering that soil aggregates are the result of soil-microbial-fauna interactions, these results point out what fractions and/or biochemical services appeared to be more sensitive to change of soil managements, suggesting new pathways for future research at this level of soil organization to understand the mechanisms of soil function in conservative agriculture models.

ENVIRONMENTAL DYNAMICS OF IMAZAPIC WHEN APPLIED ON SOIL AND SUGARCANE RESIDUE

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The physicochemical characteristics of the soil and the presence of sugarcane residue in the field after harvesting influence the environmental dynamics of herbicides. The objective of this research was to evaluate the leaching, interception, sorption, and desorption of imazapic in sugarcane residue and soil. A bioassay was conducted to evaluate leaching by spraying imazapic on soil columns 50 cm long, simulating two dry periods (0 and 30 days) and two amounts of residue (0 and 10 ton/ha). To determine sorption and desorption of imazapic in 15 soils with different physicochemical characteristics, Kd values were calculated across a range of imazapic concentrations (0.125, 0.25, 0.50, 0.75 and 1.00 PPM). Imazapic was applied at each concentration plus 0.26 KBq 14C-imazapic. To determine sorption in sugarcane residue, 0.27 g of residue was added to tubes with imazapic stock solutions at different concentrations (0.125, 0.50 and 1.00 PPM) plus 14C-imazapic (0.26 KBq). To evaluate interception rainoff of imazapic by sugarcane residue, rainfall was simulated at several intensities (0, 3, 6, 12 and 20 mm) in residue amounts of 11 gm-2 and 22 gm-2. Aliquots were taken from the water collected from the simulated rainfall and analyzed by LCMS/MS. For the leaching experiment, it was noted that most of the herbicidal phytotoxicity of imazapic was in the top 0-5 cm of the soil profile, however, the herbicide did leach up to 20 cm deep. Increased dry periods after imazapic applications reduce the leaching of the herbicide in the soil profile. Imazapic has been shown to perform differently in soils with varying physical properties, specifically with differences in organic matter (the soil Will had a Kd = 28.9 mg/g). The sorption of imazapic was less than 20% at all concentrations. Imazapic has a high water solubility and low adsorption to sugarcane residue. In the interception experiment there was not a high herbicide retention in the sugar cane residue and most of the herbicide was able to be recovered through simulated rainfall. This is probably due to the high solubility of imazapic. The sugarcane residue, herbicide concentration and physicochemical characteristics of the soil influences the environmental dynamic of imazapic.

Keywords: Adsorption, Leaching, Interception and Desorption.

EVALUATION ENZYMATIC PROFILES AS INDICATOR OF SOIL HEALTH IN RELATION TO THE DIVERSIFICATION AND INTENSIFICATION OF CROPS IN AGRICULTURAL ROTATIONS

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The project Chacra Pergamino started in 2011 aimed to develop knowledge about soil health in relation to the intensification and diversification of crop rotations (DIRC). Treatments were replicated at three independent productive fields: Las Matreras, La Matilde and San Nicolás, separated each other about 100 km in the Pampas, Buenos Aires, Argentina Each productive field belongs to a different soil series. The treatments included one pasture and four different rates of crop rotation intensification (IIR). The different sub-plots were part of a plot with a common history of use before this assay. After three years of treatments no significant differences were found in chemical and physical soil quality, so farmers asked for soil biology characterization after four years of crop rotation.. As a part a more comprehensive study that includes analyses from DNA to macrofauna, here we report our results regarding how the soil enzymes profiles are affected by the intensification and diversification of crop rotation. Soil samples were taken at each location in two consecutive years (2015/2016) in autumn and spring. For each treatment, five replicates were taken (0-5 and 5-10 cm) and six enzymes involved in carbon, nitrogen and phosphorus cycle were determined using a fluorescent assay. A clear dynamic was found in the data along sampling time in the enzymatic profile, together with a "site" effect that separated the data by location. Nevertheless, when the analysis was performed at each location, significant differences between treatments were observed. Finally, a good correlation was found between the enzymatic activities related to the C-cycle and the N-cycle and the IIR. Thus, DIRC would favour the increase of the enzymes of the soil, improving the quality of the soil and its biofertility. The changes in profiles enzymatic were detected in shorter time than the changes in chemical and physical indicators suggesting the advantage of biological indicators in the short term to monitor the agronomic process.

EVALUATION OF CROP MANAGEMENT THROUGH SOIL PHYSICAL ATTRIBUTES UNDER SUGARCANE ON SYSTEMS: NO-TILLAGE AND CONVENTIONAL TILLAGE

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The objective of this work is to evaluate the soil physical attributes using two systems of soil tillage (conventional and no-tillage) in sugarcane renewable area. The study was carried out under field conditions at Usina Santa Fé, in Ibitinga-SP, with strips experimental design. Each experimental unit was repeated three times, the dimensions were 30 meters in length by 10 meters in width, amounting 300 m2.The used treatments were no-tillage using millet as crop rotation and conventional growing, which is used at the power stations. The no-tillage using millet has gotten better results for the analyzed attributes, such as less soil density, bigger total porosity, having more macro and less microporosity on surface layers. The no-tillage has also had an average diameter on evaluated layers with values 50% greater than the conventional tillage, also a bigger aggregate stability index, proving that management more conservationist affects positively the soil structure.

Keywords: no-tillage, sugarcane, aggregate stability.

FIELD PERFORMANCE OF NATIVE PROBIOTIC PSEUDOMONAS APPLIED TO TRITICUM AESTIVUM SEEDS UNDER NO-TILL MANAGEMENT DURING TWO CONSECUTIVE GROWING SEASONS

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We have recently characterized a collection of 19 Pseudomonas spp. with direct and indirect plant probiotic traits in vitro that were isolated from agricultural fields under no-till management in the humid Pampas (Agaras et al 2015 Biol. Control 90:173–186). Here we present the output of a field test using a subset of 10 isolates, which were selected by their quantitative direct or indirect plant growth promoting potential. The experiment took place during two consecutive growing seasons (June-December 2015 and 2016), in two locations of Buenos Aires province (Pergamino and Ferré), with triplicate plots of 6×1.5 m (7 furrows) at every geographical site, using a randomized complete block design. Bacterial suspensions of washed cells were prepared at OD600= 1.0 in saline solution. One kg of wheat (Triticum aestivum var. Klein Yarará in 2015 and Baguette 601 in 2016) seeds were treated with 8 ml of each cell suspension + 2 ml of bacterial protectant (PremaxR, RASA). Besides, co-inoculation (or not) with 2 ml of the commercial biological fungicide Rizoderma (based on Trichoderma harzianum Th2 from RASA) was carried out. In control plots, seeds were untreated or inoculated only with Rizoderma. The average grain yield depended on the location in both experiments. Upon data analysis using linear general mixed models, considering the locations and season periods as random factors (InfoStat), we found that 15 out of 21 treatments significantly improved grain yield over the untreated control ($p=0.0043$, DGC with $\alpha=0.05$), among which single inoculations with isolates SPSA2, RBBP4, RBAN4, SPAN5, RPAN5, SVBP6, SVBP8 or SMMP3, increased yield by 2.7-7.2%. Co-inoculations did not improve the effect of Rizoderma alone. The impact of bacterial seed treatment on plant, tiller and spikes density, and on NDVI was not statistically significant, but depended on the geographical location and the season period. Multivariate analysis (PCA) supported the positive effect of SPSA2, RBBP4, RBAN4, SPAN5, RPAN5 and SMMP3 mainly on yield, spikes and tiller values. Thus, single treatment of wheat seeds with any of these 8 pseudomonads had a positive impact on grain yield at these two locations with different soil properties during two consecutive growing seasons.

Keywords: Pseudomonas, PGPR, field trial, wheat.

GEOSTATISTICS ANALYSIS APPLIED TO THE STUDY OF THE CHEMICAL ATTRIBUTES OF A NEOSOLO QUARTZARÊNICO UNDER EUCALYPTUS CULTIVATION

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The forest sector is growing, especially when considering the productive potential of wood and chemical uses, it is necessary to increase the regional management of the soil and the culture and, to use of alternative sources of fertilization that are part of a system of precision forestry, aiming at greater Productivity, including cerrado areas, which currently present limitations to forest productivity. One of these alternative sources is the pulp residue used to correct soil acidity, as well as to improve CTC and organic matter content. The objective of the present work was to evaluate the spatial variability of plant and soil attributes of a Quartzarenic Neosol cultivated with eucalyptus and fertilized with cellulose residues. In the year of 2014, at Farm Bom Retiro, located in the city of Três Lagoas, MS, the application of lime sludge compound + oxyfertil was carried out, and the following plant samplings were made: height (ALT) and soil in a mesh (PH), calcium (Ca), magnesium (Mg) and aluminum (in the range of 0,00-0,20 m and 0,20-0,40 m). Al) at 50 points in an area of approximately 2 ha, covering the chosen field for sampling (2ha). Data were analyzed by descriptive statistics using SAS software and spatial dependence by semivariogram calculation using GS + software. In what we say the dendrometric properties, the evaluated results have high and very high variability with the physical attributes of the soil. The performance of semivariograms presented spatial dependence for attributes Ca1, Mg1, Mg2 and Al1. In the comparison of the kriging maps, there was high spatial similarity for the attributes of Ca1, Mg1 and Al1. And, there was vertical variability, there is also horizontal variability between the depths, since for the same nutrient the range was different between the layers sampled.

Keywords: Cellulosic waste, forest sustainability, oxyfertil.

GLOMALIN AS BIOCHEMICAL INDICATOR OF SOIL QUALITY AND ITS RELATIONSHIP WITH DIFFERENT PHYSICAL, CHEMICAL, BIOCHEMICAL AND BIOLOGICAL PARAMETERS

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Glomalin is a protein produced by arbuscular mycorrhizal fungi (AMF). It is a hydrophobic gycoprotein very abundant in the soil, where it functions as a structuring biochemical component. Glomalin-Related Soil Proteins (GRSP) concentration in soils (mg BCA-reactive GRSP per g dry soil) is positively correlated with soil quality and is associated with different land uses. Analysis of easily extractable (EE) and total (T) GRSP fractions was used to characterize no-till productive agricultural soils associated with different treatments, replicated across a 400 km transect in the Argentinean pampas, during two sampling seasons, summer and winter. Treatment categories were grouped according to the sustainability of the soil management, in terms of crop rotation, fertilization, agrochemicals use and pest control, as good agricultural practices (GAP) and poor agricultural practices (PAP). Non-cultivated soils from nearby natural environments (NE) to the treatments in each geographic location were used as references. In silt soils environments the GRSP concentration showed strong potential to discriminate between different land uses, shown a significant trend NE>PAP>GAP. On the other hand, in sand or clay soils the GRSP concentration did not show this significant trend and thus did not discriminate between different land uses. This was observed both with EE-GRSP and T-GRSP and either in summer or winter. Thus the glomalin as indicator of soil quality was affected by edaphic–climatic differences between sites. Afterwards we analyzed the relationship of GRSP fractions with different physical, chemical, biochemical and biological parameters in order to better understand the applicability of the glomalin value as an indicator of soil quality. Correlation analysis showed high interdependence between GRSP and the arbuscular mycorrhiza community (spore numbers in 100 g dry soil), and also in relation to the available phosphorus. The hydrophobicity characteristic attributed to glomalin was also corroborated through its correlation with soil neutral lipid fatty acids - NLFA (nanomoles per g of dry soil) and the glycoprotein characteristic suggested by its correlation with total soil carbohydrates - CHt (kg per ha). Glomalin is consider an important component of soil organic matter, with a high correlation with total organic carbon - TOC (percentage of dry weight) and with total nitrogen – N (percentage of dry weight), possibly showing a differential and characteristic relationship with the different organic fractions of the soil: coarse particulate organic carbon - POCc, fine particulate organic carbon - POCf and mineral organic carbon -MOC (percentage of dry weight). The relationship of the glomalin with the structural stability of the aggregates (weighted average diameter per mm) was also verified. Thus, in silt soils, in which the glomalin discriminate between different land uses, its value was related to other chemical and biochemical characteristics, while it was not like that in soils were glomalin did not worked as a quality indicator. These observations suggest a more complex meaning of glomalin a soil value.

HOW TO ADDRESS THE LACK OF SOIL MAPPING IN THE SEMI-ARID CHACO, CASE IN SANTIAGO DEL ESTERO, ARGENTINA

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The semi-arid Chaco is an ecosystem shared by Argentina, Paraguay, Bolivia and Brazil, where the change of land use to commercial agriculture and social conflicts have been intense since the beginning of the 21st century. Mitigation of impacts on natural resources and land use sustainability demand a better understanding of physical and anthropic factors and the systematic organization of regional data and information. In this process the knowledge of the soil is of fundamental importance. The demand for soil mapping, faced problems such as the large extent of the area, the complexity of geomorphology and soil types, limited budget and staff capacity. The objective of this work was to show a methodology to generate soil cartography at the regional level. For this purpose, the geopedologic approach and the inclusion of geomatics techniques in conventional methodology were evaluated to modernize the system, reducing the temporal and economic costs. The study area of 8,800 km2 is located (27°30' - 28°35 ' S and 63°45'--64°35' W), in the province of Santiago del Estero. Data were obtained from maps; reports; Topographic data of SRTM 90-m, Landsat images (1972-2014); CBERS and SAC-C; field observations; and determinations of soil properties. ArcGIS 9.3, Imagine 9.3.1 and SAGA software were used for digital processing, morphometric and morphometric attributes calculation, and mapping of results. Preliminary map units were delineated, through iterative and exhaustive visual interpretation of derived topographic data and satellite imagery, a hierarchical legend of geoforms was established to define soil landscape relationships, soil description sites, and boundaries of physiographic units. The physical-chemical properties were determined and the soils were classified. All the cartography was managed in the Geographic Information System of Santiago del Estero (SigSE). Three main landscape units were recognized: 1) the Chaco fluvial-aeolian plain, including a mega fan with Haplustolls and Torripsamments, 2) the Río Dulce valley with Torripsamments, and 3) the migratory alluvial plain of the Río Salado with Torripsamments, Ustifluvents, and Natraqualfs. The approach used helped accelerate the collection of soil information at an appropriate scale for land use planning.

Keywords: Geopedology, Soil mapping, Remote sensing, GIS

IMPACT OF CONSERVATION AGRICULTURE ON CROP PRODUCTIVITY, SOIL AGGREGATION AND AGGREGATE-ASSOCIATED NITROGEN IN CEREAL-BASED ROTATIONS OF INDIA

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The impact of long-term conservation agriculture on crop productivity and soil quality in intensively cultivated regions of India is unknown. Therefore, the effect of conservation agriculture on yield, total soil nitrogen (TSN) and aggregate-associated nitrogen in wheat-based rotations was evaluated between 2008 and 2015. The experiment was conducted on sandy soils in a split plot design with three replications at IARI, New Delhi. The main plots consisted of four tillage treatments: (i) conventional tillage-raised bed (CT-B) (ii) conventional tillage-flat bed (CT-F) (iii) zero tillage-raised bed (ZT-B) and, (iv) zero tillage-flat bed (ZT-F), and four residue management strategies in subplots: (i) No residue (ii) pigeonpea/maize residues at 3.5 t ha-1 (iii) wheat residues at 3.5 t ha-1, and (iv) pigeonpea/maize residues at 3.5 t ha-1 + wheat residues 3.5 t ha-1. Results indicate that zero tillage recorded higher system's productivity than conventional tillage. Irrespective of crop establishment, wheat yield was lower in raised beds compared to flat beds (12-25%). In the 0–15 cm soil layer, ZT-B recorded 15% higher TSN stocks than CT-F (0.54 g kg−1 soil), respectively. However, the impact of tillage on TSN stock was not significant in the sub-surface soil layers (15–45 cm). Application of pigeonpea/maize + wheat residues recorded higher overall yields and TSN than no residues (0.68 g kg−1 soil) in the 0–15cm soil surface. Higher macroaggregates (0.53–8mm) and mean weight diameter was found in ZT-B with pigeonpea/maize + wheat residues than in CT-B and CT-F with no residue application. Therefore, ZT-B with pigeonpea/maize + wheat residue recorded also 20% higher macroaggregate-associated N stocks than CT-B (38 kg TSN ha−1) in the 0–15 cm soil layer. It was concluded that the retention of pigeonpea/maize at 3.5 t ha-1 + wheat residue at 3.5 t ha-1 in zero tillage has the potential to enhance the productivity, soil aggregation and associated nitrogen in cereal based rotations of India.

IMPACT OF FERTILIZATION STRATEGIES ON YIELD, GRAIN QUALITY AND SOIL FERTILITY IN PAMPAS REGION

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Soils in Pampas Region (Argentina) have been progressively reducing their chemical fertility. Phosphorous (P), Nitrogen (N), Sulphur (S) and Zinc (Zn) availability in soils has diminish. The combination associated with the increase in grain yield impacted negatively in grain nutritional quality. The low proportion of grasses in the rotation, low or lack of fertilization (especially in soybeans) can explain this processes. Therefore the evaluation of the impact of fertilization strategies on productivity, nutrient balance and grain quality becomes critical. Two corn experiments were conducted on 2015/16 growing season in Rio Cuarto (Cordoba-Argentina). Based on yield history one high productivity site and one low productivity site were selected. In each sites two planting dates were tested: an early planting date, (EPD) on October 20th and a late planting date (LPD) on December 21st both under no till system. The hybrid sown was DK 190 VTTriplePro and the seeding rate was 65.000 pl ha-1. The factor evaluated was fertilization with four levels: control (C), farmer fertilizer rate (1xFR) double of the farmer fertilizer rate (2xFR) and 2xFR plus Zn (2FRZN). The experimental design was completely randomized block design with four repetitions. Determinations included grain yield and nutrient content, N, P, S and Zn partial nutrient balance (nutrients uptake in the grain minus nutrients applied as fertilizer). Results were analyzed by ANOVA and LSD test at 5% provability. There was interaction of sowing date and site. In the most productive site the EPD yielded 8.248 kg ha-1 while the LPD reached 6.000 kg ha-1 whereas in the less productive site there were no statistical differences between planting dates (5.899 and 5868 kg ha-1 for EPD and LPD respectively). The partial nutrient balance shows that in EPD and LPD and in both sites the 2xFRZN treatment was the only one more close to cero or positive balance, meaning that will have a neutral or positive effect in soil fertility. N, P and S concentration in seed did not vary across treatments while Zn concentration diminished while more N, P and S was added without Zn addition. These preliminary results allows to conclude that to revert the degradation process of soils in Pampas Region and increase yields higher rates of fertilizer needs to be applied in order to improve the nutrient balance and micronutrients like Zn should be considered in the fertilization program for corn.

IMPACT OF WINTER COVER CROPS ON SOIL ORGANIC MATTER AND INFILTRATION IN SOYBEAN MONOCULTURE

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The process of agriculture expansion has driven to replace integrated crop-livestock systems for continuous cropping systems, in which predominate soybean. In consequence, we expect a diminution of soil quality, expressed in a reduction of soil organic matter (SOM) and in soil infiltration rates (IB). The inclusion of a cereal winter crop (CC) may mitigate the negative effects of soybean monoculture. The objective of the study was to evaluate the effect of the inclusion winter cover crops over SOM balance and soil hydrological properties as infiltration in an Entic Hapludol over 10 years in soybean monoculture (T) between 2005 and 2015. The mean biomass of CC varied between 7370 and 8652 kg ha-1 to oat and rye grass. The SOM contents were higher in CC (2.5%) than in T (1.5%) in the first 20 cm. The IB was 55% lower in T than in CC. We concluded that the inclusion of winter cover crops in a potential technology to mitigate the negative effects of soybean monoculture in sandy loam soils because of the high volume of residues produces, that increase soil coverage and soil organic matter, and associated with both, the water infiltration into soil.

IMPACTS OF CROP MANAGEMENT PRACTICES ON CORN YIELD GAP

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In south Cordoba province (Argentina) corn potential yield was determine in 20 Mg ha-1. Farmer's average yield in the area is 7 mg ha-1. This yield gap can be explained by different management factors: seeding rate, fertilization program, use of fungicides. The aim of this research was to evaluate the impact of different management practices on corn yield. During 2014/15 growing season an experiment was carry at Rio Cuarto National University Experimental Field (Cordoba, Argentina). The factor evaluated includes seeding rate, starter fertilization, nitrogen fertilization and use of fungicide. Two contrasting crop management practices were defined as high (90.000 seeds ha-1, 150 kg ha-1 of NPSZn [10-40-10-1], 110 kg ha-1 of N applied at V6, fungicide application at V8) and low technology (68.000 seeds ha-1, 75 kg ha-1 of NP fertilizer [18-46], 55 kg N ha-1 applied at V6). All possible combinations between both groups of management's practices were evaluated in a total of 10 treatments. The experimental design was factorial with contrasting management practices (high and low technology) and individual management practices (seeding rate, starter, nitrogen, fungicide. The experimental design was completely randomized design with three replications. Grain yield and number of grains per area were measured. The results shows that there was statistical interaction between factors. In high technology treatments decreasing seeding rate, starter fertilizer or nitrogen diminished yields in 15.6, 13.6 and 13.9% compared with the full high technology treatment. In low technology treatments increase in starter rate and nitrogen were statistically significant from the rest of the combinations with a positive impact in yields of 17.4 and 23.8% compared with the control. Preliminary results suggest that there is room to improve management practices to close yield gaps in the region on the study.

INCREASING SOIL FERTILITY AND DECREASING FORAGE SHORTAGES DURING THE WINTER PERIOD THROUGH THE IMPLEMENTATION OF CA IN TAJIKISTAN.

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Conservation Agriculture (CA) system, a no-till production system, has certain advantages over the conventional tillage system, as it minimizes soil erosion, reduces water loss from runoff and decreases crop establishment costs. Under the no-till system, soil biota can increase and maintain soil biopore networks, and, since the soil is never tilled, the soil structure improves (Nurbekov et al., 2013). No-till system can be one of the potential ways to efficient use of agricultural land resources and also to reverse land degradation and improve soil health and productivity in Tajikistan. Crop rotation systems have been used for millennia to maintain soil fertility and productivity and to suppress pests, and can increase yields even in situations where substantial amounts of fertilizers and pesticides are already applied. In this study, different methods of soil preparation for crop establishment included the conventional tillage method and the no-till method, with different cereal and forage crops are being investigated. The objective of the trial is to evaluate the effect of different tillage systems on the productivity of forage crops and on any decrease in fodder shortages in the winter period through he implementation no-till system or Conservation agriculture, in the irrigated conditions of Tajikistan. All data were statistically analyzed to show that there were significant differences among treatments. The first year results of the experiment showed that no-till mung bean and soybean performance was better compared to the conventionally tilled mungbean and soybean systems. No-till maize had lower yield compared with conventional tillage maize in the irrigated conditions of Tajikistan. The benefit:cost ratio for no-till soybean and mung bean production was the highest, 291.1% and 350.7% respectively compared with conventionally tilled mungbean and soybean. These results show that no-till cropping system has good potential to utilize the fallow land after the wheat harvest, and can significantly contribute to food security in Tajikistan. CA is a new approach to production intensification in Tajikistan. Promising results from this experiment is likely to increase the possibility of adoption of CA in the country.

INDIA FARMING DESPERATELY NEED RADICAL CHANGE THROUGH CONSERVATION AGRICULTURE TO SUSTAIN INCREASED FOOD PRODUCTION AND TO PROVIDE NUTRITIVE FOOD FOR THE GROWING POPULATION

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Indian Agricultural was exploited by Mughals for 300 years and later British rule till independence in 1947, and the West Bengal Famine in 1942, all this left India with 4 million people died without food. This period was of meager food production with ship to mouth PL-480 USA charitable Food Aid, which also collapsed in 1959-60. It was period with sustenance food production, poverty, occasional droughts, floods, poor roads, electricity, irrigation and infrastructure, etc., under the threat of increasing population till 1960. Onward 1960 "Green Revolution" augured up with the help of Dr Norman E. Borlaug and 20 world selected scientists worked on main crops. Wheat yields were more than doubled in 4 years (1964-68), production of other crops also increased in 10 years (1964-75) made India self sufficient in food grain by 1975 and surplus in 1985 creating problem of storage and Post harvest losses. Onward 1975 farmers grew only few main crops with maximum fertilizers, insecticides, pesticides using mostly under ground water. The soils have been depleted in most productive states due to excessive use of main fertilizers (NPK) and burning of organic residue in fields or taken out with main nutrients, and then almost all the macro and micro-nutrients to create irreversible poor soil fertility to virtually dead soils. Under ground water use, lowered the water table more than 200 ft deep in most food producing states. At present Indian Agriculture is in deplorable state with lowest fertilizer use efficiency, toxins in soil and water, less irrigated water, 65% of rainfed area till date. Farmers wants to leave agriculture due to poor income and high cost of inputs, labour and water and top of it young boys do not want to go for agriculture due to uncertain future. The Present agriculture in India needs radical change to adopt "Farming System" with crops, livestock, horticulture, medicinal plants and spices etc., to add to the income. To overcome the above melodies of soil, water and crops only, the "Conservation Agriculture" has emerged globally upcoming alternative, to conventional farming, to recycle the residue of crops in the fields in situe, residue of farm, village and urban areas of the agriculture produce back to the farm fields to regain lost soil fertility, integrated use of fertilizers, improved tillage, irrigation, water saving technology and use of bio-fertilizers, with suitable crop cultivators.

Keywords: Mughals, British, Famine, Sustenance, Charitable, Deplorable, Depleted, Integrated, Uncertain, Conventional

INTERCROPPING MAIZE BRACHIARIA MODALITIES FOR SOIL PROTECTION

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In Brazil central region, the grain production is based on the succession soybean and maize off-season. Soybean is grown in the spring-summer and maize in the autumn-winter. Brachiaria inclusion in this production system increases the soil cover, with improvements in soil physical, chemical and biological properties. The objective was to evaluate the biomass and maize grain yield in different intercropping modalities. The experiment was conducted under no-tillage in the fall-winter 2013 year, in Dourados, Mato Grosso do Sul, Brazil. The experimental design was a randomized blocks with six replications. Six treatments were evaluated by single and intercropped maize combination and three row maize spacing (reduced - 0.45 m, conventional - 0.90 m and mixed - 0.45 and 0.90 m). The Brachiaria ruziziensis was sown in the maize row in the reduced spacing, and, inter-row maize in the conventional and mixed spacing. At maize flowering maize and Brachiaria biomass, and in the maize maturation the grain yield were evaluated. Data were submitted to analysis of variance and means were compared by Tukey test at 5% probability. The maize dry biomass was greater in single maize(16,831 kg ha-1) and not different of the reduced spacing intercropping (15,856 kg ha-1). The dry biomass Brachiaria was greater in the mixed spacing (1,624 kg ha-1) as compared to conventional or reduced spacing (794 kg ha-1). The grain yield was higher in the reduced spacing in both the single maize (9433 kg ha-1) as intercropped (8287 kg ha-1). The perennial forage cultivation enables increased production of residue to soil cover after the maize harvest.

Key-words: Maize plant arrangement; no-tillage; cover crop.

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INTERCROPPING PUMPKIN-WHEAT UNDER ZERO TILLAGE AND DRIP FERTIGATION: AN EVALUATION OF THE PRODUCTIVE PERFORMANCE

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In the pumpkin production, an appropriate estrategy for early control of weeds is crucial. The broad leaf weeds are the main challenge due to the low degree of development in selective herbicides used in cucurbits. The goal of this experiment was to evaluate the yield during one productive cycle of tetsukabuto pumpkin intercropped with wheat, both as a productive intensification and integrated weed management strategy. After the chemical fallow, the direct seeding of wheat was carried out over the whole area. Two months later the wheat was drying in strips after herbicide application.The strips were 2,1 m wide spacing 4.6 m in between. One month after strip drying, the direct seeding of pumpkin in the dryed wheat strips was carried out. At the beguinning of Summer the wheat was harvested then the pumpkins extended their vines covering the whole area. The manual harvest of the tetsukabuto was at the beguinning of the Autumn. Wheat surface covering percentage was 54% and the yield over that area was 4.301 kg ha-1. Wheat competition generated on the weeds allowed the pumpkin development without any herbicides applications. The tetsukabuto yield was 36.350 kg ha-1, with an average fruit weight of 2,11 kg and a density of 17.326 fruits ha-1. The intercropping of tetsukabuto with Winter cereals turns to be the appropriate strategy on the weeds control, the significant reduction of the herbicides claim and the sustainable intensification of the production. This practice is thus feasible under the agroecological conditions in the Colorado river valley, in the province of Buenos Aires, and the technological offering of equipment and machinery available are adequate.

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LONGER-TERM IMPACT OF CONSERVATION AGRICULTURE AND HERBICIDE IN RICE-BASED SYSTEMS

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The cropping intensity is >200 % in smallholders' conventional rice-based systems in Bangladesh and repeated soil disturbance and puddling are the common crop establishment practices. Herbicide use for weed control in crop fields has increased rapidly since 2005. Increasing labour cost, labour shortages, and herbicides' efficacy are the driving factors for rapid adoption of herbicides. After harvesting of monsoon season crops (rice or jute) and winter season crops (particularly mustard and lentil), generally few weeds remain. Application of knock-down herbicides is advised for minimum soil disturbing conservation agriculture (CA), however, smallholders are reluctant to use knock-down herbicide. To assess the immediate benefit and long-term impact of herbicide, four dispersed on-farm experiments were conducted in Durgapur, Rajshali during 2012-13 and 2013-14. The crop sequences were: boro rice–aman rice–mustard–boro rice–aman rice. Nine treatments were: (T1) No herbicide application, (T2) Glyphosate, (T3) Pretelachlor, (T4) Ethoxysulfuron, (T5) Pretelachlor + Ethoxysulfuron, (T6) Glyphosate + Pretelachlor, (T7) glyphosate + Ethoxysulfuron, (T8) Glyphosate + Pretelachlor + Ethoxysulfuron, and (T9) Conventional practice. Non-puddled rice seedling establishment (Haque et al., 2016) was followed for T1 to T8, whereas, conventional soil puddling was followed for T9 in case of rice. The Versatile Multi-crop Planter (VMP) was used to establish mustard in single-pass strip planting for T1 to T8; whereas, three tillage operations followed by hand broadcasted seeding was practiced for T9. Higher production costs for all five crops in the sequences was found for the control. However, for all crops, no significant variation was found for grain and straw yield among treatments. After five crops, significantly higher total net return (US$ 3224 ha-1) was recorded for T8 followed by T3; whereas, the lowest (US$ 1678 ha-1) for the T9. Weed population and dry mass was decreased significantly over time where the non-selective herbicide (Glyphosate), one pre-emergence (Pretelachlor) and another post emergence (Ethoxysulfuron) herbicide were used. However, conventional practice (T9) enhanced the weed population and dry mass over time. This result suggests that depending on weed density in a field, farmers may able to omit the knock-down herbicide application to cultivate winter season crops in minimum soil disturbing strip planting systems.

LONG-TERM IMPACT OF CONSERVATION AGRICULTURE IN RICE-BASED CROPPING SYSTEMS

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Soil puddling for transplanting rice seedlings is the key obstacle to conservation agriculture (CA) for intensive rice-based cropping systems. A novel solution to this challenge is strip planted non-puddled rice seedling transplanting (NPT). Long terms trends with CA following the use of NPT were assessed at two long-term experiments at Durgapur (E1) and Godagari (E2) in Rajshahi district since 2010, and another at Mymensingh district since 2012 (E3). Three tillage practices: strip planting (SP including NPT), bed planting (BP) and conventional tillage (CT) at E1 and E2; and either SP or CT at E3. All experiments had low current and increased residue retention levels. Cropping sequences were lentil/mustard–mungbean/jute/irrigated rice–monsoon rice (for E1); wheat /chickpea–mungbean/ early wet season rice/jute–monsoon rice (E2; and wheat–mungbean–monsoon rice (E3). The Versatile Multi-crop Planter (VMP) was used for establishing all upland crops (lentil, mustard, chickpea, early wet season rice & mustard) in single pass operation for SP and BP, however, 3-4 tillage operations by 2-wheel tractor followed by hand-broadcast seeding and fertilizing were done for CT. In case of irrigated and rainfed rice, NPT were practiced in SP and BP; and for CT conventional puddling was followed. Significantly higher grain yields and higher net return for all upland crops were recorded in SP in all sites compared to BP and CT. In the first two years, there had no significant variation in rainfed rice yield using NPT between the tillage systems. Thereafter, significantly higher grain yield of rainfed rice in NPT was recorded in SP. However, since beginning, the SP plots showed higher grain yield with greater profit margin of irrigated NPT. In comparison with CT, considerably higher soil organic carbon was observed in SP at 0-10 cm soil depth after 3-4 years of cropping. Practicing SP for upland crops and NPT for rice crop accumulated 4.24 and 3.79 t CO2eq ha-1 in E1 and E2 experiments, respectively, after 4-5 years. The SP reduced greenhouse gas emission relative to CT by about 30 %. The long-term experiments demonstrated substantial benefits from the adoption of CA in the intensive rice-based cropping systems.

METHODOLOGY FOR DIAGNOSIS OF DEGRADED AREAS USING AERIAL IMAGES AND VALIDATION USING PHOTOS OBTAINED WITH DRONE

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The difficulty of evaluating degraded areas, especially in places with difficult access and/or natural impediments such as floodwaters, stony sites, high canopy vegetation, can be minimized with the use of relatively recent aerial Google Earth® images. Representative of the exact moment of the visit to the property. Such information with this interstice between the date of the orthophoto and the momentary image, while useful, may mask an actual situation of the area being diagnosed. New methodologies and tools are needed as strategies for a sample survey and represent the reality of how these properties are in terms of soil conservation and degree of degradation. The proposed methodology was validated by means of the "in loco" check-up, and the physical environment was surveyed, according to the manual for utility survey and land classification in the capacity utilization system and by drone aerial photos. The results demonstrate the feasibility of the applied methodology, with gains of time and low cost.

Keywords: Drone; ground; Soil degradation; Aerial image; Orthophoto; Degraded area.

NODULATION AND INITIAL GROWTH WITH SOYBEAN CO-INOCULATION BRADYRIZOBIUM IN SANDY SOIL

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The soybean yield is proportional to the availability of nutrients such as nitrogen. It is essential in amino acid biosynthesis process, chlorophyll, nucleic acids and nitrogenous bases. Currently, diazotrophic bacteria that increases the soybean yield belong to the genus Bradyrhizobium; nevertheless, there is the possibility to increase this benefit with the combination with other bacteria such as the genus Azospirillum. The aimed of this study was to evaluate nodulation in roots and initial growth of the BRS 1001 IPRO soybean with different inoculation treatments of Bradyrhizobium and Azospirillum. The study was conducted at Embrapa Western Agriculture, in Dourados, MS, Brazil in no heated greenhouse conditions glass cover and side with splint-galvanized wire. The plots were polypropylene pots containing 3 kg of dry soil. The experimental design was a randomized block with three replicates, and the following treatments: 1- no inoculation and no fertilizer, 2- nitrogen fertilizer, 3- Bradyrhizobium inoculation, 4- inoculation with Azospirillum, 5- and inoculated with Azospirillum and Bradyrhizobium. At V4 plant stage, plants were uprooted, washed and the nodes roots separated. The samples were oven dried at 40°C for dry weight determination. Data were subjected to ANOVA and averages were compared by the Tukey's test at $p<0.05$. The highest values for number and weight of nodules and root dry weight were observed in the Bradyrhizobium inoculation isolated, no differing statically from co-inoculation, however, the treatment with nitrogen fertilization showed no nodulation. The shoot as dry weight of stems, leaf area and chlorophyll b showed greater values fertilized with nitrogen, although not statistically differ from the treatments with Bradyrhizobium and co-inoculation. We conclude that inoculation with Bradyrhizobium is equivalent to co-inoculation for number and weight nodules. Co-inoculation and inoculation with Bradyrhizobium are similar to the use of nitrogen fertilizer to shoot growth of soybeans.

Keywords: Azospirillum brasilense; Bradyrhizobium japonicum; no-tillage.

Acknowledgements: CAPES, UFGD, EMBRAPA Western Agriculture.

PHYSICAL AND CHEMICAL SOIL ATTRIBUTES AFTER AUTUMN-WINTER CROPS IN DOURADOS, MATO GROSSO DO SUL, BRAZIL

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Soybean in sequence of autumn-winter crops is predominate in the region of Dourados, MS. This management could change chemical and physical properties of the soil. The aimed of this study was to evaluate the chemical and physical properties of the soil during summer soybean cultivation after corn, Brachiaria spp. and cowpea in autumn-winter. The experiment was conducted at the experimental field of the Embrapa Western Agriculture in Dourados, MS, in a Dystroferric Red Latosol (Oxisol), at 2014/15 crop season. The experimental design was a randomized block with four treatments (Brachiaria ruziziensis, intercropping corn-B. ruziziensis, single corn and cowpea) in four replicates. Samples were collected in four layers, 0-0.10m, 0.10-0.20m, 0.20-0.30m and 0.30-0.40m of depth, to analyze macronutrients, micronutrients, density and porosity of the soil. The data were subjected to ANOVA and averages were compared by the Tukey's test at ($p<0.05$). Soil chemical properties showed larger in the layer of 0-10m, in which pH (5.5 CaCl2), cation exchange capacity (12.6 cmolc dm-3), percent base saturation (71.8 %), organic matter (40.1 g kg-1), phosphorus (54.7 mg dm-3), potassium (0.79 cmolc dm-3), calcium (5.7 cmolc dm-3), magnesium (2.50 cmolc dm-3), manganese (108.0 cmolc dm-3) and zinc (4.90 cmolc dm-3). Physical properties as microporosity (5.50 %), total porosity (12.60 %) and density (71.8 kg dm-3) had higher levels in the layer 0 to 0.10 m. The single corn showed higher pH (5.0 CaCl2) and percent base saturation (51.3 %). While, intercropping corn-B. ruziziensis had higher cation exchange capacity (10.5 cmolc dm-3), potassium (0.37 cmolc dm-3), magnesium (1.40 cmolc dm-3), manganese (61.1 mg dm-3), phosphorus (12.0 mg dm-3), iron (34.2 mg dm-3), and better porosity (52.9 %) and lower bulk density (1.2 kg dm-3). The cowpea contributed with higher organic matter (44.4 g kg-1), possibly associated with the low C/N ratio. Therefore, the autumn-winter crops were able to change chemical and physical soil attributes.

Keywords: soil compaction; intercropping; crop rotation.

Acknowledgments: Embrapa Western Agriculture, CAPES, UFGD.

POTENTIAL OF AN ORGANIC FERTILIZER OBTAINED FROM SEWAGE SLUDGE AND SOLID WASTE FOR JUÇARA PALM (EUTERPE EDULIS MART.) CULTIVATION

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The uncontrolled extractive system of juçara palm (Euterpe edulis Mart.) for the extraction of palm hearts in the Brazilian Atlantic Forest and the increasing production of sludge from sewage treatment plants are distinct problems, but both affect natural resources conservation. The sewage sludge when treated and processed acquires characteristics that allow its use in agriculture as an alternative fertilizer providing nutrients, organic matter and humidity. Its use can be a potential alternative to the juçara palm cultivation, reducing its exploitation in native forests. This study aimed to evaluate how E. edulis saplings respond to different levels of organic fertilization. We expected improvements in relative growth rate (RGR) in biomass, height and stem diameter in the treatments with the highest amount of organic fertilizer. We conducted two greenhouse experiments at Araras-SP, Southeastern Brazil: one in sandy soil and another in clayey soil, during 210 and 120 days respectively. Juçara palm seedlings were grown in 8 L pots with sandy or clayey soils mixed with 0, 0.5, 1 or 2 kg of organic fertilizer. We observed that the treatments with organic fertilizer increased juçara palm RGR in biomass, height and stem diameter in the sandy soil, and the most satisfactory treatment to the initial development of juçara palm was with 1 and 2 kg per pot. With the clayey soil, no effects in the RGRs were observed. Nutrient availability and soil attributes such as pH, organic matter, cation exchange capacity, and base saturation increased with increasing organic fertilizer amounts, proving that the organic fertilizer improves soil quality. We conclude that the highest amount of organic fertilizer did not provide the highest growth for E. edulis plants. However, intermediates amounts provide a satisfactory development of juçara palm plants, suggesting that this organic fertilizer obtained from sewage sludge could be used for E. edulis cultivation.

PUBLIC POLICY INHERENT IN THE SUGAR AND ETHANOL IN BRAZIL ACTIVITY: FEASIBILITY IN ELECTRIC POWER COGENERATION BY SUGARCANE BIOMASS

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The concern with the environment and how to preserve it has been a great challenge to the Nations. Among the current issues is the replacement of fossil fuels by other, renewable, that have the same capabilities and qualities. This work aims to demonstrate how it is possible to achieve through public policies cogeneration of electricity from biomass.The Brazil is a major producer of sugar cane in the world and ranks first in electric power cogeneration with biomass use. However, despite the Brazilian energy policy have been created in 1997, the creation of public policies that enable the use of waste as biomass surfaced a few years ago. For the activities of the sugarcane mills, for the production of culture as the acquisition of local producers for the production of sugar and ethanol. After the process, there is a large amount of waste that is used both on the fertilization of fields as well as in animal feed. Even with this destination, much of bagasse and sugarcane straw tip (waste) are still unused, causing real hills of biomass. Brazilian water crisis between 2011 and 2012 and the recognition of the use of biomass from sugar cane in cogeneration of electricity, there was a significant change in the matrix energy: raised if the value of the MWH of electricity produced by cogeneration plants making the sale on the open market. Residue is significant economic value in cogeneration of energy, making it a byproduct of power plants. Domestic consumption of electric power is reached, cogeneration plants or making electricity sustainable. After brazilian water crisis, the public policies have become scarce. Waste continue to be produced and the demand for power increasing. Need on environmental preservation and not degradation must be obeyed and followed by all. New policies are necessary to encourage cogeneration of energy through biomass to be made to achieve sustainable consumption and the reduction in the use of fossil fuels, making Brazil a world spotlight on environmental protection.

PURPLE NUSTEDGE (CYPERUS ROTUNDUS L.) CONTROL THROUGH CLIMBING LEGUMES SUCH MUCUNA PRURIENS L. AND LABLAB PURPUREUS L.

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The adoption of Conservation Agriculture in Mozambique poses new challenges for smallholder farmers. One of these challenges is the control of perennial weeds without herbicides which is beyond the reach of this group of farmers in Cabo Delgado due to: a) High prices (low-income farmers), and b) Cabo Delgado is a remote area where affordable access to herbicides and other inputs is not yet possible. Looking for sustainable solutions according to local agro-ecological and socio-economic conditions of the region was the aim of the on-farm research carried out. The present study aimed at testing the efficiency of two cover crops, Mucuna pruriens L. and Lablab purpureus L. in the control of purple nustedge (Cyperus rotundos L.) in Conservation Agriculture systems. The trials were conducted in the village of Nangua, in the province of Cabo Delgado during the rainy seasons of 2014/15 and 2015/16 crop years in a field that was abandoned due to purple nustedge weed infestation. Two cover crops, mucuna and lablab, were established in 12 m^2 plots, in three replications. Three counts of the quantity of purple nustedge were made in these plots: 1st count, 1 day before sowing; 2nd count, 30 days after germination, and 3rd count, 60 days after germination. Before the cover crops were sown, the purple nustedge counts were made in 1 m^2 area in 2 sites located in each plot, during two seasons. In the first year, there was a decrease in the number of plants of purple nustedge in the plots where both legumes were grown. Both legumes showed greater efficiency in the control of purple nustedge with increase in their duration in the field mainly between 30 days and 60 days after sowing. Results show that mucuna and lablab can replace each other in the control of purple nustedge because the effect of the application of both cultures is indifferent. Mucuna and lablab usage as cover crop in Conservation Agriculture Systems favors dormancy of the bulbs and creates unfavorable conditions for the viability of purple nustedge seeds and thus decreases their proliferation capacity in field crops.

SOIL COVER USING INTERCROPPING CORN-BRACHIARIA

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The climatic characteristics of the Brazilian Cerrado difficult to maintain a cover of soil quality and satisfactory amount for the implementation of tillage system. Intercropping corn with brachiaria is a viable alternative to increase the production of residues. The objective was evaluate the plants population most appropriate to increase dry matter production brachiaria without decrease corn yield. The study was conducted in the fall-winter 2016 year at experimental area of Embrapa Agropecuaria Oeste, in Dourados, Mato Grosso do Sul, Brazil. The experimental design was randomized blocks design with split split-plot with four replications. The main plots were composed of single and intercropping corn with Brachiaria brizantha cv. Paiaguás; subplots by row corn spacing (0.45 m and 0.90 m), and subplots by the population of corn plants (45,000; 52,000 and 65,000 plants ha-1). Brachiaria was sown in row spacing 0.50 m and 20 plants m-2. At physiological maturity of corn were evaluated corn and Brachiaria morphological components and grain yield. Data were submitted to ANOVA and means were compared by Tukey test ($p < 0.05$). The treatment had no significant effect on the corn (207.8 cm) and brachiaria (22.6 cm) plants height and dry biomass brachiaria (1.249 kg ha-1). The intercropping increases the straw total production in 605 kg ha-1, although reducing corn leaf area (8,776 cm^2) and leaf area index (4.73). Better results were observed for the spaced 0.90 m, stem diameter (22.37 mm) and grain yield (9.947 kg ha-1) were significantly higher when combined with the intercropping, except for the corn dry biomass, which was higher in the single corn and reduced spacing crop (7.257 kg ha-1). The corn populations of 52,000 and 65,000 plants ha-1 increased dry biomass corn (6,977 and 7,333 kg ha-1) and straw total production (8,031 and 8,434 kg ha-1), and grain yield in both spacing 0.45 m (5,320 and 5,960 kg ha-1) and in 0.90 m (9,487 and 9,167 kg ha-1).

Keywords: Zea mays, plant arrangement; tillage; biomass.

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SOYBEAN YIELD AFTER BRACHIARIA SPECIES AND DESICCATION TIMES

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The cultivation of brachiaria in corn and soybean fields is a reality in the Tropical region of Brazil. The objective of this study was to evaluate the soybean yield after desiccation periods of brachiaria species cultivated for 18 months in soybean soil. The work was carried at Embrapa, in Dourados, MS, Brazil, in a glass ceiling and galvanized iron fence walls green house. The plots were 0.3m diameter wide and 0.4m height, with 19 kg of dry soil. The experimental design was randomized blocks with three replications. In the plots, the soils (red distroferric latosol and red distrofic latosol) were allocated. In the subplots, the treatments/species of Brachiaria (Brachiaria ruziziensis, B. brizantha cv. Paiaguás and cv. Xaraés, and a test without brachiaria). In the subsubplots the desiccation times (1, 15 and 30 days before soybean sowing). The desiccation was done with glyphosate at 1.08 liters of the acid per ha-1, in 200 L of water per ha-1. The soybean seeds, cv. BRS 1003 IPRO, were inoculated with Bradirhizobium japonicumm and sowing on 10/10/2016 with two plants per pot. Soil moisture was kept at 80% of field capacity. In the soybean maturation, agronomic characteristics and grain yield components were evaluated. Data were submitted to analysis of variance and the means were compared by the Tukey test at 5% probability. It was verified higher soybean height after Paiaguás (79 cm) and smaller after Xaraés (67 cm). The grain yield was higher in red distroferric latosol (12.51 g plant-1) than in red distrofic latosol (8.77 g plant-1). A higher number of pods per plant (89 and 73), stem dry mass (27 and 22 g plant-1) and grain yield (14.1 and 10.2 g plant-1) were observed when sowing, respectively, 1 and 15 days after the brachiaria/treatments desiccation, and no difference between the treatments when sowing 15 and 30 days after desiccation. For Xaraés and ruziziensis, grain yield didn`t dependent on desiccation times, while for Paiaguás the highest yield was verified at one day after desiccation.

Keaywords: no-till, biomass, intercropping.

Acknowledgements: Embrapa Western Agriculture, CAPES, UFGD.

SPECIES FOR PASTURE PRODUCTION AND SOIL PROTECTION

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In central region of Brazil, agriculture and livestock are the basis of the economy. However, most farms develop these separately. The crop-livestock integration (CLI) is able to provide greater benefits for farmers. The intercropping of forage species with annual crops is an important step in starting one CLI system. Using legumes crop, as Crotalaria, could increase the protein content in animal feed. The aimed of this study was to identify annual and perennial species with greater potential productive in the beginning of autumn and winter. For this, an experiment was established in Nova Andradina City, MS, Brazil, in a dystrophic Red Latosol, sandy texture, with sowing done without chemical fertilization on 02/16/2017, after soybean harvest. The experimental design was in Streep test with three replicates, and seven treatments: Brachiaria ruziziensis, Panicum maximum cv. Mombaça, cv. BRS Zuri, cv. BRS Tamani, and the intercropping of Tamani with Crotalaria Juncea, C. ochroleuca and Pennisetum glaucum. On 04/6/2017 samples of 0.5 m-2 of plants were cut to the ground, weighed, oven dried at 60oC for 72 hours to determine dry mass yield. The data were submitted to analysis of variance and the averages were compared by the Tukey test ($p<0.05$). The species sowed lonely did not differ among themselves and produced an average of 3,214 kg ha-1 of dry mass. The total dry mass yield of Tamani grass decreased when intercropped with crotalaria. When intercropped was made with P. glaucum, the yield increased by 59%. Although crotalaria has inhibited the development of Tamani grass, it is necessary to study if there is a significant improvement in the nutritional value of the forage produced, since these legumes have a high percentage of crude protein. Intercropping cultivation of a perennial and an annual species may be useful to anticipate the first grazing and increase soil cover.

Keywords: forage production, intercropping, soil cover.

Acknowledgements: EMBRAPA Western Agriculture, CAPES, UFGD.

STABILITY OF UREA TREATED UREASE INHIBITOR

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Urea treated with the urease inhibitor N-(n-butyl thiophosphoric acid triamide) (NBPT) was stored for up to one year at two locations in Brazil: Rondonópolis, MT (16°26' S and 54°49' W) and Paranaguá, PR (25°30'S and 48°30'W). Treated urea samples were collected for the determination of NBPT concentration and for ammonia (NH3) volatilization tests under laboratory controlled conditions. NH3 losses from untreated urea varied from 32 to 48% of applied nitrogen (N); the corresponding values for freshly NBPT-treated urea varied from 8 to 26% of applied N. Up to the sixth month of storage, NH3 losses from untreated urea were significantly higher than those of the NBPT treated urea treatments, and no difference was found among NBPT treated urea samples regardless of storage site and bag size. After 6 months, volatilization losses of NBPT treated samples from Rondonópolis started to be higher than those from Paranaguá. When samples were stored for 9 months, NH3 losses for Paranaguá samples and freshly NBPT-treated urea were about 15% of applied N, while for Rondonópolis samples were about 30% of applied N. Losses for untreated urea were about 45% of applied N. After 1 year, Paranaguá samples were still performing the same as freshly NBPT-treated urea. The degree of degradation of NBPT on urea stored under conditions similar to those of Paranaguá grants a shelf-life longer than those stored under conditions similar to Rondonopolis.

STRIP PLANTING INCREASES YIELD AND WATER PRODUCTIVITY OF WHEAT (TRITICUM AESTIVUM) IN NORTHWEST BANGLADESH

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Minimum tillage is proposed for saving water or increasing water productivity of crops. Here we compare the yield, irrigation water use and water productivity of wheat in strip planting (SP), bed planting (BP) and conventional tillage (CT). SP and BP were carried out using a Versatile multi-crop planter mounted on a 2-wheel tractor. Residue treatments were 20 or 50 % of rice straw retained. The study was carried out on long-term replicated plots at Rajshahi, Bangladesh (silty clay loam soil), which were established in 2010. The current experiment was conducted in cool dry seasons of 2015-2017. In 2015, the yield of wheat under SP (5.10 t ha-1) and BP (5.03 t ha-1) were significantly higher than under CT (4.34 t ha-1). In 2016, the yield of BP wheat (3.38 t ha-1) was significantly lower than the yield of CT wheat (4.02 t ha-1). In 2017 there were no significant yield differences among the tillage treatments. Over the three years, SP saved 11-33 % water compared to CT; while water input was 16-27 % lower in BP. Irrigation was applied based on the soil moisture content at the time of irrigation, the bulk density and the field capacity of the soil in the root zone. Water savings in the minimum tillage treatments (SP, BP) are attributed to the lower bulk density of the soil in the root zone that helps retaining more water compared to CT. Water productivity of wheat was higher in SP and BP compared to CT in the three years. In 2015, water productivity of wheat was 2.06, 2.01 and 1.25 g grain kg-1 water for SP, BP and CT respectively. Similarly, water productivity of wheat in 2016 and 2017 was highest (2.32 and 1.95 g grain kg-1 water respectively) in SP. Water productivity of wheat in 2016 and 2017 was intermediate for BP between SP and CT. The results showed that minimum tillage approaches have the potential to increase production and water productivity in the northwest region of Bangladesh; however, the challenge will be to apply them in the annual crop rotations on smallholder farms.

STRUCTURAL COMPOSITION OF COVER PLANTS BEFORE SUGARCANE CULTURE IN DIFFERENT SOIL PREPARATION SYSTEMS

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The use of cover cultures is essential to the cultivation of sugarcane in Brazil; however, it should be taken into account when choosing the culture for its structural composition, since it is directly related to the decomposition rate, cycling and release of nutrients. The objective of this study was to assess the structural composition of four cover plants (crotalaria juncea, peanut, sorghum, and millet) in sugarcane areas under soil preparation system without stirring and with deep subsoiling. This study was conducted at the Santa Fé station, Ibitinga, São Paulo, Brazil. Its experimental design occurred in horizontal lines involving different legumes as well as vertical lines with the different systems of soil preparation. Each experimental unit was constituted of an area of 300 m2 with three repetitions. The cover plants were seeded from December 2014 to April 2015 and after reaching the maximum flourishing point, they were managed through dissection. The sugarcane planting occurred in April 2016. Right after the soil preparation and the sugarcane planting, 12 decomposition bags were distributed on the surface of the soil on the central line of the parts, including two bags collected per part of each sample. The contents of lignin, cellulose, relations C:N, Cellulose:Lignin, Lignin:N in the remaining tissue of the cover plants were assessed on days 0, 15, 30, 60, 90, 120, and 150 after the distribution of the bags in the field. The cover plants presented distinguished structural composition regarding the attributes assessed. The results proved the importance of adjusting the cover plant decision with the objective of its use. It is interesting to use crotolaria in order to provide an amount of nutrients in a fast way already on the early days of the sugarcane cultivation. However, if the objective is to assure longer soil coverage time through a longer permanence of the plant residues and to provide nutrients gradually along the sugarcane development cycle, it becomes more advantageous to use sorghum and millet.

Keywords: Decomposition rate, lignin, cellulose.

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SUGARCANE PROPAGATED BY PRE-SPROUTED BUDS IN DIFFERENT SOIL MANAGEMENTS AFTER GREEN MANURING FOR BRAZILIAN CROP SYSTEM

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In Brazil the sugarcane crop is cultivated in almost 10 million hectares, which 60% of plantations are concentrated in Sao Paulo state. Due to this social pressure, nowadays the majority of fields are harvested without burning (around 80 %), then a great amount of straw (average 15 Mg of dry matter per hectare each year) is deposited over the soil surface. The great amount of residues increase the cost with tillage in almost 30%, consequently is desirable the adoption of conservation soil management to cultivate leguminous used as crop rotation and to grow sugarcane. The objectives of this research were; to study the vegetative and root growth of two varieties of sugarcane in different soil managements after green manure and to quantify the changes on agronomic and technological characteristics, as well as to understand the changes on the soil carbon stock. This long-term experiment was started in 2003 in an eutrophic Clayed Rhodic Hapludox (Oxisol) located at Experimental Station of APTA/IAC, Ribeirao Preto city, Brazil. It was adopted a randomized complete block design in a split-plot scheme, with four replications. The main plots are consisted by three soil managements; conventional tillage, reduced tillage (use of Rip Strip® before planting) and no-tillage. After twelve years with cultivation of grain crops, two sugarcane varieties (IACS95-5000 and an energy cane, used for biomass) were planted as a subplot, in rotation with green manure (Mucuna aterrima L.). Samples of plant, roots and soil were collected during fifteen months (from planting to harvesting) in order to evaluated vegetative and roots growth, agronomic and technological characteristics, as well as some physics (soil strength) and chemical attributes (soil carbon stock). It could be conclude for both sugarcane varieties planted by pre-sprouted bud that the adoption of conservation agriculture principles, increase the stalk yield up to 18, 4 Mg ha-1 and the soil carbon stock up to 16,4 Mg ha-1. Furthermore, the conventional tillage showed the highest soil strength at 0,14 m depth.

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SUSTAINABLE CROPPING INTENSIFICATION REDUCES SOIL LOSS BY WATER EROSION

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Soil water erosion is one of the most important problems associated with agricultural production, not only for the land degradation process itself but also for the negative impact on crops productivity. The objective of this research was to compare the impact of diferent crop rotations, tillage systems, and technology to control water erosion on soil loss. We used INTA-USLE RUSLE software to estimate soil loss. This software is available on-line and allows calculating soil loss using the Revised Universal Soil Loss Equation (RUSLE). Crop rotations considered included different participation of soybean in the crop sequence. A crop intensification index (CII) of each sequence was estimated as the ratio between the number of months with soybeans crops and the total length of the crop sequence. As expected, results showed that soil loss was always higher under conventional tillage (CT) compared to no-till (NT) in all crop rotation evaluated. The highest values of soil loss were obtained in soybean monoculture (CII=0,42) in both tillage systems (70 t/ha/year in CT and 22,1 t/ha/year in NT). When the participation of soybean in the rotation was 60 %, CII=0,56 (Wheat/Soybean-Soybean-Maize-Soybean crop rotation), soil loss was still higher than the tolerance. However, with the inclusion of cover crops in the sequence, CII=0,77 (Wheat/Soybean-Cover crop/Soybean-Maize-Cover crop/Soybean crop sequence), soil loss decrease about 50 %, reaching the upper limit of the tolerance. The inclusion of soil conservation practices such as contouring and terracing produced a 40% decrease in soil loss in both tillage systems. We concluded that sustainable crop intensification under NT in fields with high susceptibility to soil water erosion helped to reduce sheet erosion but there were not good enough as a soil conservation practice to avoid erosion. Because of that, the implementation of other technologies such as terraces are needed to evacuate excess runoff water. The use of INTA USLE/RUSLE software allow us to perform easily soil loss estimations in different scenarios. This software may orient users to consider strategies and management alternatives better suited to protect the soil resource by preventing soil water erosion and avoiding not only soil loss, but also preserving soil organic matter and nutrients associated.

SUSTAINABLE INTENSIFICATION OF FORAGE CROP SEQUENCES IN THE ARGENTINEAN PAMPAS: DRY MATTER PRODUCTION AND WATER PRODUCTIVITY

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The Argentinean Pampas is one of the most important livestock production areas worldwide, in which in the last years animal feed has been based predominantly on forage crops sequences (FCS) (i.e. sequences based on annual crops for grazing, hay or silage). However, it is unclear how year-by-year precipitation variability affects FCS dry matter (DM) yield in these environments. Crop models are potential tools to assess crop yield variability across several climate and soil conditions. Agricultural Production Systems Simulator (APSIM) is a crop simulation model that integrates agronomic management with weather and soil data in a mechanical way to predict growth and crop development on a daily time-step. The aims of this work were to assess the APSIM capacity to simulate: (i) sole crop and total FCS DM yield, (ii) the spatial and temporal variations of DM yield and water productivity (WP, i.e. defined as the DM yield produced per unit of water supply) of crops as a component of a FCS and (iii) FCS DM yield and WP. Thirteen FCS involving summer (maize [Zea mays L.] and soybean [Glycine max L.]) and winter forage crops (oats [Avena sativa L.], annual ryegrass [Lolium multiflorum Lam.], barley [Hordeum vulgare L.], wheat [Triticum aestivum L.]), were simulated by APSIM in five sites across the Argentinean Pampas. Generally, our results indicated that the model was capable to simulate crop DM yield (1.7 Mg ha-1 and 0.96 for root mean square error [RMSE] and concordance correlation coefficient [CCC]), FCS DM yield (RMSE=3.2 Mg ha-1; CCC=0.93), seasonal (RMSE=1.9 g m-2 mm-1; CCC=0.71) and annual WP (RMSE=0.4 g m-2 mm-1; CCC=0.94). The APSIM ability to predict WP declined when the seasonal WP was higher, i.e. for low precipitations. For seasonal precipitation inputs, less than 200 mm, APSIM tended to under predict WP. Our research demonstrated the capability of APSIM to accurately predict DM yield and WP of several forages species growing in sequence over a wide region encompassing numerous soil-climate combinations. Indeed, APSIM appears a potential tool for further evaluate the sustainability of the intensified forage cropping systems based on FCS in the Argentinean Pampas.

SUSTAINABLE INTENSIFICATION USING IRRIGATION AND N FERTILIZATION FOR PASTURE PRODUCTION IN TOCANTINS, BRAZIL

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Cattle raising is among the main Brazilian economic activities. Currently, there are 169 million hectares covered by tropical grasslands and 30% of this area is degraded. In the last 40 years, the area occupied by grasslands in Brazil increased only 17% while the meat production increased 114% and that fact was only possible due to national effort and investments on agricultural research, development and innovation. To verify the influence of irrigation in a pasture of Panicum maximum cv. Massai was carried out a field research testing rainfed and two irrigation depths (50 and 100% of evapotranspiration) and 300 kg ha^{-1} year^{-1} of N-urea, during one year at the periods Jun-Sep, Oct-Nov, Dec-Mar and Apr-May, in Tocantins state, Brazil. The parameters are one animal unit (AU) corresponding to 450 kg of liveweight, a daily dry matter intake of 11.25 kg. The accumulated dry matter (kg ha^{-1} day^{-1}) obtained by the 100% depth was significantly higher than the others in almost all periods analyzed, and during Jun-Sep the treatment 50% depth showed no significant difference when compared to 100% depth suggesting seasonality probably related to low temperatures. The results revealed the potential to achieve a stocking rate of 6.44, 4.20 and 3.51 AU ha^{-1} year^{-1} with 100%, 50% depths and rainfed treatment, respectively. Despite promising results, further studies on physiology, phenology and economy must be done to confirm the feasibility of using irrigation for pasture production in Tocantins.

Keywords: intensive forage production, tropical forages, Panicum, Guinea grass, sprinkler.

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THE DIVERSIFICATION AND INTENSIFICATION OF CROP ROTATIONS IN NO-TILL SYSTEMS IMPROVE SOIL MACROFAUNA IN THE PAMPA REGION OF ARGENTINA

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A group of farmers have begun to explore new alternatives for diversification and intensification of crop rotation (DICR) under no-till, aiming to increase crop yields and productivity per unit area, at the same time that reducing negative environmental impact. The impact of DICR on soil biology has been little explored. The aim of this contribution was to analyze the effect of DICR on soil macrofauna community, in the Pampa region of Argentina. A total of 24 sites were sampled in 4 farms located near Pergamino city (Buenos Aires province) where a DICR essay was established 3 years before sampling. In each farm, 5 treatments with different rotations were established in a field with the same land use history and soil type: soybean monoculture (MC), typical rotation (Ty), high intensification with legume (HL), high intensification with 100% grass (HG), pasture and a natural grassland as a reference. The treatments had different indexes of crop rotation calculated as: days of the year with plants/365 days, from 0,43 for typical crop rotation (wheat/soybean-corn-soybean) to 1 in pasture. To obtain the macrofauna, 5 soil samples (25x25x20cm) were collected at each site, macrofauna was hand-sorted, taxonomically identified and counted. Earthworms presented higher abundance in the HL rotation than in the Ty and HG rotations. Beetles had a similar response, whereas ants were more abundant in HG and HL than in Ty and MC. Enchytraeids -indicators of disturbed soils-showed an inverse response to the increase in the DICR. Regarding the taxonomic composition, a response of the whole fauna together with the management changes was observed, showing that the rotations HL and HG were the more different from the rest. We conclude that after only 3 years from the beginning of the DICR essay, important changes occurred in soil macrofauna. These findings reflect their sensitivity and importance as indicators.

THE RECOVERY OF DEGRADED AREAS AND THE SOCIAL AND ENVIRONMENTAL ROLE TO FOMENT THE BRAZILIAN AGRIBUSINESS

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This abstract deals the legal and environmental importance of areas in recovery process of degradation. Techniques with a high percentage of success using the culture of sugar cane, the sugar cane energy kind, have been used in recent years. Among the environmental principles, sustainable development, with emphasis on the preservation, protection and restoration of native areas. The recovery of degraded areas is an instrument of environmental management, closely linked to ecological restoration, aiming to assist the restoration of ecosystems degraded, damaged or destroyed. The restoration of essential ecological processes and environmental recovery obligation of degraded lands are constitutional principles, demonstrating the importance of safeguarding and preserving the environment. In addition, with the national environmental policy for the recovery of degraded areas and protection to threatened areas of degradation are principles: preservation and restoration of environmental resources to rational use and constant availability. A recovery happened when the damaged site worked for the environmental conditions approach the previous intervention. Returns the local balance and active processes are stabilitied again. Techniques that have potential of degradation such as mining, waste disposal, occupation of hillsides, urban and rural "boçorocas", irrigated agriculture and water courses and bodies deposits need to be fixed. For the recovery of a degraded area its physical, chemical and biological integrity, as the nature and severity of degradation, is required for reverting the use of restoration techniques, the return to the condition prior to degradation or stable intermediate state; rehabilitation, return the intermediate state of that which has been degraded; and redefining or redestinação. Strong anthropogenic intervention by recovering the area for use or destination other than pre-existing is indispensable. It´s necessary check what is the best technique that suits to the reintegration of the areas according dominant landscape of the region. The use of other crops for soil degraded recovery seeking effective social and environmental role brings benefits to the environment and the national economy.

THE RESPONSE OF EARTHWORMS TO THE DIVERSIFICATION AND INTENSIFICATION OF CROP ROTATION IN NO-TILL SYSTEMS OF THE PAMPA REGION OF ARGENTINA

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A new alternative called sustainable intensification of agriculture has recently emerged in the context of conventional agriculture. Its goal is to use environmental resources more intensely for increasing crop yields, through the reduction of fallow's time and the increase of crop number per unit of area. Nevertheless, it effect on soil fauna is still unknown. The aim of this contribution is to assess the effect of different degrees of intensification and diversification of crop rotations on earthworm communities in the Pampas Region. Agricultural systems were also compared with natural ecosystems. A total of 24 sites were sampled in 4 farms located near Pergamino city (Buenos Aires province) where a DICR essay was established 3 years before sampling, in a field with the same land use history and soil type. Five crop systems with different intensification degrees (soybean monoculture, typical intensification, high intensification with legume, high intensification with 100% grass, pasture) and a natural grassland were sampled in each farm. The treatments had different indexes of crop rotation calculated as: days of the year with plants/365 days, from 0,43 for typical crop rotation (wheat/soybean-corn-soybean) to 1 in pasture. For earthworm sampling, five 25x25x20 cm soil monoliths were extracted from each site and hand-sorted in-situ. All the collected individuals were identified till species level. We observed that all crop systems had a negative effect on earthworms comparing with natural systems. However, the legume intensification system had a positive effect on earthworm abundance, regarding the other crop rotations; probably related to the greater percentage of nitrogen fixing crops.

THE USE OF AGRICULTURAL WASTE FOR ELECTRICITY COGENERATION AND ENVIRONMENT PROTECTION

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In the 21st century the concern with the environment grows everywhere in the world. One of the big problems is the accumulation of residues, both in rural urban. This work aims to demonstrate how the wastes from agricultural production can be used to the cogeneration of energy. Waste such as bagasse, leftover grains, straws, are of great potential for biomass burning, and may be raw material for cogeneration of electricity.

Brazil is signatory country of international treaties for the environment protection and preservation, having already been the headquarters of two major world conferences: Eco 92 and Rio + 20. Among the issues discussed, the development of clean and renewable energies with capability equivalent to fossil fuels was present. With economic growth and the increasing demand of energy, it is essential to invest in renewable energy sources, sustainable development. The use of biomass in electricity cogeneration encourages sustainable consumption and helps in the reduction of solid waste, respects the national solid waste policy and minimizes the use of natural resources, toxic materials and GHG emissions. Brazil is one of the countries with the higher cost of electric energy. The use of renewable energy from electricity cogeneration according to brazilian legislation, enforces environmental protection and demonstrates that the country has potential in production and sustainable development. The exploitation of energy sources produced bioenergy of sugarcane biomass causes independent producers get the electric self-consumption. The World Energy Outlook report (2011) demonstrates that there is a world trend to reach the percentage 15% of renewable electric energy until 2035. The world major producer of sugar cane, Brazil can be transformed into a producer of bioelectricity clean, renewable and efficient while respecting national legislation. The rational utilization of energy sources in accordance with the Brazilian needs make the contry one of the world's bioenergy largest cogenerators using biomass.

UNDERGROUND KEYS FOR AGRICULTURAL SUSTAINABILITY

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The world has food needs and environmental challenges. It is necessary to produce more but we need to impact less into the environment. Agroecosystems are sustainable when they are capable to achieve greater biological or economical productions with the lowest amount of negative impacts. To pay attention to the emergency of our planet, a new green revolution is necessary. Roots, their associated rhizospheres and beneficial microorganisms are the keys that the crop breeders should focus to improve crop efficiency and to reduce the use of pesticides and fertilizers. The microbial inoculants, also named biofertilizers sometimes, are bioinsumes that generally are applied onto the seeds of crops to promote their growth through several mechanisms. Argentina has a long trajectory in this subject with available technology for the manufacturing and quality control of several types of inoculants. This is a business model which generate qualified employment positions and annual exportation incomes around 13000000 $ only in the province of Buenos Aires. The use of this type of bioinsumes is an alternative which favor the agricultural sustainability because collaborate with a more efficient use of available resources. Nitrogen air supply through biological fixation of this macronutrient can only occur with the participation of bacteria with enzymatic capacity in symbiotic associations such as Rhizobium-legumes or non-symbiotic associations such as bacteria living in maize, rice or wheat rhizospheres. As soil microbial communities are the responsible for all biogeochemical cycling, the potentiality to obtain new and sophisticated bioinsumes is high. We have studied for a long time certain rhizobacteria strains which produced significant advantages for crops through several mechanisms. We observed that each microorganism-plant association should be characterized in order to obtain the maximum of its potential and to evaluate the impact over the system. We obtained data that shows the biotechnological potentialities of the bioinsumes with these strains when they are applied to several crops in the Pampa region. Also, the impact on soil microbial communities of inoculation alone and in combination with other agricultural practices, such as fertilization and use of glyphosate to dry cover crops in succession with soybean, will be shown.

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UTILISATION OF COVER CROPS BY SHEEP IN CONSERVATION AGRICULTURE SYSTEMS

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In dry Mediterranean regions cover crops substitute cash crops and may result in lower profit margins. The viability of incorporating cover crops between cash crops in rotation can be enhanced by utilisation by sheep. However, utilisation of cover crops reduces crop residue and may lower the positive effects of cover crops. This study aims to investigate the effect of cover crop utilisation on the functional role of cover crops. The trial was conducted in the Swartland, Western Cape, South Africa with a Mediterranean-type climate. Three treatments were laid out in a split plot design, replicated 24 times in 15 x 10 m plots. The treatments consisted of three management groups where material was 1) grazed by sheep, 2) cut and removed as hay, and 3) left as a mulch layer. Biomass samples were cut from 0.25m2 quadrants after the growing season and analysed. Extensive soil data was taken from each plot after the growing season. The utilisation of cover crops reduced the amount of crop residue ($p<0.01$). The composition of cover crops changed due to utilisation. This meant the minerals in crop residue did not necessarily change in the same proportion as the amount of material. Nitrogen, phosphorus and potassium content of the crop residue was higher in the grazed plots ($p<0.05$). The unutilised plot had a higher potassium content than the plot where material was removed for hay ($p<0.05$). Total soil nitrogen levels of the grazed plots were the highest ($p<0.05$). Other than soil nitrogen no differences was observed between treatments in soil composition. High nitrogen levels in grazed plots can be the result of urine and manure from the sheep. The utilization of cover crops does not have a negative influence on soil. Utilizing cover crops influence the amount of material more than the amount of nutrients in cover crop residue. Grazing has a positive effect on cover crops in terms of soil nitrogen. When utilization does not have a negative effect on cover crops, it will increase profit margins.

Keywords: Grazing, Mulch, Hay, Nitrogen.

VETCH EFFECT AS COVER CROP ON MAIZE YIELD IN A VERTIC ARGUIDOLL SOIL OF BUENOS AIRES

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Cover crops (CC) are usually used in order to protect soils during winter seasons from water erosion processes and as an alternative to optimize the use of environmental resources as water and radiation. Legumes used as CC also have the extra benefit of bringing nitrogen (N) into agricultural systems through biological fixation. This is achieved by inoculating vetch with N-fixing bacteria and once the CC is dried with herbicide, N is incorporated into the soil as its tissues are decomposed. To observe this effect, during the 2014/15 season, an experiment with vetch was carried out in the demonstrative unit of the experimental agricultural agency of INTA San Antonio de Areco, Buenos Aires province. The essay had 4 treatments: (1) Control, (2) Fertilized control, (3) Vetch as CC and (4) Vetch as CC fertilized. The main crop was maize, which was sown during the first week of dicember. In fertilized treatment 150 kg of N was applied to maize as UREA. Nitrates (NO3) were measured in soil, N concentration in vetch tissues, and maize yield at the end of the experiment. As main results, a N concentration of 176 kg ha-1 was obtained in vetch tissues, being recycled at the moment of maize flowering a total of 130 kg ha-1. This correlates with NO3 soil concentration at maize flowering, which was 40 kg ha-1 higher in vetch treatments than control treatment. Thus, at the moment of the highest demand of N by maize, soils with CC treatments had a greater availability of this nutrient. Regarding to yields, treatments with CC maize yield were on average 10,2 tons (without differences by N fertilization), control fertilized maize yield was 8,0 tons and without fertilizing control maize yield 6,1 tons. Therefore, the use of vetch as CC, not only provides a soil protection benefit, but also increased maize yields with a completely replace of nitrogen fertilization.

WATER AND SOLAR RADIATION-PRODUCTIVITY IN NO-TILL FORAGE CROPPING SYSTEMS IN THE SOUTH-EAST PAMPAS OF ARGENTINA

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Livestock Argentinian systems show a current process of change in the forage base composition, with an ongoing increase in the proportion of their area assigned to annual crop sequences (ACS) at the expense of the area assigned to cultivated perennial pastures (PP). However, there are several concerns about efficient use of available resources due to differences in the length of crop establishment and fallow periods, as well as the crops involved in these systems. Therefore, the aim of this work was to assess the water (WP) and solar radiation productivity (RP) of fertilized and unfertilized PP and ACS through the analysis of their components, water (WU) and radiation uptake (RU), and water (WUE) and radiation use efficiency (RUE). Resource uptake (WU and RU) is the ratio between the uptaked (evapotranspiration and intercepted solar radiation) and annual available resource (precipitation and incident solar radiation). Resource use efficiency (WUE and RUE) is the quotient between biomass production and uptaked resource. A two-year field experiment was conducted under no-till dryland conditions in the south-east Pampas of Argentina. The differences in resource uptake between PP and ACS were directly related with the nature of the considered resource. When PP were not fully established, the WU was higher for ACS (0.92-1.05) than for PP (0.77-0.83) ($P<0.05$). On the other hand, RU was strongly dependent on the length of crop establishment and fallow periods. Indeed, once PP were completely established, RU of ACS (0.51-0.53) was lower than RU of unfertilized (0.59-0.62) and fertilized PP (0.68-0.74). A curvilinear association between WUE and RUE was found. However, for RUE values up to ~2-2.5 g m-2 MJ-1 this association was linear, which in this range included all treatments except maize-oats in the first year of evaluation. The highest WP (2.75-3.64 g m-2 mm-1) and RP (0.93-1.42 g m-2 MJ-1) were achieved by ACS, which did not differ ($P>0.05$) from completely established fertilized PP. Our results confirmed that resource productivity in ACS was not necessarily higher than in PP. Accordingly, ACS were similar to PP in resource productivity, once PP were completely established and under optimal N availability.

WHAT EARTHWORMS CAN TELL US ABOUT SOILS AND LAND USE SYSTEMS IN BRAZIL

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Earthworms are the most well-known animals of the soil fauna and contribute to the delivery of various ecosystem services. They modify the environment for other organisms and affect the distribution and decomposition of organic matter. As ecosystem engineers, they affect soil aggregation and soil structure, and their presence is usually associated with fertile soils. Therefore, they are commonly used as indicators of soil quality, something that can be done relatively quickly and inexpensively, even by farmers. In order to test this notion further, a large Brazilian database (BD) was created, using around 150 papers+grey literature data, and contributions from researchers all over the country. The BD includes earthworm abundance (no. indiv. m-2) from 1714 sampling sites and earthworm biomass (g m-2) from 751 sampling sites in Brazil, as well as information on soil type, biome, ecosystem (agricultural, native vegetation, forest plantations, integrated systems, pasture), climate, altitude, precipitation, temperature, soil texture (% sand, silt, clay) and main chemical properties (pH, C, N, P, K, Ca, Mg, Al, CEC, H+Al). Analysis of the BD showed that earthworm density was higher in Amazonia than in Cerrado and Atlantic Forest, and biomass was significantly lowest in the Cerrado. Integrated systems and pastures had higher earthworm density than cropping systems and native vegetation, and biomass was significantly lower in cropping systems. In terms of soil classes, density was significantly lower in shallow/sandy soils (Neossols) compared with all other soil types. Biomass was higher in Gleissols, Cambissols and Argissols compared with Nitossols, Latossols and Neossols. Soil disturbance in cropping systems was crucial for earthworm abundance: density was higher in no-tillage than conventional tillage, while biomass was higher in perennial crops versus annual cropping systems. Regressions of soil physical and chemical properties resulted in very low r2 (generally <0.1), even though some were significant (H+Al, Mg, P, Base saturation, C:N and silt content). Density tended to be higher in soils with intermediate pH (4.9-5.4), low H+Al (<2.5 cmolc dm-3), low P (<12 mg dm-3), while biomass was higher in soils with higher C (>2.3%) and N (>0.5%) contents.

Keywords: earthworm, bioindicators, soil.

YIELD OF SWEET SORGHUM GENOTYPES IN THE BRAZILIAN MIDWEST

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The sorghum has a high potential for crop rotation for being more resistant than maize to drought and pest. With similar cultural techniques as corn crop, sorghum has greater versatility and could be used for biofuel production, animal feed and soil cover because of the post-harvest regrowth. Therefore, the aimed of this study was to evaluate the productivity of different sorghum genotypes in Mato Grosso do Sul. The experiment was conducted at Embrapa Western Agriculture, in Dourados, MS, Brazil. Sorghum was seeding in November of 2016, in a Dystroferric red latosol (Oxisoil). The climate is classified as Tropical Monsoon, according to Koppen classification. The experimental design was a randomized block with three replicates of 25 genotypes. Chemical fertilization was not performed. The control of diseases and pests was carried out as recommended for the culture. Data were subjected to ANOVA and averages were compared by Tukey test at $p < 0.05$ probability. The genotype 201636B016 was statistically significant among the others for the cultivation environment, with higher height, green mass yield of stem (119,326 kg ha-1), total (139,413kg ha-1) broth (75,022 L ha-1) and yield dry weight (51,599 kg ha-1);however, it showed lower concentration of sugar in the steam (11.3 % sugar) and medium disease tolerance. The variety 201636B008 showed the best health index for major diseases sorghum, yet the production performance was lower than the other genotypes, with lower dry matter yield of 18,479 kg ha-1 and broth production 35,335 L ha-1. The highest concentration of sugar in the steam (22% Brix) was observed in the genotype 201636B005, and medium performance of the other parameters evaluated. In general, the 201636B016 genotypes was the most productive in the analyzed variables, with possible use for the cultivation of soil cover or for animal feed, while the production of 201636B005 genotype is more appropriate for bioenergy production and ground cover.

Keywords: crop rotation, Sorghum bicolor, biofuel.

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ZERO TILLAGE AND DRIP FERTIGATION IN BUTTERNUT SQUASH: PERFORMANCE AND EFFICIENCY OF USE OF THE MAIN RESOURCES

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The technology for growing cucurbits in Argentina is comprised to a large degree of tillage work. The diversity of goals to reach implies a high frequency and intensity of work, as well as complementary manual labor. The conservationist systems that have been very popular for the extensive production of grains have not been developed yet for the production of vegetables such as squash and other cucurbits in Argentina. The experiment consisted in the comparative analysis of two typical situations in the area (L1 and L2) with respect to the cultivation of butternut squash with zero tillage + drip fertigation (L0). The conditions and performance obtained in the two typical situations L1 and L2 were estimated as a function of regional information for the Buenos Aires province valley of the Colorado river, and from the literature. The cultivation of L0 was carried out during two production cycles in 2015 and 2016, recording the work carried out, along with provision of water and nitrogen, and wages. Regarding the best productive condition in the area (L1), the L0 crop demanded only 35% of the work, 50% of the irrigation water, and 85% of the wages. The performance of L0 was 51,000 kg ha-1 in 2016 and 49,600 kg ha-1 in 2017. These values double the best records in the area under traditional techniques (L1) and are four times greater than the area's average (L2). Considering the amount of commercial product harvested for each unit of resource consumed, L0 afforded double the efficiency in the use of labor, and was four times more efficient in the use of water. The production of squash under zero tillage is thus feasible under the agroecological conditions of a valley in the Buenos Aires Province in the Colorado river, and the technological offering of equipment and machinery are adequate.

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Evolution, benefits and difficulties of Conservation Agriculture

COMPARISON OF THE PERFORMANCE SEEDING OF DIFFERENT DIRECT SEED DRILLS

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Conservation agriculture is a promising alternative to solve problems of soil degradation and water resource management problems related to conventional agriculture practices widely used in North Africa region. However, performance evaluation of different ZT seeders in the North Africa context is one of the importance idea to select and adapt technologies according to the technical and economical comparisons. The adoption of different ZT seeding technologies requires some field test to validate its performance. The field performance testing aims to recommend the preferred contexts of use and guide their promotion/adoption process. Our objectives were: To evaluate and improve the field performance of modified existing seeders over a range of soil/residue/crop conditions and identify their preferred context of use; To evaluate the field performance of new imported ZT seeders over a range of soil/residue/crop conditions and identify their preferred context of use; To evaluate and improve the field performance of new locally manufactured ZT seeders over a range of soil/residue/crop conditions and identify their preferred contexts of use; Develop suitable operator and spare parts manuals, including best practice recommendations for use of ZT seeders. The experiments were conducted in the experimental station of INGC in Bousalem region in Tunisia during two cropping seasons (2013-2014 and 2014-2015). The target region is characterized by semi-arid climate with 450 mm of the average annual rainfall. The soil had a clay texture. The Soil Organic Matter content (SOM %) in the surface layer is 1.9. During the first year of experiment, four seeders [Semeato (Brazil), Gil (Spain), John Shearer (Australia) and ICARDA seeder (Syria)] were tested. In the second year of experiment five seeders were tested [Semeato (Brazil), Gil (Spain), John Shearer (Australia), Fert seeder (French) and ICARDA seeder (Syria)]. Durum wheat "Triticum durum Desf", was used. Maali variety was used in the first year of experiment and Karim variety in the second year. The sowing density was 350 grains m^2 for the tow cropping seasons.

Keywords: Conservation Agriculture, zero tillage seeder, reduced tillage

CONSOLIDATION OF THE PARTICIPATIVE QUALITY INDEX FOR THE NO-TILL SYSTEM (IQP) IN AREAS OF WESTERN PARANÁ

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Oftentimes, the adoption of the fundamentals of the No-Till System (NTS) is neglected, so the "quality" of the NTS is currently being talked about. The Participative Quality Index for the No-till System (IQP) is a tool that qualifies and monitors the quality of the NTS. The Brazilian Federation of No-Till System and Irrigation (FEBRAPDP), in parternship with the Itaipu Binacional, proposed the IQP, as a participative methodology, involving farmers. with the purpose of evaluating the quality of the NTS, based in scientific criteria. The indicators that compose IQP are grouped in: (1) crop rotation, (2) soil disturbance, (3) soil and water conservation, (4) plant nutrition, and (5) commitment of the farmer to the NTS. The aim of this study was to correlate IQP scores and the indicators that compose it, with physical, chemical and biological parameters of soil from 40 sites under NTS in the Paraná Watershed 3. Soil organic matter, base saturation, degree of clay dispersion, resistance to penetration, structural quality and time of NTS implantation were evaluated. Samples were collected in June and July 2015. Correlations with coefficients higher than 0.50 were considered strong, being: IQP version I and IQP version II; frequency of tillage and IQP II. Still in relation to the variable frequency of tillage, it was strongly correlated with residue persistence. The correlation between residue persistence and IQP II was considered strong, and this was one of the components that contributed to the highest IQP scores verified. The commitment of the farmer also correlated positively with the IQP II, as well as with the time of implantation of the NTS. It was possible to consolidate the validation of IQP, through correlation with its components and with physical, chemical and biological attributes.

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CORN PRODUCTION AND SOIL PROTECTION IN MATO GROSSO DO SUL, BRAZIL

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In Brazilian tropical region, the predominant corn production is in the “late season” - autumn-winter - with soybean crop in succession. The work was carried out with the objective of characterizing the “late of season corn” in Mato Grosso do Sul State. From 2007 up to 2015, every two years, participatory rapid diagnosis (PRD) were done with technical assistants and spike samples were collected in representative fields. Direct sowing of corn is predominantly made in clay soils, on soybean straw, with higher proportion in March, but it is been anticipated to February, due to the early soybean harvest. The anticipation of sowing prevent productivity losses due to frost in the South region or drought all over the State. Sawing anticipation improves corn productivity by being cultivated in a period of higher temperature, insolation and humidity, but exposes the crop to pests and diseases. Fertilization was done mostly at sowing, according to soil analysis and harvest expectancy. The smaller doses were used mainly in small properties or in sandy soils, where the soil natural fertility is lower. Bt@ technology, with insecticide to seed treatment, was introduced in most corn crops but did not eliminate the need for insecticide applications. RR@ technology was introduced in some crops of the cereal and decreased weeds infestation but made it difficult to control corn plants in RR@ soybean in succession. The predominant corn line spacing was 0.90 m and has became 0.50 m for providing the best plant arrangement and higher productivity. Plant population increased from 48,000 to 54,400 plants per ha and productivity from 4,547 to 7,751 kg ha-1. The area with intercropping corn-Brachiaria ruziziensis in Mato Grosso do Sul was inexpressive in 2007 and increased to 34% in 2015, predominantly in the Center-South region of the State. Soil cover (above ground crop residue) was 32% in 2007 and rose to 44.2% in 2015. Corn-brachiaria intercropped is a system that increases soil cover.

Keywords: biomass, corn, intercropping, no-till.

Acknowledgements: Embrapa Western Agriculture, CAPES, UFGD.

DEVELOPING VIABLE CONSERVATION AGRICULTURE ADOPTION PATHWAYS FOR SMALLHOLDER FARMERS IN EASTERN AND SOUTHERN AFRICA

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Adoption pathways for Conservation Agriculture (CA) by smallholder in eastern and southern Africa have generally be promoted via spatial expansion of CA as an aggregate technology, where modified utilisation is seen as undesirable. This is manifested through adoption pathways that are based on small experimental plots that are expected to be expanded over time. Yet lead farmers often struggle to expand beyond these small plots and the wider population often have difficulty in finding viable entry points. Through qualitative exploration with 325 key informants (both farmer and non-farmer) we explore why such stagnation occurs, and identify issues with physical, financial, labour and informational resources which primarily reflect constraints at the community and institutional levels. These constraints often make adoption pathway based on spatial expansion difficult to implement. Hence, we find a need for alternative adoption pathways to address such constraints, particularly for low cost entry points and pathways that adapt to community practices such as communal grazing and rodent hunting. Informants identified that transitional and stepwise pathways based on incremental use of CA component would address many of these issues. This would involve the development of locally relevant pathways that build on CA components in a stepwise manner. We find the most likely pathway to involve the intensification of locally relevant legumous cash crops in the first instance, which facilitates the development of financial capital. This capital, when sufficient, can be used to invest in relevant inputs that facilitate biomass growth. Minimum tillage is then likely to be the final component utilised. In this way, many of the key limitations we find with the stagnation of adoption of CA may be overcome. The implementation of such pathways will require a wider framing of CA beyond the plot level and greater incorporate farmer objectives, non-cropping activities and the community and institutional context that farmer operate in. We provide a framework to facilitate such a pathway to aid in the promotion and greater utilisation of CA by African smallholder farmers.

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EARTHWORM ABUNDANCE AND RICHNESS IN NO-TILL FARMS IN WESTERN PARANÁ, BRAZIL

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Earthworms are ecosystem engineers that contribute positively to various soil processes and their populations can favoured by sustainable management practices such as the No-Till System (NTS). In the present study, we determined earthworm abundance and species richness in 40 farms under NTS in western Paraná (Brazil). Earthworms were hand sorted from five 20 x 20 cm width x 20 cm depth monoliths per farm, using an adaptation of the Tropical Soil Biology and Fertility method, and using a complementary qualitative sampling (5 random points) to enhance assessment of earthworm diversity. Earthworm were manually sorted in the field and preserved in absolute alcohol, for subsequent counting, weighing and identification. Mean earthworm abundance ranged from 0 to 715 no. indiv. m^{-2}, biomass from 0 to 8,1 g m^{-2}, and richness from 0 to 5 species. A total of 17 species of earthworms were found (9 native, 7 exotic and 2 unidentified spp. of unknown origin), belonging to four families: Glossoscolecidae (6 spp.), Rhinodrilidae (2 spp.), Ocnerodrilidae (3 spp.), and Acanthodrilidae (4 spp.). Earthworm abundance and richness differed among the 40 NTS farms, and highlighted the negative effects of soil management, mainly soil disturbance (subsoiling) and the positive effects of crop rotation quality.

Keywords: Oligochaeta, soil management, ecosystem engineers.

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INDICATORS MODEL FOR SUSTAINABILITY ANALYSIS AS A SUBSIDY FOR THE INTEGRATED MANAGEMENT OF WATER RESOURCES AND AGRICULTURAL FOOD PRODUCTION

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The main agricultural practices to the intensification of the production reflect in water scarcity, that consequently influence negatively the own production, being considered unsustainable to development. Therefore, the approach of water and food nexus is crucial to the management of water resources, in order to promote and evaluate a sustainable development. Furthermore, it is noticed that there is a lack of a support tool for decision-making in the context of integrated management of watersheds to assess a sustainable development, considering integrated and synergic the aspects of agricultural food production. In this way, the aim of this proposal is to develop a model of indicators for sustainability analysis as a support to integrated management of water resources and agricultural food production. Besides to diagnose sustainability from this perspective in the region covered by the Committee of the Upper Iguaçu and Upper Ribeira watersheds and affluents (Comitê das Bacias do Alto Iguaçu e Afluentes do Alto Ribeira - COALIAR) in Paraná state, Brazil. To reach these tasks, will be performed a bibliometry to identify aspects and indicators of integration between water and agricultural food production to compose a conceptual model, adapted from on already proposed. For the calibration and validation of the model, will be used present and historical data from the COALIAR coverage region. A Principal Component Analysis and Clustering Techniques will be used to define the indicators and subdivisions of the model weights and to treat similar issues. There will be carried out two diagnoses of the watersheds region: the historical and the present. Afterward, decision-making scenarios will be simulated based on the historical diagnosis for comparison to the current diagnosis, in order to validate the proposed model and test its predictive capacity. It is expected that the proposed indicator model can help the integrated water resources and agricultural food production management, to support decision-making and diagnosis of the sustainability of watersheds, specifically those covered by COALIAR. Therefore, the role of this proposal is to propagate the importance of studies related to water sustainability integrated with aspects of agricultural food production, to promote sustainable development, noted the complexity of environmental management.

SUSTAINABLE SOIL MANAGEMENT: ITS PERCEPTION AND THE NEED FOR POLICY INTERVENTION IN THE EUROPEAN CONTEXT

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As stated in the strategic objectives of the Global Soil Partnership "healthy soils and sustainable soil management are the precondition for human well-being and economic welfare and therefore play the key role for sustainable development". Although the functional properties of a healthy soil are well understood, in practice it is easily overlooked what is necessary to achieve and sustain healthy agricultural soils. This contribution intends: to discuss the concept of sustainable soil management in agricultural production with regard to soil health, and to highlight its importance in the achievement of both Sustainable Development Goals and the 4 per mille objectives, as well as for the Common Agricultural Policy (CAP). In Europe, soil and the need for its conservation and stewardship gained visibility at the beginning of this century during the discussions related to the Soil Thematic Strategy. This higher level of awareness concerning the status of Europe's soils led to the introduction of soil conservation standards into the cross-compliance and recently into the greening mechanisms within the 1st Pillar of CAP. However, the business-as-usual model of tillage based agriculture continues and soil degradation through erosion, soil organic matter and soil biodiversity decline and compaction together with general yields' stagnation continues.
In light of the above, urgent action is needed to extend the timid European efforts of agricultural soil conservation and to include measures that would cover and apply directly to a much larger area under agricultural production while preserving and enhancing the production potential and capacity of the farmland. Crop production and agricultural land management based on the principles of Conservation Agriculture (no-till seeding and weeding, maintaining soil mulch cover, crop diversification) has proven to improve decisively the delivery of all soil-mediated productivity and ecosystem services, including soil carbon sequestration (4 per mille), the efficient use of natural resources and external inputs, and thus improved cost efficiency and profit, while maintaining or increasing productivity. However, especially in Europe, institutional and policy support is needed to mainstream this truly agro-ecological approach of Conservation Agriculture to sustainable farming and land management.

Keywords: Soil health, Common Agricultural Policy, Conservation Agriculture, Ecosystem Services, Productivity

IS CONSERVATION AGRICULTURE INCREASING HERBICIDE USES? A BANGLADESH CASE

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Influential researchers, extensionists and policy planners in Bangladesh are cautious about conservation agriculture (CA) as they think it might increase herbicide use. To assess present herbicide use in Bangladesh, a study was carried out in nine districts involving 287 farmers. Respondent farmers who practiced conventional cropping had an average 1.26 ha farm size and 66% had 5-20 years of farming experience. Respondents estimated that hand weeding increased weed control costs over herbicide uses by 108 to 597% for the main cultivated crops: monsoon and irrigated rice, wheat, maize, potato, onion, garlic, lentil, chickpea, mustard, jute, mungbean, sesame, and vegetables, during 2015-16. In 2015-16, about 85 % of respondents used herbicides (30% herbicides only and 55% herbicide+one hand weeding) and only 14% used hand weeding alone to control weeds in their crop fields; whereas, five years back it was only 19% by herbicide+one hand weeding and 81% was sole hand weeding. The respondents also confirmed that at present about 87% of farmers used herbicides to control weeds in their localities and 98% farmers bought the herbicides from local dealers. The crop-wise herbicide use in their localities were 75, 78, 55, 56, 60, 48, 76, 51, 48, and 45 % for monsoon rice, irrigated rice, wheat, maize, jute, mustard, potato, lentil, chickpea, and mungbean, respectively. However, 100 and 99% farmers confirmed that they used insecticides and fungicides, respectively, for crop protection. About 45, 29, 10, 7, and 4% farmers first learnt or got advice to use herbicide from the Department of Agricultural Extension officials, dealers, neighboring farmers, herbicide companies, and NGOs, respectively. Conventional agriculture is the common practice in Bangladesh, but herbicide use has increased rapidly since 2005. Thus, it can be concluded that CA will not promote herbicide use in Bangladesh (it is already well adopted in conventional cropping), but, labour shortages, increasing labour cost, and herbicides' efficacy are driving more interest among farmer's herbicide use. However, with innovative research to develop integrated weed management packages for CA in Bangladesh it could lead to safer and more effective use of herbicides in all forms of crop production.

PERFORMANCE OF TINE AND DISC OPENER THROUGH RESIDUE FOR CANOLA PRODUCTION

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Canola is produced in the Western Cape of South Africa with a Mediterranean climate. Although farmers have widely adopted conservation agriculture (CA) in this area, the residue of the previous crop retained as cover becomes problematic during establishment. Stubble obstructs tine openers and farmers have started to consider disc seeders. Theoretically, disc seeders can cut through residue. The aim of this study was to compare establishment of canola with a tine and disc opener through residue on soils of high and low quality. Trials were conducted at Langgewens Research Farm (33.2765 S 18.7048 E) where CA have been implemented for the past 20 years. Three factors were assessed in a split-plot design, i.e. soil quality (high and low as whole plots), opener (tine or disc as split-plots) and residue level (low, medium and high, nestled within split-plots), replicated in four blocks. Soil quality was determined using the Soil Management Assessment Framework. Following planting, soil microrelief (disturbance) was measured. Plant density, biomass production and yield were assessed. The tine opener disturbed soil more ($p<0.05$) than the disc. There was a higher ($p<0.05$) plant density for the tine planter at all three residue levels, which indicates more effective establishment. Canola established with the disc seeder compensated well to the end of the growing season, thus the difference in biomass production at 30 days ($p<0.05$) after planting between the tine and disc seeder were eliminated at 120 days ($p>0.05$) after planting. No difference ($p>0.05$) in yield was observed between any of the three factors. Although tines established canola more efficiently than discs, canola had the ability to compensate towards the end of the season. Similar ($p>0.05$) yields were achieved between the different openers regardless of residue level or soil quality. The trial will be repeated for three years before solid conclusions could be drawn.

Keywords: conservation agriculture, planting method, stubble

PROGRESS AND PROSPECTS OF FARM MECHANIZATION AND CONSERVATION AGRICULTURE IN RICE-BASED SMALLHOLDINGS: A BANGLADESH CASE

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Smallholders mechanization based on diesel engine irrigation pumps, threshers, Chinese-made two wheel tractors (2WT) over the last 20 years helped Bangladesh achieve food security. Including started to spread and take over most of soil tillage for land preparation initiated since 1990s. Generally, the machinery was accessible to small and medium-sized farmers through custom-hiring of services and has helped push cropping intensity to over 200%. However, repeated rotary tillage and soil puddling damage soil structure, accelerate the decomposition of soil organic matter and induce plough pans, as well as enhancing weed pressure. These cropping systems would derive multiple benefits from conservation agriculture (CA) but rice establishment with minimum soil disturbance is the main challenge. The strip planted (SP) direct seeded rice (DSR) does not yet have reliable practices to handle severe weed infestation, uneven rainfall distribution, variation of temperature, which limits adoption. We developed non-puddled rice transplanting (NRT) for CA and several thousand farmers have tried it. Since 2006, SP by the Versatile Multi-crop Planter (VMP) has been at the forefront of mechanizing planting of varied crops on small farms, while at the same time applying CA practices that save production costs, time, increase crop yields, improve soil organic matter, and increase farmers' income. The main focus now is on scaling out the CA technology including NRT. We have partnered with a local manufacturer, Hoque Corporation, to further improve and market the VMP, and established a network with 7,000 farmers to start the scale out. Scientists provide training to farmers on CA, NRT, VMP operation and work with famers to build their confidence in the technology. The target market for sales of the VMP is local service providers, who are willing to buy the planter to hire out as a business on a fee-for-service basis. The 104 VMP sold in 2016 planted >1,500 hectares in the Rajshahi, Bangladesh. Based on the potential yield increases and costs savings to farmers, adoption of CA and the VMP planting services by only 10 % of all farmers in Bangladesh would generate an additional US$ 80-143 million year per year.

SHORT, MEDIUM, AND LONG-TERM EFFECTS OF NO TILLAGE ON SOIL ORGANIC MATTER AND AGGREGATE STABILITY IN MOROCCO VERTISOLS

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In Morocco, land degradation under a changing climate is a major factor limiting agricultural and economic and social development, especially in semi-arid and arid regions. Indeed, Morocco is a hot spot for soil erosion and organic matter depletion. The situation is worsening with climate change as well as a lack of the use of the best management methods of soil (e.g., traditional tillage, over-grazing and misinformed use of fertilizers, etc.). Conservation agriculture, using, practically no tillage is a reliable alternative technique designed to ensure the sustainability of the agricultural production system under a changing climate. It reduces the soil's vulnerability to instability through improved organic matter content in the topsoil, and with time in deep soil. This study helps to emphasize the impact of no tillage and describes its evolution in three Moroccan regions on two physical properties of Vertisols: -aggregate stability and soil organic matter-. In this article, we present the preliminary results that show the short-term impact of adopting no tillage and how examine its likely evolution to medium and long-term impacts. The results presented in this paper help to show the birth of the beneficial effects of no tillage on soil organic matter content and improved structural stability of Vertisol. There is significant evidence in favour of using no tillage for additional medium- and long-term benefits. This led to the conclusion that Vertisols becomes more stable with time under no tillage compared to conventional seeding due to the crop residues under the no tillage system.

Keywords: Conservation agriculture, no tillage, soil organic matter, aggregate stability, Vertisol.

STRUCTURAL AND MICROBIAL SOIL QUALITY IN SUGARCANE

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The northwestern region of the Paraná State, Brazil, is the fifth largest producer of sugarcane in the country. Seventy percent of the soils in this region are derived from Caiuá Sandstone. They are generally medium-textured to sandy soils with low levels of clay and organic matter, impairing aggregate stability and water retention capacity. A new cropping system has been introduced in the cultivation of sugarcane and it is now necessary to check its effect on soil quality and sustainability. The aim of this study was to assess structural volumes in a dystrophic Red-Yellow Latosol subjected to conventional tillage (CT) and deep localized soil tillage (DLST) and to verify how this treatment has affected the soil microbiological parameters. The study was conducted in the northwestern region of the Paraná State, Brazil, in soil derived from the Caiuá Sandstone Formation and the experimental design was fully randomized. For each soil tillage system, 4 trenches (3.5 m long x 2.5 m wide and 1.2 m deep) were dug in order to describe the Cultural Profile. The structures found in the profile were assessed for carbon microbial biomass (CMB), basal respiration (BR) and metabolic quotient (qCO2). Samples were also collected at depth in order to determine levels of CMB, NMB and glutaminase. The CT profiles exhibited a predominance of cracked soil volumes, medium-sized and large compact clods with some porosity, and continuous volumes with no cracks and intermediate porosity. The DLST profiles were predominantly free soil volume with no cohesion and porous in appearance, and compact, cohesive volumes with no visible porosity. The highest level of CMB was found in the cracked soil under CT. Higher microbial activity, indicated by BR and qCO2, were found in the free, powdery soil under DLST. In the deep analysis, higher levels of CMB and NMB were found in the 0.00-0.20 m layer under CT. Under CT, NMB was 60% higher than DLST. Glutaminase activity in the nitrogen cycle was also higher in the top layer under CT. The results found in the profiles and at depth indicate that the soil pulverization caused by DLST could have serious consequences on soil functionality, boosting erosion, facilitating mineralization and nitrogen exhaustion, and inducing metabolic stress in the microbiota.

Keywords: Cultural profile, soil tillage, microbial biomass, basal respiration, glutaminase.

WIND EROSION CONTROL OF NO TILLAGE IN ARGENTINA. AN ANALYSIS OF RESULTS, MECHANISMS AND CHALLENGES

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Wind erosion is an irreversible soil degradation process of arid and semiarid environments. More than 50% of soils of Argentina are susceptible to wind erosion. The most effective practice to reduce wind erosion in Argentina has been the no tillage (NT) system. The comparison of wind erosion trials have shown that wind erosion rates were always lower in NT than in conventional tillage (CT). The mean wind erosion rate of NT was only 5% of that of CT. Studies in central region of Argentina found that NT reduce the wind erodible fraction and increase the dry aggregate stability of soil compared to CT in loamy soils. This enhancement of soil structure and a high amount of crop residues ensure a high soil coverage over time. However, the climate change and a lower proportion of winter crops in rotation are the main challenges to wind erosion control in present continuous cropping systems. Although in most of the semi-arid regions of Argentina there has been a gradual increase in precipitation, the inter-annual variation in rainfall is very high. In Central Argentina, the ENSO (El Niño Southern Oscillation) can increase the risk of wind erosion by 75%. In addition, the predominance of summer crops in rotation produces a combination of high erosivity and erodibility conditions, as period of high wind velocity and low rainfalls coincide with fallow and early stages of crops. In those sequences where the levels of crop residue are low, the inclusion of a winter cover crop would be an alternative to minimize possible levels of wind erosion.

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