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ORAL ABSTRACTS

Harnessing the Biological Potential of Australian Grain Production Soils.

Soil Biology Initiative II
Supported by the GRDC

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Australia's rain-fed grain production systems span a diverse range of soil types and climates. Generally these soils are low in organic carbon (<1%), are structurally fragile, with pH related subsoil toxicities associated with boron and aluminium. Average annual precipitation ranges from less than 200mm in the semi-arid regions in southern and western Australia to above 800mm in the high rainfall areas in the northern and southern regions. The diversity of grain growing conditions has necessitated the development of regional and local soil management strategies to combat soil based constraints and to optimise the efficient use of inputs such as fertilisers and herbicides.

Many Australian grain producers and their advisers recognise that a vital, yet largely missing part of the grain profitability equation relates to the soil biological contribution to soil health, nutrient supply and disease suppression. The emergence of a $20M, 5 year National Soil Biology Initiative (SBI; 2009-2014) supported by the Grains Research and Development Corporation and partners was a direct outcome of the strong grower interest in defining the contribution of soil biology to profitable Australian grain production systems. This presentation will also focus on the approach taken to capture this interest and integrate it into a research program that ultimately delivers to growers. It also highlights some of the key learnings arising from this approach. More critically, SBI focussed on three outcomes; a web-based soil quality monitoring tool incorporating more meaningful soil biological measures; management recommendations to enhance biological N&P release; and the identification of biological traits associated with disease suppressive soils and management recommendations associated with their expression. These outcomes were delivered by a team of scientists (∼30) and communicators and extension specialists.

The first listed outcome focused on the development and deployment of the National Soil Quality Monitoring Program (eg www.soilquality.org.au). This program enables farmers & advisers to monitor the status of their soils with respect to potential biological chemical and physical constraints to plant production. A primary outcome of this tool is that farmers can make a decision to i) not do something (eg burn stubble) or ii) to do something (eg lime). The thresholds that inform decisions are based on regional values and expert opinion and these are refined as more data comes to hand. In recognition of the rudimentary nature of the biological tests, a whole range of potential new tests have been developed. Based on DNA extraction approaches, measures of beneficial nematodes and microbes are currently being validated across a range of soil types using an existing commercial disease testing platform (http://www.sardi.sa.gov.au/diagnostic_services/predicta_b).

A significant component of the soil quality equation relates to the need for soil borne disease control using management as an alternative or additional tool to pesticide control. Several long-term experimental trials have demonstrated the biological nature of disease suppression, defined as the absence of disease expression even in the presence of the pathogen, host plant and favourable environmental conditions. The occurrence of disease suppression and the identification of biological traits associated with these soils (eg for bare patch disease; *Rhizoctonia solani* AG-8 and root lesion nematodes , *Pratylenchus neglectus* and *P. thornei*) have been studied. In lighter sandy soils of the Western

Australian grain production regions, suppressive soils are rarely found and are often transient from season to season and influenced by the type of crop. In the heavier soils of the southern and northern Australian grain production regions, suppression of rhizoctonia and root lesion nematodes respectively, is induced by management regimes that result in the build-up of organic matter (eg stubble retention). The presence of biological traits associated with disease suppression will provide further validation for adopting a management regime in high disease risk locations.

Another emerging interest for Australian grain producers is in the more strategic application of inputs and particularly fertilisers as a means of making cost savings. Management practices that deliver more nutrients and in a 'preferred' form (especially N & P) when the crop demand is high, are under investigation. Specifically, the biological mechanisms at play (eg nitrogen fixation, mineralisation and immobilisation) under these practices (tillage, break crops/residue quality) are providing insights into the potential interventions that will contribute to more timely N&P release. This will then provide refinement to current 'blanket' fertiliser application recommendations.

It is becoming increasingly evident to farmers and researchers engaged in SBI that there is a very intricate link between specific elements of the soil biological community and the profitability of grain production systems. The preservation and enhancement of these linkages through strategic management of inputs offers the best strategy for long-term soil and food security. Here we will highlight the evidence generated and how it might guide management practice decisions to improve the economic viability of Australian grain production systems in the 21st century.

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Entrepreneurship and the Adoption of Conservation Agriculture by Smallholder Farmers - Key Learning from Bangladesh

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Introduction

Crop establishment under minimum soil disturbance and crop residue retention -two core principles of conservation agriculture (CA) – can be mechanized for small holders if reliable planting machinery is developed and available in the market place at suitable prices (Johansen et al. 2012). Programs to promote CA for smallholders need to develop entrepreneurs along the supply chain for planting equipment including manufacturers or importers, dealer networks for distribution, spare parts sales outlets, repair workshops, skilled planter operators, and very importantly the local service providers (LSP) who hire out minimum tillage services to the surrounding smallholding farmers. Here we report lessons learnt from a decade of effort to develop CA for small holder farmers by promoting the develop of supply chains and the commercialization of key services.

Farm Mechanization

The development of CA is supported in Bangladesh by the widespread availability of mechanized farm power. In rural Bangladesh, the importation of Chinese-made two-wheel tractors (2-WT) began in the 1990's following the removal of Government tariffs and suspending of standardization policy to avert a farm power shortage caused by the loss of draught animals in the massive floods of 1988. Importation of 2-WT has progressively grown with numbers now exceeding 450,000 (Haque et al. 2013). The 2-WT now account for over 80 % of primary tillage. The 12-16 horsepower (hp) China made diesel engine is also used as a power source for local transportation. While importation from China remains the main source of 2-WTs, local manufacture has grown for most of the spare parts. The continued growth of mechanization is predicted because of the shortage of farm labour and rising costs of labour. Such trends in labour availability and cost are emerging in many economies across Asia. Hence, market demand among smallholders for mechanization is predicted to grow strongly in the coming decade. Bangladesh is well placed to capitalize on this demand based on established 2WT supply chains but many other parts of Asia and Africa are still to develop the supply chains.

Planters

Crop establishment is a major period of labour demand which can be addressed by mechanized planters. Initial attempts by CIMMYT to introduce mechanized planting powered by 2-WT in Bangladesh promoted local manufacture of planters. However, it was not possible to achieve adequate quality of machinery with local small-scale manufacturers at that time. From 2003, CIMMYT shifted its focus to importation of Chinese-made planters. Initially the sales of planters benefitted from a 50 % subsidy that was progressively decreased over 3 years to zero. More than 15 small to large-scale importers and manufacturers of minimum tillage planters and spare parts have come into business since then. Over 5,000 planters have been imported and a supply. Approximately couple hundreds of repair and servicing workshops have sprung up to maintain these planters in service. Hence a supply chain for planter sales and repairs already exists in Bangladesh.

Local Service Providers

Most of the 450,000 2-WTs in Bangladesh are run as small businesses by owner-operators, known as local service providers (LSP), who provide primary tillage services to farmers in their locality on a fee- for-service basis. More than 3,000 LSPs also operate a planter on their 2-WT. Haque et al. (2013) outlines the characteristics of the LSP. They are recognized as risk-takers who can act as a critical link between farmers and new mechanized technologies. Greater understanding is needed of their business model to target further interventions that increase their numbers and the provisions of their services.

Manufacturing

Manufacture of 2-WT planters failed when first started in the early 1990's due to sub-standard materials and lack of precision engineering experience. Conditions are more conducive to local manufacture now. However, manufacturers react to orders placed before making new planters and have been reluctant to market planters or develop their own dealer networks for sales and service. Further interventions and possibly incentives are needed to stimulate increased supply of planters. Our experience indicates that quality assurance processes and readily available of planters remain crucial to build confidence by LSP and farmers in the planter technologies.

Implications for conservation agriculture

All of the above actors need to be linked by a market chain to promote the adoption of CA by smallholder farmers in Bangladesh. Different types of engagement with entrepreneurs will accelerate minimum tillage technology diffusion. The key findings from Bangladesh could be of relevance elsewhere in Asia and Africa where rising labour costs and increased spread of 2-WT are providing farm power options for mechanized crop establishment and the adoption of CA.

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Identifying New Sustainable Intensification Pathways for Smallholder Farmers in Southern Africa

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Background

Global demand for agricultural products is expected to double in the coming decades (Godfray et al., 2010) and the lion's share of this increase will have to come from rainfed systems in developing countries, including those in sub-Saharan Africa. Climate variability and change as well as the continued decline in soil fertility, due to unsustainable land-use practices, is threatening to negatively impact overall crop yields, the environment and farmers' food security and livelihoods (Lobell et al., 2008; Wall et al., 2013). The negative trend especially in southern Africa has induced a shift away from plough- and hoe-based intensive tillage systems towards more sustainable agriculture interventions (Thierfelder et al., 2014). Sustainable intensification of smallholder cropping systems through conservation agriculture (CA) has been promoted in this region since the beginning of the millennium to enable farmers to combat increasing soil degradation, reduced crop productivity and risks associated with climate variability and change. Although CA offers many potential immediate and longer-term benefits to farmers, its adoption amongst smallholder farmers is constrained by numerous multi-scale factors (Thierfelder et al., 2014). This paper aims at summarizing existing longer term data and identifying pathways towards sustainable intensification through CA for resource constrained smallholder farmers in southern Africa.

Experimental Approach

Research was conducted at multi-locational on-farm and on-station trial sites in Malawi, Mozambique, Zambia and Zimbabwe comparing conventional plough or hoe-tillage with CA systems. Major crops studied were maize as sole crops, in rotation or intercropped with other, mainly leguminous crops. The effect of CA was tested on different soil quality indicators as well as on yield response to different interventions. Detailed materials and methods on the approach used can be found in (Thierfelder and Wall, 2009; Thierfelder and Wall, 2012; Thierfelder et al., 2013a; Thierfelder et al., 2013b).

Results and Discussion

CA systems maintained significantly higher water infiltration rates (by 24-38 mm h^{-1}), retained more available soil moisture in seasonal dry-spells, improved soil quality indicators and had greater cereal and legume yields compared to conventionally tilled practices. In 76 % of cases, CA displayed positive maize yield responses in comparison with conventional control plots (Figure 1) with an increasing trend over time. There is growing evidence from southern Africa that CA can significantly improve productivity and viability of present farming systems (Ngwira et al., 2012; Thierfelder et al., 2013a). However, the adoption of CA systems in many areas remains (s)low due to the complexity of African smallholder farming systems, lack of appropriate extension, poor resource endowments, limited access to credit and underdeveloped input and output markets. Nevertheless, improved cereal-legume rotations and intercropping systems as well as locally adapted drought and low nitrogen tolerant maize germplasm in combination with CA are important pathways for sustainable intensification that have shown promise to address future food, fibre and nutrition demands.

Applications and Implications for Conservation Agriculture

The research results highlight the need for site specific adaptation of CA cropping systems to the circumstances of farmers and agro-ecological conditions. Combination of several climate-smart technologies (e.g. CA with drought-tolerant varieties in improved cereal-legume system) can lead to greater overall benefits for smallholder farmers in Africa. However, there are no quick fix solutions available, thus sustainable intensification strategies need to be embedded into sustainable agricultural research and development initiatives at all scales in order to contribute more towards poverty reduction and food self-sufficiency in southern Africa.

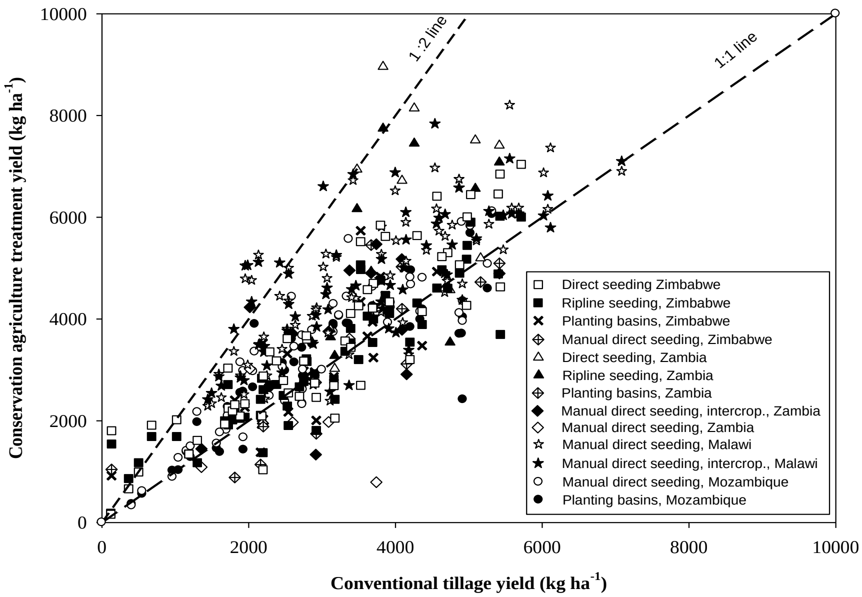

Figure 1: Performance of different conservation agriculture (CA) systems in comparison to a local conventional control across southern Africa 2004-2013

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Measuring the Impacts of Conservation Tillage (CT) on Household Income and Wheat Consumption: A Syrian Case

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Conservation agriculture (CA) which involves many different conservation measures and sustainable soil and water management practices including zero tillage (ZT), early sowing, reduced seeding rates, crop rotations, and residue retention is believed to be one of the promising technologies that can provide a panacea for the longstanding agricultural problems in the drylands of the West Asia region. However, CA is often looked upon with high degree of skepticism mainly due to lack of information and evidence particularly on its profitability relative to traditional tillage and other agronomic practices (Belloum, 2007).

ZT conserves soil moisture and reduces fuel, labour, and machinery costs (Ribera et al., 2004). In addition, a reduction in wind and water erosion provides significant environmental benefits. Apart from moisture conservation and cost savings, ZT can often lead to higher yields and increased net returns with reduced yield and income variability which is particularly important in dry areas. As in many high income countries, CA can also lead to possible benefits to smallholder farmers, consumers, and rural and national economies in low and middle income countries in Asia and Africa, especially in dry regions (ICARDA, 2012). With this premise, a number of efforts have been made by the governments of Syria and Iraq to introduce ZT and few other components of CA using local resources and funding from international development organizations including the Arab Agency for Agricultural International Development (AAAID), Arab Center for Studies of Arid Zones (ACSAD) and ACIAR-AusAID. Given its fairly recent introduction, adoption and impacts of ZT in Iraq are relatively low. However, in Syria, given the awareness created through earlier efforts by the government through funds from AAAID and ACSAD, ZT has been well received by relatively larger number of farmers in a fairly short time when it was introduced through the ACIAR-AusAID funded project in early 2005. The success of the ACIAR-AusAID project in enhancing the adoption of ZT in Syria may be attributed mainly to its ability to: 1) facilitate the local production of the much needed ZT seeders at affordable prices and 2) be flexible in terms of letting demonstration farmers to choose the adoption of the ZT technology individually or in combination with the other components of the CA technology package. Survey results from Syria show that adoption is taking place rapidly. Moreover, the benefits of CT for increasing soil fertility and soil health have been extensively documented in the literature. However, it remains to be established that CA in general and ZT in particular are attractive especially in mixed crop-livestock production systems with clear social, economic and environmental benefits.

This study aims at assessing the impacts of conservation tillage (CT) on household income and wheat consumption among Syrian farmers. Analysis is based on 621 wheat producing farmers in Syria. The propensity score-matching method and the endogenous switching regression model are employed in this study to analyze the impacts of CT where the necessary check for covariate balancing with a standardized bias was conducted. Results from both the propensity score matching and switching regression suggest that after controlling for all confounding factors, adoption of the ZT technology leads to about US$192/ha higher crop income. Moreover, the average gain in wheat consumption by the matched adopters over the matched non-adopters is about 26kg per adult equivalent per year (34%).

Table: Average treatment effects on the treated (ATT) for net income and consumption using the propensity score matching (PSM) approach

Group	Treatment group	Control group	Average treatment effect on the treated (ATT)	S.E.	T-stat
			Net income		
Unmatched	38024.4	27299.3	10725.1	966.5	11.1***
ATT	37131.8	27534.2	9597.5	1722.6	5.57***
			Consumption		
Unmatched	79.6	48.6	31.0	2.8	11.3***
ATT	76.9	50.5	26.4	7.6	3.5***

Source: model results

Note: *** indicates significance at 1% level

These results confirm that apart from the benefits documented in many studies in terms of enhancing sustainable management of land, ZT is also associated with increased livelihoods of farm households. Therefore, CT is one of few technologies which can be justified on environmental, economic and food security grounds and hence can have sizeable impacts in transforming the agricultural sector in the developing world. The policy implication of these results is that governments should consider embracing CT as one of the priority technology packages in their national extension programs.

In view of the tremendous skepticism about the profitability of CA, especially in the context of the mixed crop-livestock production systems, this paper is expected to make substantial contribution to the literature. By providing the much needed empirical evidences on the benefits of ZT for improving livelihoods of farmers, the results of this study are expected to be useful to policy makers, extension offices, government and non-governmental development organizations, development agents and researchers working in Syria and other areas with similar agro-climatic and production systems.

Key words: Food security; household income; CT technology; propensity score; matching endogenous switching

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Development and Expansion of Conservation Agriculture Systems in California's Central Valley

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Background
California's Great Central Valley (CV) contains some of the nation's most productive farms that benefit from the region's highly developed irrigation infrastructure, well established, advanced production technologies, and a mild Mediterranean climate. The evolution of today's mature production systems in the CV has relied largely on intensive, clean-cultivation tillage. Since 1998, however, a growing number of farmers, university, USDA Natural Resource Conservation Service, private sector and environmental group partners have worked to develop conservation agriculture (CA) alternatives for the CV that reduce soil disturbance, preserve surface residues, use cover crops to benefit soil function, reduce soil water evaporation and also decrease dust emissions. This group, - the Conservation Agriculture Systems Innovation (CASI) Center, has documented movement toward broader adoption of CA systems in California across a wide variety of specific cropping contexts including dairy silage, tomato, cotton, wheat, and other vegetable production systems through its biennial surveys of different management systems. Goals of the CASI Center are 1) to increase the sustained adoption of conservation agricultural systems to more than 50% of cropping acreage by the year 2028, 2) to develop and deliver information on the economic and environmental benefits of conservation agriculture systems, 3) to partner with national and international conservation organizations and serve as a clearing house for information to promote conservation agriculture systems, and 4) to increase funding for conservation agriculture systems research, education, and adoption in California

Results
Research conducted by CASI during this time has demonstrated a number of economic and environmental benefits that are achieved when CA practices are used including 1) tillage costs typically reduced by $40 - $150 per acre (Mitchell et al., 2012a), 2) lower fuel use (Mitchell et al., 2012b), 3) reduced PM emissions by 50 – 80% (Baker et al., 2005), 4) increased soil carbon levels (Veenstra et al, 2007), 5) lower soil water evaporation (Mitchell et al., 2012c), 5) increased irrigation application efficiency and uniformity (Submitted, Mitchell et al.), and 6) biologically-fixed nitrogen added to the soil (Mitchell et al., 2013).

Applications and Implications for Conservation Agriculture
One of the yet-to-be-realized, but potentially most impacting aspects of this locally-derived research is the the ability of CA farming systems to increase water use efficiency and reduce soil water ("green water") evaporation in the face of uncertain climate and sustained droughts. Thus, developing production techniques that increase the water storage capacity of soil--the green water availability--and the amount of green water flow that is actually transpiration--productive green water flow, which 'takes the E out of ET' and increases crop yield is an ongoing focus of CASI. Unlike other regions of the world where CA systems are now common and well developed, this potential attribute of CA has not yet seen widespread recognition although there is now a growing farm experience base that has demonstrated this benefit in specific California cropping contexts.

Experimental Approach

An important core strength of CASI is its ability to develop information on cropping systems alternatives that will enable producers to attain sustainability goals over the long term. This has involved both coordinated research-based performance evaluations of alternative CA systems, technologies, and practices, and also local and successfully implemented demonstration evaluations of CA systems.

Results and Discussion

While California farmers and researchers have successfully proven the efficacy of CA, adoption remains less than optimal. The gap between successful integration of CA practices on farms and widespread adoption highlights the need to study barriers limiting adoption. Using a combination of survey and interview methods, we also distinguished characteristics between CA adopters and non-adopters in California. Results indicated that many farmers who are not adopting CA do not see it as a viable option given the risk involved or the incompatibility of the practices in their current cropping system. In order to reduce the risk of adoption and learn how to make CA practices compatible with California crop rotations, both exchanging information and gaining meaningful experience that can be used to improve and develop these practices are needed. Extension education typically has focused on the first part of this learning process where information is exchanged from university research to farmers. Our work suggests that gaining meaningful experience with CA practices is also a large component of successful adoption. Extension programs therefore should consider how to facilitate this meaningful experience to complement the distribution of relevant, local information.

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The Good Growth Plan

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Background

In September 2013, Syngenta announced The Good Growth Plan, a series of six global commitments designed to address one of the planet's greatest challenges -- the need to provide food security for a rapidly-growing population from increasingly limited resources.

Addressing this challenge will require land already under cultivation to produce to its fullest potential. This journey will likewise require efforts to protect the planet's biodiversity while delivering profitable returns for farmers.

The Good Growth Plan commitments outline global goals that we as a company have set for ourselves to address major food security and sustainability challenges by 2020. Specifically, we commit to:

- **Make crops more efficient:** Increase average productivity of the world's major crops by 20 percent without using more land, water or inputs
- **Rescue more farmland:** Globally, improve the fertility of 10 million hectares of farmland on the brink of degradation
- **Help biodiversity flourish:** Enhance biodiversity on 5 million hectares of farmland
- **Empower smallholders:** Reach 20 million smallholders and enable them to increase productivity by 50 percent
- **Help people stay safe:** Train 20 million farm workers on labor safety, especially in developing countries
- **Look after every worker:** Strive for fair labor conditions throughout our entire supply chain network

Over the coming years, we would like to work in partnership with farmers, downstream value chain partners, governments, NGOs and others on these commitments. Through our offering of integrated solutions, the breadth of our technologies, and substantial investment in R&D, we aim to support growers to become as efficient and productive as possible, so that they can continue to make a significant contribution to addressing these global challenges.

The Good Growth Plan is a significant undertaking, and a complex one. While Syngenta has multiple examples of successes in each of these areas, The Good Growth Plan is the first time we as a company have been tasked with pulling these disparate elements together. Our first work will focus on assessing our current projects and accomplishments, such as the Field to Market initiative with leading consumer brands. We believe this initiative is highly representative of the downstream demand we continue to see for improvements in sustainable production. We anticipate this drive will intensify in the future, creating additional socio-economic incentives for conservation agriculture.

Results

The Good Growth Plan currently is in its formative stages. Going forward, historical data will be evaluated against practices in selected operations (reference farms). Information from North Americanoperations will be just one component in the plan, with additional data from both reference farms and benchmark farms being analyzed from other Syngenta territories around the globe.

This data will capture, among other things, the impact of the Syngenta portfolio on crop productivity, including genetic gains from seed, plant health benefits from fungicides and seed care products, and yield gains from controlling plant and insect pests.

In the stewardship area, Syngenta already has significant activity in North America, including biodiversity programs such as Operation Pollinator.

Applications and Implications for Conservation Agriculture

Certainly, conservation agriculture will play a role in The Good Growth Plan commitment to global stewardship of farmland. Millions of growers have already benefited from soil conservation practices, and that trend is expected to spread and intensify. Syngenta is already exploring pilot project and partner opportunities in cover crops in the Midwest. Conservation practices also are critical within the sustainable sourcing protocols now in place with Syngenta AgriEdge Excelsior growers in a variety of crops, as well as projects with Field to Market partner organizations General Mills and Archer Daniels Midland. In May, Syngenta launched its inaugural Good Growth Plan Grant contest in North America. The company is soliciting project ideas for all commitments, including those related to soil conservation and soil health. Grant winners will receive up to $20,000 toward implementing their projects. More information and entry forms are available at www.goodgrowthplangrant.com.

Experimental Approach

In North America, The Good Growth Plan will utilize designated reference farms to compare practices vs. standard data as collected by the USDA.

Results and Discussion

As a part of its commitments, Syngenta will publish regular reports of its progress. Results will be audited by a third party and will used to fine-tune programs and protocols moving forward.