Conservation agriculture in a subsistence farming system: Lessons from on-farm research in Gansu, China

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Abstract

An on-farm research trial was established in the Gansu province of north western China, as a way of applying five years of experimental research work. The aim was to investigate address the question; what is the grain yield and profitability of no-till with stubble (NTS) compared to conventional tillage without stubble (T) under farmer conditions. A participatory on-farm research methodology was used to test the new technology while understanding the farmer perspectives and concerns about the use of NTS. In contrast to experimental research the T treatments out-yielded the NTS treatments at both sites, but the observational and survey data explained this difference to be associated with the implementation of the on-farm trials. This work has demonstrated the adoption of NTS practices is more about overcoming issues surrounding stubble management rather than issues about crop establishment or soil fertility improvement.

Introduction

The Loess plateau of north-western China consists of highly erodible hills, slopes and tablelands. The area is home to some of China's rural poor with an average household income of ?1,946 (US $243) per year (Nolan et al. 2007). Research has shown no till farming in conjunction with stubble retention is a practice that has the potential to significantly improve crop yields, reduce farm labour demands and reduce soil erosion within this region (Huang et al. 2008). However, the adoption rates of no-till farming practices in developing countries are poor (Lal 2007). To understand the social and economic constraints to adoption, and explore no-till farming within a Chinese context participatory on-farm research trials were established with two groups of farmers in two localities, Dingxi (36.03' N, long 103.53' E, elev. 1517 m a.s.l.) and Qingyang (35.40' N, long 107.51' E, elev. 1298 m a.s.l).

On farm research is a common form of research within developed and developing countries (Packham, 2003). It emerged when technological solutions from agricultural research at universities and research stations required local adaptation to the priorities and situations of local farmers. Within China, research has traditionally been removed from farmers with new technologies being introduced from a structured top down approach through government extension agencies. This project tried to involve farmers in the research process following a similar approach to that reported by Lawrence et al. (2008). However, language barriers, high levels of illiteracy and the strength of the farmer-researcher relationship meant that this work was largely driven by the researchers.

This paper will report at two levels, firstly, the content issue of on-farm no-till research and secondly the on-farm research process. Huang et. al (2008) through on-station research showed that no-till farming on the Loess plateau has the potential to improve yields and reduce farm labour and erosion. The on-farm research reported in this paper aimed to take this knowledge and apply it at the household farmer level. It was proposed that results achieved under a resource rich, research station situation may differ to those achieved at the farm level. To test this proposal and understand the cause of any difference between on-station and on-farm results, the participating farmers' crops were monitored, farmers were interviewed and their farm management decisions observed.

Methods

In designing the on-farm research activities in this project, the research staff from both Chinese institutions (Faculty of Agronomy, Gansu Agricultural University, Lanzhou and College of Pastoral Agricultural Science and Technology, Lanzhou University, Lanzhou), senior staff from each institutions' research station, and Australian researchers participated in the "Doing successful on-farm research workshop" (Whish et al. 2003, Lawrence et al. 2007). This workshop focused on defining the research question and then developing the operational plan to answer that question. The specific question developed was "What is the grain yield and profitability of no-till with stubble (NTS) compared to conventional tillage without stubble (T) under farmer conditions?". A detailed operational plan was developed that identified specific tasks and the individuals responsible for their completion. It was decided that a formal agreement would be entered into with each of the farmers and a fee of ?100 be paid for the use of the land and farmers' labour. The intent of this agreement was to ensure that the farmers were not out of pocket for being involved in the project should the NTS treatment yield significantly lower than the conventional tillage.

The on-farm research trials were conducted with farmers who lived close to the research stations located in Qingyang County (35.40' N, long 107.51' E, elev. 1298 m a.s.l) and Dingxi County (36.03' N, long 103.53' E, elev. 1517 m a.s.l.). Qingyang is located on the tablelands of eastern Gansu at an elevation of 1298 m a.s.l., the area experiences a variable summer dominated rainfall that averages 551 mm. Dingxi is located in the loess hills of central Gansu at an elevation of 1517m a.s.l. and experiences a lower annual rainfall of 396 mm. Dingxi is typically comprised of small farming villages located within narrow valleys. A more detailed description of the region and farming systems is presented by Nolan et al. (2007).

Farmer participants were selected at both sites by research station staff. In Qingyang a strong link exists between the local farming community and the research station (mainly the station manager) and through this link farmers were recruited to participate within the experiment. Many of these participants agreed to participate more out of respect to the research station manager than a desire to understand no-till farming. In Dingxi the research station does not hold a strong presence within the community and many of the research staff are unknown to the local farmers. Friends and relatives of station staff dominated the participating farmers, the majority of whom had no more than a casual interest or understanding of no-till farming.

The experiment was a single factor, completely random design with 10 replicates (each farm). Each replicate was approximately 1mu (c.a. 660 m^2) and divided in half to produce two treatment plots (T) and (NTS).

Crops were to be sown using the research station no-till planter. However, mechanical problems and poor communication saw a mixture of planting methods and equipment used to sow the trials. In Qingyang, wheat is mechanically harvested, but maize, millet and soybean are hand-harvested. At Dingxi there is little mechanical harvesting – wheat plots are cut by hand or pulled out by the roots. Within this experiment the straw was removed from the plots and returned in varying degrees to the no-till plots after threshing.

All farmer participants were interviewed during the experiment following two types of interview format. Initially the interviews were loosely arranged with open-ended questions in an informal setting. Later interviews were more structured with more specific questions and fewer interviewers. In addition to the formal interviews research staff made ongoing observations and continually monitored the crops.

Results

The use of the formal agreement, although well intended, was problematic. The physical distance between researchers and farmers meant contact and communication was sporadic. This combined with the high levels of illiteracy and untimely breakdowns with research equipment made it difficult for either party to meet their responsibilities and compromises to the experimental design were made.

Working in Dingxi, Huang et al. (2008) reported a significant yield improvement by using no-till with stubble retention. Similar work in Qingyang (unpublished) showed no significant grain yield difference between NTS and T. In contrast, the on-farm results reported here did not reproduce these past results with the T treatment significantly out yielding the NTS treatment at both sites (Table 1). Two factors were identified as the reasons for this; firstly, poor implementation of the on-farm trial process, where farmers were lost from the research loop and were not motivated to understand the issue. Secondly, the research focused on the tillage practice and not the wider implications of no-till stubble retention on the overall farming system.

Table 1: Millet yield data from on-farm experiments conducted in Qingyang 2005

	No-till (NTS)	Tillage
Mean (kg/ha)	1911	2887
Median (kg/ha)	1781	2918
SD (kg/ha)	681	591
Sample No (*n*)	9	9

An analysis of variance of the Qingyang data showed a significant difference between treatments ($p<0.001$), a significant difference was also seen between the replicates $p<0.05$) and as an interaction between replicates and treatments ($p<0.01$). To understand the cause of this interaction the observational data collected during the experiment were examined. These observations combined with monitoring data showed the NTS treatments experienced quite different conditions at each farm. All farms were located close to each other within an area of 10 ha so it is unlikely that the differences were a result of climate. Some of the constraints experienced by the NTS treatments were the removal of stubble for threshing and then returning it over a period of up to 3 months. Grazing of animals on stubble by farmers not involved in the trial, poor weed control within the NTS treatments (weeds are generally controlled with tillage). The firmness of the soil surface in the NTS plots meant that they were used to access other areas by different vehicles. Seed emergence was higher in the NTS plots compared to the T plots, resulting in crowding and lodging. Finally the NTS millet was observed to mature 5-7 days earlier than the T treatment and some seed shattering had occurred before harvest.

The lack of understanding or interest by participating farmers in conducting a scientific test of the two systems could explain the majority of these problems. However, a more likely explanation is that the farmers did not have the skill, knowledge, time or equipment to manage all aspects of an NTS system. This idea was explored during interviews where it emerged that some of the participants had a good understanding of the benefits of stubble retention for water infiltration. One participant remarked, “When building caves (dominant form of housing in this area) you never select a cultivated area because the ground is harder than an area covered with grass or straw.” Many participants were interested in no-till because of the potential labour savings, removing the traditional 3 cultivations and 2 harrows used to prepare a seed bed. These farmers were, however, quick to point out this labour saving is lost if stubble has to be returned to the fields after harvest. Leaving stubble at harvest was a major constraint to Dingxi farmers and caused a few to pull out of the project. At Dingxi, crop stubble has high opportunity cost as feed for livestock and/or fuel for heating and cooking. In addition to its value, cutting stubble at ground level with a sickle is much easier and less labour demanding than cutting it half way up. The longer straw is easier to tie, stook and thresh compared to shorter cut straw.

Qingyang is more level and more farmers have access to contract mechanical harvesters for wheat harvesting; these participants were happy to leave the wheat stubble in the fields. The loss of this stubble

for fuel and animal feed did not appear to be a concern. This is possibly because different crop residues have different values as livestock feed – soybean, millet and maize stubble is valued more highly than wheat. One Qingyang woman commented that she currently has a 2 year supply of wheat stubble that she has not yet used. What was a concern to most farmers in Qingyang was access to no-till planting equipment, capital to purchase equipment and methods to easily control weeds without tillage. In Dingxi, the loss of stubble for fuel and fodder was of some concern, but without machine harvesting, the process of returning stubble after threshing was seen as an additional labour cost, making the use of no-till planting more difficult than conventional tillage.

The results of this trial were unexpected and detailed examination showed that the implementation of the experimental test was the main cause. This could have been improved with greater involvement of the farmers when developing the research question. However the value of this work was the engagement and interaction with the farmers during the trial. This interaction has helped us understand the system from the farmer's perspective and demonstrated how the implementation of a crop establishment system is far more than supplying no-till planting equipment; but requires a rethinking of weed control, harvesting processes, labour availability, and alternative livestock feed options. It also requires the focus to be on stubble retention not planting without cultivation. Huang et al. (2008) showed no-till without stubble retention was the least productive system within this region and the results from many of these farms have reiterated this.

No-till farming is a proven success in many developed farming communities around the world (Lal, 2007). The technology to successfully farm without cultivation is rapidly being modified and implemented within farms of the developing world (Esdaile, 2008). However, providing equipment is only part of the issue. Without an understanding of the farming system from the farmer's perspective new equipment will not cause a change of practice. This work has shown how the process of participatory on-farm research can involve farmers and enable researchers to co-learn about the system and, in time, it is this knowledge that will facilitate the successful adoption of new farming practices.

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