Conservation Tillage Research for Dryland Grain Production in China

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ABSTRACT

ACIAR research project 9209 has investigated a range of conservation tillage options for maize and wheat production in China. Zero till planters were developed using combinations of Chinese and Australian technology, and research plots established to assess tillage effects in terms of soil properties, water use, and crop yield. The results show that conservation tillage can improve yield, economic viability and sustainability, so the extension prospects for this technology are very good. Preliminary experiments have also demonstrated the negative effects of wheel traffic in terms of tillage energy and inflation of rainfall in China. The work is continuing under ACIAR 96143, which is investigating the relative contribution of residue, soil disturbance and traffic to soil/crop performance

1. INTRODUCTION AND BACKGROUND

Rainfed agriculture occurs over nearly half the total cultivated land in China, and much of this area (approximately 35Mha) is located in the northern 16 provinces. Limited annual rainfall and frequent drought result in poor and unreliable yield, while extensive soil degradation reduces sustainability. Annual soil erosion in the areas surrounding the Yellow River, for instance, are estimated at > 15t/ha and the resulting rills and gullies reduce the area of productive land. Shanxi, where this research is carried out, is a typical dryland province in the northern loess plateau area. A broadly similar program has been carried out in both maize and wheat, but only selected are presented and discussed here.

2. MATERIALS AND METHODS

The traditional production system in this area involves two mouldboard plough operations prior to planting, and recent attempts to improve productivity and included ridging, subsoiling, furrow planting, sand mulching and the use of plastic or residue mulch. Because there are no large tractors (above 75 kW) in China, and most production occurs in small fields, medium-sized, 3 point linkage, mounted planters are required. This constrains the use of wide tine spacing to achieve zero tillage planting.

A 4 row, 3 point linkage, mounted zero till planter has been developed over several years work. This unit can effectively cut the straw, divide the residue and assist its passage through the machine. Field trials have shown that this planter can work with occasional blockages in unchopped maize residue. Its performance is significantly improved with working in chopped residue providing < 60% cover (Li, 1998).

Table 1 shows the range of tillage/residue cover treatments used to test conservation tillage effects. Two treatments -- zero tillage/standing residue and subsoiling/rolled residue – which gave a poor initial yield response, were replaced by zero tillage/chopped residue cover/disk harrow and subsoiling/chopped residue cover/disk harrowing treatments in 1996. Each treatment was replicated four times.

Table 1. Treatments applied in maize production.

Tillage	Zero	Zero	Zero	Zero	Subsoil	Subsoil	Subsoil	Mould
Residue	Standing	Rolled	Chopped	Chopped	Rolled	Chopped	Chopped	Board
Disk harrow	No	No	No	Harrow	No	No	Harrow	Plough
Treatments	ZT/SDRS	ZT/RLRS	ZT/CPRS	ZT/CPRS/HR	SB/RLRS	SB/CPRS	SB/CPRS/HR	Control

A preliminary exploration of controlled traffic effects was carried out using a pair of instrumented tines on the same toolbar to evaluate wheeltrack energy effects, and a rainfall simulator to assess crop residue and wheel compaction effects on inflation of rain. Field-scale experiments to evaluate controlled traffic effects in crop to production have since been established with the treatments shown in Table 2. All the treatments are set out in a controlled traffic pattern with wheeltracks on 1.5m centres. Results are available for the first year's work in wheat only, where the wheel compaction treatment was carried out using a small (13 kW, 1t mass) tractor.

Table 2. Treatments applied in controlled traffic experiments.

Tillage	Zero	Zero	Shallow	Shallow
Residue	Cover	Cover	Cover	No Cover
Compaction	Non Compaction	Compaction	Non Compaction	Non Compaction

3. RESULTS

1). Conservation Tillage Yields and Benefits

Figure 1 shows the mean maize yield over the years for years 95, 96 and 97. Most conservation tillage treatments provide greater yields in most years, although effects were not significant ($P<0.05$) in all years. Crop yields were greater where residue was chopped, or after harrowing. It is suggested that this occurred because the soil surface was more level, optimizing planting conditions and improving the soil temperature. This aspect needs to be validated with more experiments (Gao *et al.*, 1997).

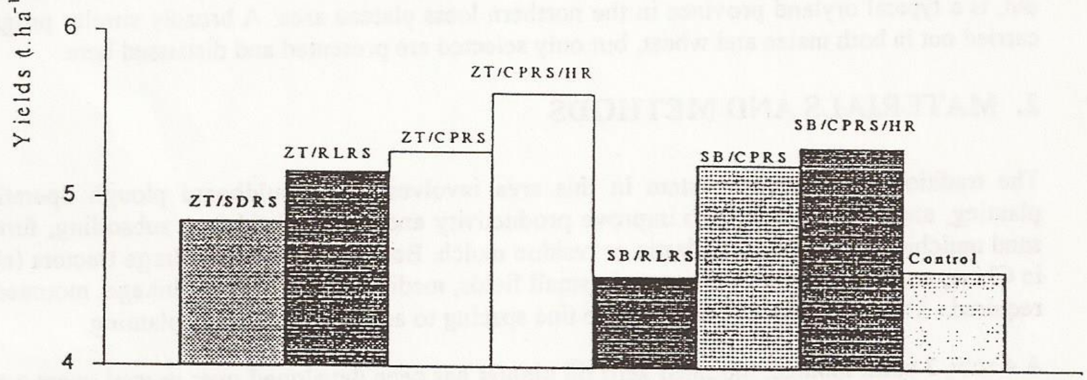

Figure 1. The yields for maize conservation tillage

Table 3 sets out the economic benefits of conservation cropping, based on an examination of cropping inputs and outputs, including seed, chemical, labour, cattle, and machinery operation. The value of crop residue was not considered. Conservation tillage can increase net income by more than 50% compared with conventional tillage through increased yields and reduced cost.

Table 3. Economic benefit of maize conservation tillage[1]: RMB Yuan/ha

Tillage	Zero	Zero	Subsoiling	Zero	Subsoiling	Mould
Residue	Rolled	Chopped	Chopped	Chopped	Chopped	Board
Disk Harrow				Harrow	Harrow	Plough
Input	2100.3	2160.3	2340.3	2250.3	2379.3	2775.6
Gross output[2]	5477.44	5595.53	5537.86	5974.16	5639.2	4870.30
Net income[3]	3377.14	3435.23	3197.56	3723.86	3208.90	2094.70
Response to CK(%)	61.2	63.9	52.6	77.7	53.2	/

1. Two treatments: ZT/SDRS and SB/RLRS were omitted in 1996
2. The price is based on 1997, A$1.00=5 RMB Yuan
3. Net income = Gross output – input

2). Preliminary Results –Controlled Traffic

Tillage energy requirements were assessed by measuring tine draft in wheeled and non-wheeled soil at four tillage depths, following different overall tillage treatments. These results are set out in in Figure 2 as tine draft/depth characteristics, and demonstrate that the average tillage energy requirement of wheeled soil is approximately 80% greater than that of the non-wheeled soil. The data also shows that surface tillage in zero tilled soil requires more energy than conventional tillage. At depths below 7cm, however, the energy for zero tillage is less than that for conventional tillage.

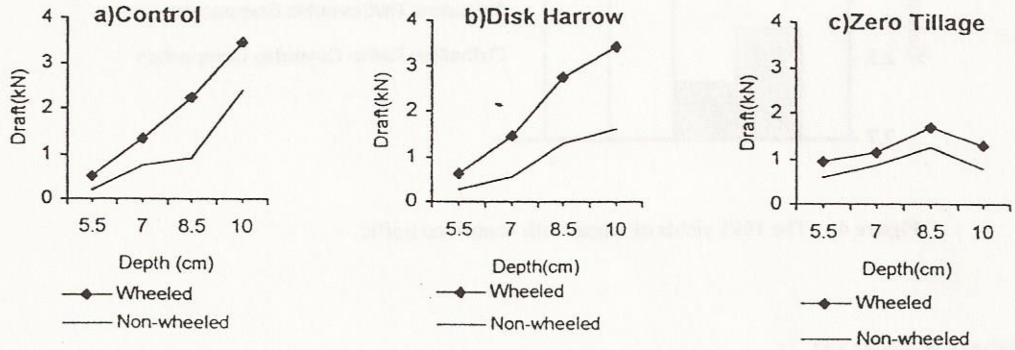

Figure 2 Energy requirement with different tillage for wheeled and non wheeled soil

Simulated rainfall at 80 mm/h was used to assess the effects of wheel traffic and crop residue on runoff. Rainfall/runoff data for maize is set out in Figure 3, and demonstrates that a single pass by the wheels of medium (30 kW) tractor had a greater impact on runoff than any residue treatment. Greater surface cover reduced runoff, and the minimum runoff occurred in non-wheeled situations with 100% residue cover, resulting from zero tillage.

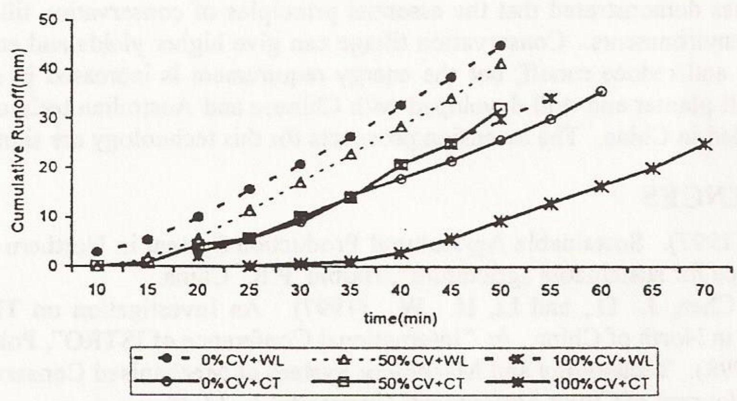

Figure 3 The effect of wheeling and ground cover level on runoff from zero till maize plots.

Controlled traffic effects on soil and crop performance of wheeled and non-wheeled treatments are currently being monitored, with the first complete crop cycle finishing in June 1998. Yield differences illustrated in Figure 4 suggest that wheeling might have reduced wheat yields slightly compared with non-wheeled treatments, while cover had no effect. The differences in wheat have just failed to meet the

5% test of significance, but this work will continue for at least two further years. The first maize harvest will occur in October, 1998.

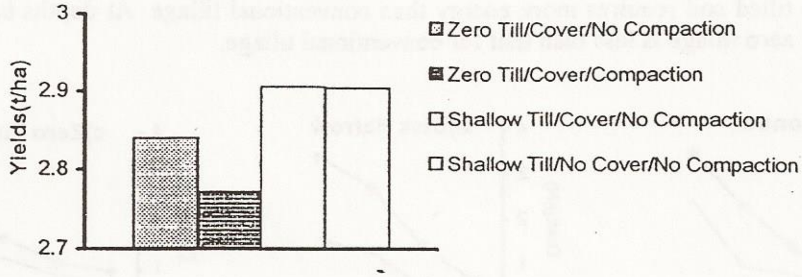

Figure 4. The 1998 yields of wheat with controlled traffic

4. CONCLUSION

After 5 years of research and 2 years of extension work, conservation tillage has been adopted in 12 counties of two Provinces, an area of about 1000 ha. In applying this technology, most farmers agreed that it is a good technology, but difficult to carry out, particularly if they can't afford feasible machinery. They need sprayers, no-till planters, subsoilers and choppers. Some farmers without feasible no-till planters have to chop the straw two or three times, so that they can use a heavy traditional planter. Regardless of the method used, yields tend to increase, while conserving soil and water.

Conservation tillage can conserve soil and rainfall, and also improve crop yield and farming income. Although there are many differences between the farming systems of Australia and NW China, ACIAR project 9209 has demonstrated that the essential principles of conservation tillage and controlled traffic apply in both environments. Conservation tillage can give higher yields and economic benefit, conserve soil and water and reduce runoff, but the energy requirement is increased in some operations. With a suitable zero till planter and drill developed with Chinese and Australian technology, conservation tillage is being extended in China. The extension prospects for this technology are significant.

5. REFERENCES

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