

Improved no-till seeding performance in Northern China using powered-chain residue manager

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Introduction

Conservation tillage (CT) is defined as a system of planting (seeding) crops into untilled soil by opening a narrow slot, trench or band only of sufficient width and depth to obtain proper seed coverage. No other soil tillage is done (Phillips and Young, 1973). This has been demonstrated and extended by the Chinese Ministry of Agriculture (Gao et al., 1999) in the annual double-cropping (winter wheat - *Triticum aestivum*, L., and summer maize - *Zea mays*, L.) regions of northern China since 1997. No-till seeding of maize after wheat harvest has been achieved with increasing success in these regions and several small-medium-sized no-till maize seeders have been developed for these conditions (Li et al., 2000), but no-till seeding of wheat after maize harvest is still a problem (Gao et al., 2003). No-till wheat seeders, equipped with various kinds of maize residue anti-blocking mechanisms (e.g. strip-choppers, powered cutting discs), were designed to cut through maize stubble (Yao et al. 2009). In annual double-cropping regions of northern China, the strip-till seeder using a powered rotor to till shallow strips ahead of the seed opener is the most widespread option to plant crops into stubble, but with high power consumption and soil disturbance. This approach was shown to reduce soil water storage and retention capacity due to low residue cover on seedbeds (Wei et al., 2005), which does not conform to the principles of conservation agriculture. A power chain unit residue management attachment for a more conventional no-till seeder unit has since been developed to overcome these problems, and this paper reports a comparative evaluation of the powered-chain no-till seeder (PCNTS) and strip till seeder (STS).

Materials and Methods

The new approach is derived from the simple concept of throwing residue aside manually by the fingers, achieved by using rigid fingers welded to the chain of the PCNTS (Figure 1a). The complete machine is 1.62-m wide with 6 openers at 0.2-m spacing and 6 powered-chain residue managers 30-60mm above the ground. It is equipped with tine openers to provide a groove 30-50mm wide and 80-120mm deep for fertilizer placement and a double-disc opener with individual-row depth control mechanisms to place seed 40-50mm above the fertilizer (Figure 2a). The STS (Figure 1b) is equipped with 6 powered strip-till rotary hoes at 260-mm spacing, to chop the cover crops and till strips of seedbed to 30-50mm below the soil surface (Figure 2b) and create a 120-mm-wide, 100-mm-deep tilled zone. Behind a single narrow tine-type opener, a pair of offset delivery tubes place 2 rows of seed at 120mm spacing and a single, centred delivery tube places fertilizer, 30-40mm below the seed, within the tilled zone. The anti-blocking mechanisms rotate at 320 rpm in the same direction in both seeders. These units were evaluated sowing winter wheat into cover crops in field A near the Zhangziying town (39°41'N, 116°35'E) in plots with a 5-year history of no-till cropping, and in field B in

the Daxing district of Beijing, over the 2009-10 seasons with three replicates, respectively. Figure 1(c) and (d), show field “A” with its residue from maize and wheat crops and field “B” covered with freshly chopped maize (3.1kg/m^2). At both experimental sites, average annual rainfall was 600 mm, 80% occurring in summer. The soil type is silt loam, and in the top 20cm layer, soil bulk density is 1.36g/cm^3 . The performance of PCNTS and STS was assessed in terms of residue handling ability, soil disturbance, fuel consumption, residue cover after planting, soil moisture in the seed zone after planting and crop yields (Yao et al. 2009; Zhang 2010).

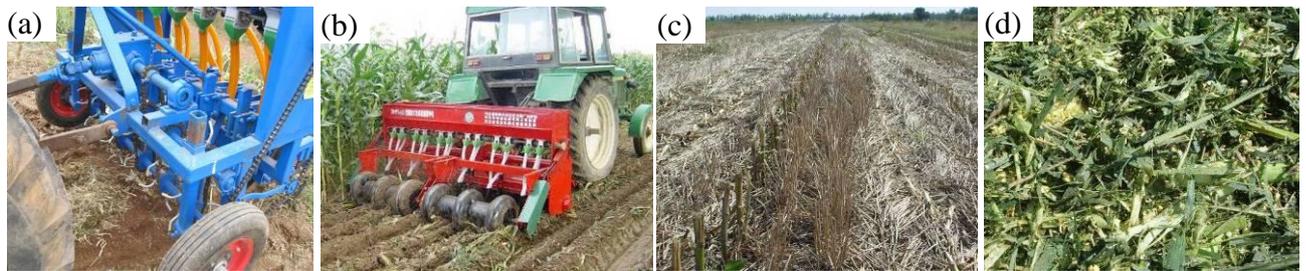


Figure 1. (a) powered-chain no-till seeder (PCNTS), (b) strip till seeder (STS), (c) test field A: covered with standing maize and wheat stubbles, (d) test field B: covered with freshly chopped maize.

Results and Discussion

In the field A, both seeders operated without blockage at similar velocity (5.3 km/hr), while in field B at a planting speed of 3.2 km/hr , slight blocking occurred with both seeders once in the three experimental runs in this high moisture, dense residue. Average seed depth was 38 mm after STS planting and 42 mm after the PCNTS in field A, and in field B 43 mm after STS and 45 mm after PCNTS but the differences were not significant ($P>0.05$) in either case. Fuel requirement of the STS was greater than PCNTS, which used energy to move residue, rather than cut through residue and soil. This difference was significant, and greater in field B (Table 1), with its greater mass/unit area of the green material, but field A represented more typical no-till seeding conditions. Both seeders appeared to have a similar capacity to avoid blockage in heavy residue conditions, but the residue covered area after PCNTS planting was almost 50% greater than that after STS, and the strip of disturbed soil (proportion of width of furrow groove to row space) is smaller by factor of approximately 4. Additional soil movement probably accounts for the greater fuel use of the STS.

Soil moisture is one of the most important factors limiting crop yields, and soil volumetric moisture content in field A for each planter was taken at critical growth period of the winter wheat (Figure 3a). Soil moisture content in the field planted by PCNTS was about 10% higher than that planted by the STS at seedling, heading and filling stages, and 33% greater than the STS at the jointing stage. The wheat yields in Figure 3b show that the yields for PCNTS are 262 and 237 kg/ha more for the STS in field A and B, respectively. These differences are likely to be a consequence of the greater soil disturbance and residue burial produced by the STS. These results show that both seeders can meet the Agro-technical requirements for no-till planting of wheat after maize. Furthermore, the performance of the PCNTS appeared to be a substantial improvement on that of the STS, particularly when judged in terms of compliance with the needs of conservation agriculture.

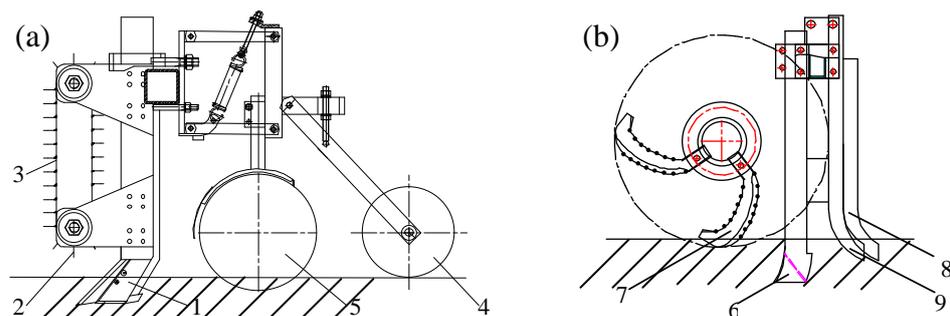


Figure 2. (a) powered-chain residue manager of PCNTS: 1,tine opener; 2,rigid fingers; 3,chain; 4, press wheel; 5,double-disc opener; (b) integrated strip-tillage unit of STS: 6,tine opener; 7,rotary

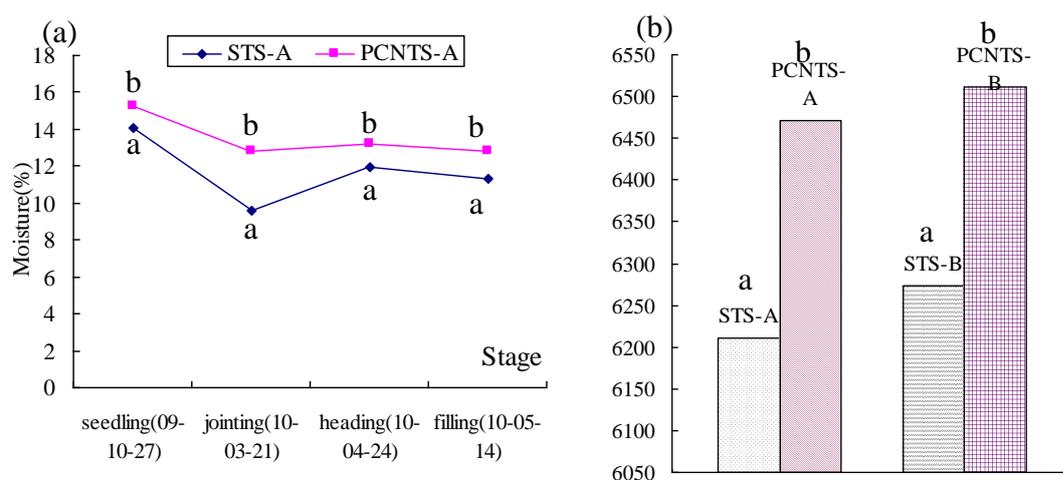


Figure 3. Comparison of the winter wheat yields in field A and B for each planter taken at harvest stage, and soil volumetric moisture content in field A for each planter taken at critical growth period: (a) Soil volumetric moisture content(%); (b) Yield (kg/ha) comparison. Values within a chart in each experimental field and growth stage followed by the same letters are not significantly different ($P>0.05$).

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