Damien Hauswirth of CIRAD in Vietnam, has sent this picture of a single row Fitarelli (Brazilian) CA seed drill being operated behind a 2WT. The picture shows a unit which is made up of a cutting coulter, followed by a tine opener, with a steel drive wheel/press wheel behind. It is fitted with a horizontal flat plate metered seed box, and a fertiliser box is also fitted. The rubber tired wheel on the side is for stability and depth control. Note also the small operator platform.

However I suspect the farmer is ‘cheating’ as the residue has been burnt before the seed drill is operated. Or perhaps this is the ‘burnt treatment’ in a research trial?

Following the report on 2WT racing in Thailand, which was mentioned a few issues ago, the Americans have now also embraced this sport. See link below.

I note from the report that motors up to 100 horsepower are fitted. Is this going to extremes?

A U.S. Foreign Aid website is featuring two videos on CA with 2WT in Bangladesh. One is on strip tillage, and the other on bed planting. Have a look at:
http://www.feedthefuture.gov/video/strip-tillage-bangladesh

On the next four pages I have reprinted a copy of a recent publication ‘Farm power and Conservation Agriculture – the potential for two wheel tractors in Sub Saharan Africa’ This has been written by Brian Sims (a British Ag. Engineer with many years of experience in mechanisation in the developing world) and Frederic Baudron of CIMMYT (based in Ethiopia). It is an excellent summary of the ‘state of the art’ with 2WT and CA up to this time. It recently appeared in ‘Landwards’ a UK Agricultural Journal.

This publication is set out here in low resolution format for easy email transfer to subscribers – especially those with slow connections. If you would like this publication in higher resolution, please go to the link:
https://sites.google.com/site/twowheeltractorgroup/home/two-wheel-tractor--large-files
Farm power and Conservation Agriculture:
The potential for two-wheel tractors in sub-Saharan Africa

by Brian Sims (FAO agricultural engineering consultant) & Frédéric Baudron (International Centre for Maize and Wheat Improvement [CIMMYT])

ABSTRACT
CONSERVATION agriculture (CA) is needed in sub-Saharan Africa (SSA) if we are to achieve the necessary sustainable intensification of food production that is required in the light of projected increases in world population.

CA, as all agricultural production, needs farm power as a necessary input to allow it to grow and become more productive. Two wheel tractors (2W Ts) are a power source currently being explored for SSA smallholder farmers. Experience from Bangladesh has shown how successful they can be and how well the supporting infrastructure can develop organically, creating employment and keeping the machinery in productive work throughout the year.

No-till planter development for 2W Ts is discussed and examples are given for cereals and strip-tillage machines. CA planning should be developed as a component of innovation networks and all relevant stakeholders should be involved. The best way to supply services to SSA smallholder CA farmers is through well-trained and well-equipped CA mechanisation services providing entrepreneurs.

1. INTRODUCTION
Farm power is an essential input for agricultural production and a lack of it can cause smallholder farm families to a downward spiral of food insecurity and poverty (FAO, 2005).

Sources of farm power in sub-Saharan Africa (SSA) include human, draught animal and engine-power with the human contribution being the most prevalent and contributing around 65% of the total. Draught animals contribute 25% and tractors only 10%. The availability of farm power is seriously depleted by pandemics such as malaria and HIV/AIDS which can deplete key workers in the household. HIV/AIDS has a more pronounced impact on the male population so that women tend to be left to attend to agricultural production tasks.

A further factor which exacerbates an already difficult situation is the tendency for people to abandon agricultural work in pursuit of a perceived easier life in towns, so that there is a migration of able-bodied workers from the rural to urban sectors. It is estimated (FAO, 2011) that by 2050 70% of the global population will be urban, compared to the 50% today.

At the same time world population is growing and needs to be fed, clothed and housed. The Green Revolution did a remarkable job in boosting world agricultural production but had the tendency to deplete natural and social capital. Production intensity was increased with expensive external inputs without taking natural resource conservation into account. And its technologies were generally only available to the better-off who tended to prosper at the expense of those who could not afford them or did not have access to them. But they did feed people.

Linked to the situation of rising populations and insufficient food production we have the uncertain impacts of climate change precipitated by the Anthropocene. More prolonged dry seasons, more irregular and violent rain storms and reduced reliability of weather patterns are becoming the norm as a result of greenhouse gas emissions (CO2, CH4, NO2) emanating from mankind’s polluting activities.

Current agricultural practices are estimated to contribute about a third of GHG emissions. There is little scope on Earth to expand the agricultural area available for growing crops and raising livestock and to the increasing use of crops (especially maize) to produce biofuels puts additional strains on food production.

Against this background the pressing need to produce more food in a more sustainable way becomes apparent and it is why there is an urgent priority to promote methods of sustainable crop production intensification - SCPi (FAO, 2011a). SCPi takes an ecosystems approach to crop production, protecting and nurturing the planet’s natural capital (principally soil, and water) and working with it to raise crop yields in a way that can continue to be practised indefinitely.

Central to SCPi is the concept of conservation agriculture (CA) which, in summary, involves the site-specific adaptation of three basic principles.

Firstly by keeping the soil covered with organic matter which means retaining crop residues and augmenting them with specially sown cover crops.

Secondly the soil is not disturbed more than is absolutely necessary to get the seed through the organic mulch and into the soil at the required depth. In effect this means practising no-till agriculture.

And thirdly is the application of the well-understood concept of crop and cover crop rotations and associations. Legumes fix nitrogen and fertilise the forthcoming crops; mixing different crop types in the sequence has a major effect on reducing the build up of pests, diseases and weeds.

CA, because it does not involve the employment of energy-intensive and destructive soil tillage operations, drastically reduces the need for farm power and so
can contribute significantly to alleviating the farmers power deficit afflicting millions of farm households in SSA.

It is estimated that 80% of agricultural production in the region is from smallholder farmers and so small-scale power options are relevant to their situation. Draught animal power (DAP) is one way to improve farm power input and can make a difference comparable to that between night and day according to women farmers (FAO, 2006).

However, adoption of DAP is constrained by cattle health problems, especially trypanosomiasis (transmitted by the tsetse fly) and East Coast fever, a tick borne disease, and so is common in only a few countries and regions (including Ethiopia and Eritrea, Mali and Burkina Faso, the Lake Victoria region, and southern Africa). Another option that is currently attracting interest is the use of two-wheel tractors (2WTs) to pull conventional tillage equipment and to replace draught animals as primary power sources. It is argued that they are much cheaper than conventional four wheel tractors (4WTs) whose introduction into SSA has been somewhat problematic in the past (FAO, 2011b).

2. THE ROLE OF 2WTs

2WTs are single-axle, light-weight tractors typically fitted with a 10-35 hp engine. Their traditional function has been to cultivate soil for rice and the 2WT achieves this with a rotary cultivator. 2WTs are less suited to pull conventional tillage equipment such as mouldboards and disc ploughs because their light weight reduces their tilling capacity (however this does not stop such high-draft implements being supplied to several government-supported 2WT import programmes in SSA - see Figure 1). The problems of limited traction, high slip and consequent heavy fuel consumption of small-scale machines, including 2WT, which are used for high-draft tasks such as ploughing are discussed by Crossley and Kigour (1993). 2WTs have been successfully introduced into previously un-mechanised situations to replace draught animal power. One notable example is Bangladesh where, in the space of 20 years small-scale farming has moved from a reliance on muscle power (predominantly oxen) to 2WTs. After the disastrous flood of 1987 which decimated the draught animal population, oxen, zebu cows, and testing requirements were all removed from imported tractors and the result has been a dramatic rise of 2WTs.

![Figure 1](image1.png)

**Figure 1:** Two-furrow mouldboard plough as supplied with a 2WT in SSA. It was being stored beneath the recipient's bed where it is likely to remain until its draught would exceed the capability of the light-weight tractor, Photo: Brian Sima.

2WT imports (mostly from China) from 34,080 in 1992 to over 350,000 today. Today 80% of agricultural land is cultivated using tractor power and this comprises predominantly the use of rotary power tillers for rice production (Boga et al., 2011). Even though all farmers, even the poorest, have access to 2WT services in Bangladesh, only one in thirty farmers actually owns one. Others gain access via custom service providers for which there is now a highly developed supply chain. Supplying cultivation services is a seasonal business and service provision entrepreneurs need to ensure that their expensive acquired tractors are in profitable and productive work throughout the year (or as much of it as possible). This means investing in auxiliary equipment and the most important item is a transport trailer for taking produce to market; over 60% of 2WTs are equipped with a trailer in addition to the rotary cultivator. Other useful equipment includes water pumps and crop threshers. 2WTs have been successfully introduced into previously un-mechanised situations to replace draught animal power. One notable example is Bangladesh, where, in the space of 20 years small-scale farming has moved from a reliance on muscle power (predominantly oxen) to 2WTs. After the disastrous flood of 1987 which decimated the draught animal population, oxen, zebu cows, and testing requirements were all removed from imported tractors and the result has been a dramatic rise of 2WTs.

3. DEVELOPMENT OF CA EQUIPMENT FOR 2WTs

We have seen that 2WTs do not lend themselves, for technical reasons, to be used with high draught tillage equipment; we have also seen that they have been widely adopted for rotary tillage work. This evidence has guided the ascent work on developing planters for CA using 2WTs as a power source. Work to date has focused on the use of disk implements to open a slot for seed placement and on using the 2WT for final tillage:

The following are examples of some recent developments:

3.1. Tillers

ARC Gongli. The most successful development of a no-till planter with chisel-tine openers for 2WT has been Jeff Eades’s Australian Centre for International Agricultural Research (ACIAR) - Rogno (www.rogno.com.au) machine (Eades, 2012). The original planter was designed with the aim of producing a machine costing no more than US$ 500. This is not an easy task as there will always be suggestions for ‘improvements’ which usually carry a heavy increased cost burden. The machine is now made and marketed as the ARC (ACIAR; Rogno; China Agricultural University) Gongli series (drill by Gongli Ltd, Shandong, China) (Figure 3).

The design concept is straightforward, there are adjustable chisel-point tines on two tool-bar frame members for the delivery and placement of seed and fertiliser. These are followed by press wheels, also adjustable in number and position, seed and fertiliser metering is by slotted rolls and can be adjusted by sliding the rollers vertically along their drive shafts. A wide range of additional options are being evaluated and include the use of

![Figure 2](image2.png)

**Figure 2:** 2WTs have been successfully introduced into previously un-mechanised situations to replace draught animal power.

![Figure 3](image3.png)

**Figure 3:** ARC Gongli no-till planter for 2WTs. Photo: ARC Gongli seed drill instruction manual.
discs for cutting residue and opening the seed and fertiliser slots, seed covers and an operator platform.

Other no-till drills with chisel-tine openers. No other machines have been developed as far as the ARC Gondi, but other projects are in the pipeline, to our knowledge there is little readily available published literature on these machines. John Morrison (University of Texas) on trial in Tanzania, Photo: Peter Chisomwillo.

Nkure, Kenya. Nkure (www.nkurekenya.com) is a well established agricultural machinery manufacturer which has recently ventured into the market for CA equipment for smallholder farmers. Their trial machine (commercially available) is mounted on a Chinese Kungfu 16 hp 2W7 (Figure 4). The seed and fertiliser metering mechanisms are driven from a ground wheel via a chain and wheel transmission.

The pump of an optional sprayer is driven from the engine flywheel shaft. Furrow opening is by reversible narrow chisel-point tines.

**FIGURE 4.** Nkure no-till planter and sprayer mounted on a Kungfu 2W1. Photo: Brian Sims.

Intermech, Tanzania. Intermech has developed a prototype no-till planter after having been involved in the construction and field trials of the ACIAR-Rogra and John Morrison machines. The planter (Figure 5) has a mulch-cutting disc followed by a chisel-tine opener for seed and fertiliser delivery and placement.

The two seeding units can float independently and are spring loaded to maintain working depth. Seed and fertiliser metering mechanisms are driven by a chain and sprocket transmission from the front cutting disc.

**FIGURE 5.** Intermech two-row no-till planter for rear mounting on a 2W1. Photo: Peter Chisomwillo.

**FIGURE 6.** Department of agriculture designed no-till drill for dry direct seeding of rice. Photo: Jack Desselaers.

3.2. Strip tillage

Chinese 2W7s can be equipped with a seeding box (e.g., the BG-6A) mounted above a rotary cultivator for full-width, full cultivation, one-pass sowing and so are not suitable for CA (Figure 7).

**FIGURE 7.** Chinese BG-6A full width, full cultivation one-pass seeder. Not CA. Photo: Brian Sims

The rotary cultivator can be modified by removing most of the tiller blades so that only narrow strips are tilled (Figure 8). A metering unit — such as the ACIAR-Rogra — can then supply seed and fertiliser to narrow line openers running in the tilled strips (Figure 9). The versatile Multi-crop Planter (VMP) developed in Bangladesh (Haque et al., 2011) can now up to four lines and one version has rotary blades bolted on to a square cultivator shaft so that row spacing is indefinitely variable and rapidly adjusted (Figure 10).

**FIGURE 8.** Full width rotary seeder / fertiliser modified for strip till sowing. Photo: Ken Sayre.

The use of rotating soil-cutting blades in strip tillage is a good way to manage heavy residue on the soil surface. Also by cutting seeding slots in the soil in this way, the draught requirement of the planter is reduced to practically zero.

**FIGURE 9.** VMP seed and fertiliser delivery from an ACIAR-Rogra set up. Photo: Brian Sims

**FIGURE 10.** VMP square shaft for infinitely variable and rapid adjustment of row width. Photo: Emanul Haque.
In the development process leading to the evolution of relevant CA machinery, it is really very important to involve all relevant stakeholders in an innovation network.

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