TWO WHEEL TRACTOR NEWSLETTER – OCTOBER 2012

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.
http://vivialice.typepad.com/blog/2012/09/the-most-incredible-2012-world-championship-power-tiller-race.html
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) &
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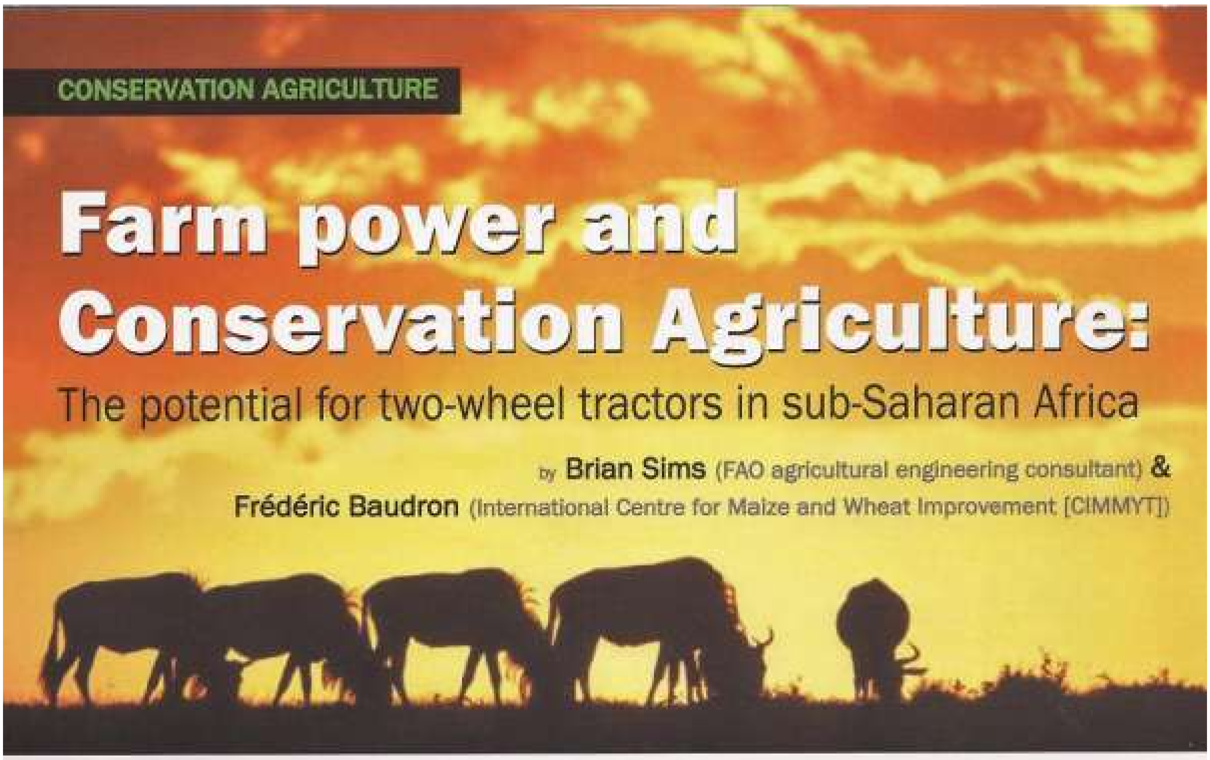

ABSTRACT

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 (2WTs) 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 2WTs is discussed and examples are given for chisel-tine and strip-tillage machines. CA planters 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 service providing entrepreneurs.

1. INTRODUCTION

FARM power is an essential input for agricultural production and a lack of it can consign 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 debilitate 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 (CO_2, CH_4, NO_2) 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 so 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 farm 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 smaller-scale power options are relevant to their situation. Draught animal power (DAP) is one way to improve farm power input supply 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 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 replace human and 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 10-15 hp engine.

Their traditional function has been to cultivate soil for paddy rice and the 2WT achieves this with a rotary cultivator. 2WTs are not ideally suited to pull conventional soil tillage equipment (such as mouldboard and disc ploughs) because their light weight reduces their tractive capacity (however this does not stop such high-draught implements being supplied to several government-inspired 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 2WTs, when used for high-draught tasks such as ploughing are discussed by Crossley and Kilgour (1983).

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, duties, taxes, and testing requirements were all removed from imported tractors and the result has been a dramatic rise of

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 as its draught would exceed the capability of the light-weight tractor. *Photo: Brian Sims.*

2WT imports (mostly from China) from 35,000 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 (Biggs 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 expensively acquired tractors are in profitable and productive work throughout the year (or as much of it as possible). This means investing in ancillary equipment and the most important item is a transport trailer for taking produce to market; over 40% of 2WTs are equipped with a trailer in addition to the rotary cultivator. Other uses include water pumping and crop threshing.

The increase in 2WT imports has, perhaps paradoxically, resulted in a marked stimulation of the local agricultural machinery manufacturing, repair and supply market. Locally-made equipment is needed for transport, soil cultivation and crop processing; and the 2WTs need good quality maintenance and repair. Repair workshops have sprung up in response to this demand and they are able to offer rapid, effective service at low cost to the tractor owner.

The local machinery manufacturing industry is not very sophisticated and can best be described as being able to produce equipment that is 'good enough' for local conditions and can be produced at a price attractive to local 2WT owners and operators.

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 nascent work on developing planters for CA using 2WTs as a power source. Work to date has focused on the use of tined implements to open a slot for seed placement and on adapting rotary cultivators for strip tillage.

The following are examples of some recent developments:

3.1. Tined openers

ARC Gongli. The most successful development of a no-till planter with chisel-tine openers for 2WTs has been Jeff Esdaile's Australian Centre for International Agricultural Research (ACIAR) - Rogro (*www.rogro.com.au*) machine (Esdaile, 2012).

The original planter was designed with the aim of producing a machine costing no more than USD 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; Rogro; China Agricultural University) Gongli no-till drill by Gongli Ltd, Shandong, China (Figure 2).

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 fluted roller and can be adjusted by sliding the rollers laterally along their drive shafts.

A wide range of additional options are being evaluated and include the use of

FIGURE 2. ARC Gongli no-till planter for 2WTs. *Photo: ARC Gongli seed drill instruction manual.*

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discs for cutting residue and opening the seed and fertiliser slots, seed coverers and an operator platform.

Other no-till seed drills with chisel tine openers. No other machines have been developed as far as the ARC Gongli, 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). This prototype (Figure 3) uses a spider wheel to clear residue from the planting line, followed by a vertical disc and a chisel tine opener for seed and fertiliser delivery and placement. It is mounted on the front of the 2WT which makes it rather difficult for the operator to see.

FIGURE 3. Prototype no-till planter (John Morrison, University of Texas) on trial in Tanzania. *Photo: Peter Chisawillo.*

Ndume, Kenya. Ndume (*www.ndumekenya.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 2WT (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. Ndume no-till planter and sprayer mounted on a Kungfu 2WT. *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-Rogro 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 2WT. *Photo: Peter Chisawillo.*

Department of Agriculture, Thailand. This machine, already available commercially, is designed for dry direct sowing of rice in low-surface residue conditions. It has single disc openers and only delivers seed at one dose rate (by design). There are spring-loaded seed coverers (Figure 6).

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

3.2. Strip tillage

Chinese 2WTs 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-Rogro - can then supply seed and fertiliser to narrow tine openers running in the tilled strips (Figure 9).

The Versatile Multi-crop Planter (VMP) developed in Bangladesh (Haque et al., 2011) can sow up to four lines and one version has rotary blades bolted on to a square cultivator shaft so that row spacing is infinitely variable and rapidly adjusted (Figure 10).

FIGURE 8. Full width rotary seeder / fertilizer 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 fertilizer delivery from an ACIAR-Rogro set up. *Photo: Brian Sims*

The VMP concept is designed to be versatile in terms of the range of crops that can be sown so that its use can be extended over the farming year and so is a useful implement for contractors supplying planting services.

It is also suitable for planting on permanent beds which allows the concept of controlled traffic to be brought in. Controlled traffic farming, for example as achieved by planting on raised beds, coupled with CA can produce the best possible conditions for crop establishment, rooting system development and crop performance (Yule and Chapman, 2011).

FIGURE 10. VMP square shaft for infinitely variable and rapid adjustment of row width. *Photo: Enamul Haque.*

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3.3. Draught animal no-till planters modified for 2WTs

Brazil has experienced exceptional success in the development of no-till planters for manual, animal traction and 4WTs (Casão Junior, et al., 2012).

Although 2WTs are not widely used in Brazil, it is possible to attach machines made for draught animal power to them. Two manufacturers have been notably successful in this activity - Knapik (*www.knapik.com.br*) and Fitarelli (*www.fitarelli.com.br*).

The planters are of relatively sophisticated design (Figure 11), the Knapik machines use off-set double disc openers for seed and fertiliser, and so are expensive compared with the machines designed for African and south Asian situations described in this overview.

FIGURE 11. Two Knapik no-till planter units attached to a 2WT.
Photo: Brian Sims

4. THE FUTURE

EFFORTS are being made to introduce 2WTs into SSA agriculture to increase the power supply available for smallholder farming. But a mistake commonly made in the past - thinking of power units in isolation rather than as movers of vital productive machines - is still apparent.

Measures to increase agricultural production sustainably, that is whilst protecting the planet's natural resource capital have been investigated and are being promoted and adopted. Development work on suitable CA equipment for 2WTs is still in its infancy although there are important developments, especially in China with the advent of the Gongli no-till planter and in Bangladesh with the development of strip till planting machinery.

So this time we can expect that there will be fewer graveyards of expensive machinery discarded as being inappropriate for the needs of agricultural development in the region.

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 (Johansen et al. 2012). In the case of CA mechanisation innovations these will include: farmers; manufacturers; researchers, extensionsists, academics, input suppliers and finance providers.

It is still a frequently encountered failure that equipment developers work in isolation from other vital stakeholders in the supply chain. It is also the case that working in this way fails to encourage the synergies that participatory collaboration can bring.

Much the same is true of CA as well. CA is a knowledge intensive concept and will require a great deal more training and demonstration before it becomes more widespread, which it must if we are not to plunge into a Malthusian abyss of persistent hunger and degraded natural resources.

Bringing innovations in CA machinery to the smallholder farmer can best be done by entrepreneurs trained in CA and machinery operation who can offer a high quality service to a large number of farmers. This is the model that has proven to be so successful in getting mechanisation to smallholder farmers in Bangladesh and it is one that should be followed for extending mechanised CA to farmers in SSA (FAO, 2012).

REFERENCES

Biggs, Stephen; Justice, Scott; & Lewis, David. 2011. Patterns of Rural Mechanisation, Energy and Employment in South Asia: Reopening the Debate. Economic and Political Weekly, Vol. XLVI, No. 9, pp. 78-82.

Casão Junior, R., Guilherme de Araújo, A. & Fuentes-Llanillo, R. 2012. No-till agriculture in southern Brazil: factors that facilitated the evolution of the system and the development of the mechanisation of conservation farming. Rome, Italy and Londrina, Paraná, Brazil. Food and Agriculture Organization of the United Nations (FAO) and Paraná Agricultural Research Institute (IAPAR). 77pp.

Crossley, P and Kilgour, J. 1983. Small farm mechanisation for developing countries. John Wiley & Sons. pp190-194.

Esdaile, J. 2012. Conservation farming with a two wheel tractor. MELISA workshop, Addis Ababa, Ethiopia, 10-13 April. https://sites.google.com/site/mechanizationineso

FAO 2005. Contribution of farm power to smallholder livelihoods in sub-Saharan Africa. Clare Bishop-Sambrook. Rome, Italy. Food and Agriculture Organization of the United Nations. Agricultural and Food Engineering technical Report No. 2. 87pp.

FAO. 2006. Farm power and mechanisation for small farm in sub-Saharan Africa. Brian Sims and Josef Kienzle. Rome, Italy. Food and Agriculture Organization of the United Nations. Agricultural and Food Engineering technical Report No. 3. 65pp.

FAO. 2011a. Save and grow. A policy maker's guide to the sustainable intensification of smallholder crop production. Food and Agriculture Organization of the United Nations. 102pp.

FAO 2011b. Investment in agricultural mechanisation in Africa. Conclusions and recommendations of a round table meeting of experts. John Ashburner and Josef Kienzle. Rome, Italy. Food and Agriculture Organization of the United Nations. Agricultural and Food Engineering technical Report No. 8. 76pp.

FAO. 2012. Hire services by farmers for farmers. Brian Sims, Alexandra Röttger and Saidi Mkomwa. Rome, Italy. Food and Agriculture Organization of the United Nations. FAO Diversification booklet 19. 82pp.

Hoque, M.E., Bell, R.W., Islam, A.K.M.S., Sayre, K. and Hossain, M.M. 2011. Versatile multi-crop planter for two-wheel tractors: an innovative option for smallholders. Proceedings 5th World Congress of Conservation Agriculture. September 2011, Brisbane, Australia. pp102-103. http://aciar.gov.au/WCCApapers

Johansen, C., Hoque, M.E., Bell, R.W., Thierfelder, C., & Esdaile, J. 2012. Conservation agriculture for small holder rainfed farming : Opportunities and constraints of new mechanised seeding systems . In press: Field Crops Res. doi:10.1016/j.fcr.2011.11.026.

Yule, D. and Chapman, W. 2011. Controlled traffic farming - more productivity, sustainability and resilience. Proceedings 5th World Congress of Conservation Agriculture. September 2011, Brisbane, Australia. pp174-175. http://aciar.gov.au/WCCApapers

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