Expert Forum

Thoughts on developing small/medium size no-till equipment for conservation agriculture in Asia: Summary of post-publication peer review comments

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Abstract: Traditional agriculture bases most of its operations or practices on soil tillage, which causes likely occurrence of water and soil erosion and sediment runoff. In order to conserve soil, water and environment, Conservation agriculture (CA) is increasingly adopted to replace traditional tillage agriculture to achieve sustainable and profitable agriculture and subsequently improve the livelihoods of farmers. CA holds great potential for all sizes of farms and agro-ecological systems, but its adoption is most urgently required by smallholder farmers, especially those short of laborers. Small/medium size no-till machines and implements are the key to CA adoption. A review article on small/medium size no/minimum-till seeders in Asia published in IJABE triggers a lot of scientific conversation on how to develop suitable no-till equipment among peer experts. This paper presents a collection of these post-publication peer review comments including commentary, questions, answers, suggestions, critical thinking, etc. The authors of the review article also provide response, summary of the review comments and their own standpoints. This open post-publication review and commentary may add value to the published review article and provide new ideas useful for future research and development of CA equipment.

Keywords: conservation agriculture, conservation tillage, no-till equipment, post-publication peer review

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With rapid growth of world population, degradation of soil fertility, soil and water erosion, and environmental pollution, particularly heavy haze in Beijing, people pay more and more attention to environment we live. Conservation Agriculture (CA) can change the way humans produce food and energy since agriculture is one of the most destructive forces against environment and biodiversity. CA can bring environmental benefits, including less erosion possibilities, better water conservation, improvement in air quality due to less emission being produced, and a chance for larger biodiversity in a given area. As a supporter and advocator of CA, Dr. Wang Yingkuan, editor-in-chief of

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IJABE, invited review/research articles on CA from a leading CA expert in China Prof. Li Hongwen. With the leadership of Prof. Li, we have organized and published series of articles on CA including three articles: The first is a global overview of CA by Derpsch R, et al[1] published in the first issue of IJABE in 2010, which ranks the second most-cited paper in IJABE; the second is a review on small/medium size no-till seeders in Asia by He J, et al[2] published in the fourth issue of IJABE in 2014; and the third is a review on policy and institutional support for CA in the Asia-Pacific region by Kassam A, et al[3] in the fifth issue of IJABE in 2014. We received a lot of response and discussion on CA from readers. Particularly, after the second article entitled "Development of small/medium size no-till and minimum-till seeders in Asia: A review" was published, the corresponding author Prof. Li Hongwen received a lot of comments from peer experts including questions, discussion and commentary covering extensive topics described in the above three articles. When Prof. Li communicated with Dr. Wang on how we should deal with those continued post-publication peer review comments, Dr. Wang welcomed and encouraged this kind of open commentaries, because Dr. Wang believes that the present pre-publication peer-review process is far from perfect, and post-publication peer-review seems like a great idea, which may open up useful scientific conversation. Therefore, Dr. Wang worked with the authors to put those comments together to publish them in IJABE. In order to respect for the comments of expert reviewers, we list the comments in their original versions by reviewers. We believe those useful discussion and comments will add more value to the paper and provide good references for the future research.

Comments by Prof. John Blackwell, Charles Sturt University, Wagga, Australia

I thought the paper was an excellent review as to what is available to small holders in the way of Conservation Agriculture (CA) planters. Where I think what we all fail to some degree is the evaluation of "drudgery" i.e. the effort required to operate these devices. This is I guess difficult to measure and quantify but should be attempted as I feel it is a major consideration as to choice of approach, often only realised post purchase and use in field conditions.

For those of us familiar with this field of endeavour the term "blockage" is an adequate description of the problem. For the layman farmer it hides a plethora of obstacles that he will only come to appreciate when he tries to operate in field conditions. In all reports residue load should be well described as to state, quantity, type, etc.

Comments by Mr. R. J. Jeff Esdaile, Agricultural consultant, Tamworth Australia

I note the comment on "drudgery". By way of historical comment, I was told by Wes Buchele (Prof. Emeritus- Ag. Eng. at Iowa State University, USA) a few years back that you will never have CA with a two-wheel tractor (2WT) extensively adopted until there is a seat for the operator.

At present I think that there are very few CA implements for 2WT with a seat. One is the standard rotavator. However the implement cannot conveniently be raised at the end of the row.

The other is the 2 row trailing Fitarelli disc drill which has a raise/lower lever as well as a seat. Small trailing boom sprayers for 2WT have a seat as well.

Several other seeders have an 'operator stand' which I guess is an in between solution.

This is the ultimate aim of the latest 'Gongli Africa' seed drill, (now being developed) which will have a seat similar to the standard rotavator set-up. The operator can always stay seated, conveniently raise the soil engaging parts at the end of the row, and also travel quickly between fields or farms with the entire implement in a transport position.

The only down side of this arrangement is that it is a bit more complex and costs more money. However perhaps the other benefits compensate for this.

Comments by Mr. Scott Justice, CIMMYT (Nepal) Small farm mechanisation specialist

I tend to agree with Jeff's assessment that a seat will make a huge difference to the acceptability of 2WT's – so

it's interesting that the company doesn't see the market. **I CANNOT AGREE MORE WITH JEFF.** Is this because the domestic Chinese market has moved on from 2WT? Companies are interested only in what they see as the expanding market? Statistics from 2010 showed that sales growth of 2WT's had reduced from approx. 5% annually to 2.5%-3%. What I do see is a movement towards even smaller 2WT's. As even Dr. Li Hongwen has remarked there is a real disconnection on what the National Government is promoting and what is actually going on in the market and on "regular" farms there.

Comments by Prof. Ding Qishuo, Nanjing Agricultural University, China

Admiringly, Scott is now talking about the other hidden half of agriculture in China. In my personal opinion, in the last decades the attention of the society in China and abroad has been drawn too much on large-scale farming systems and the development of big tractors and high-tech and high-capacity implements. All of us acknowledge that China has been successful in developing powerful machineries and also had gained enormous achievements in implementing conservation agriculture in North China. And thanks to Prof. Li Hongwen and his colleagues' effort, conservation agriculture is now more widely accepted in north China agriculture.

Compared to the North, South China agriculture is characterised by small plots, scattered sites, hilly or mountainous terrain, but un-ambiguously high land output. The 4.8 million ha rice-wheat farmland in South China now contributes 55% of grain food to China market, which plays a critical role in safeguarding the country's food security.

However, as a worker staying in field, I realize that the south China agricultural system is very poorly managed. I fully agree with Prof. Li's suggestion. It is time for us to voice to society that it is the right time for us to do something to promote the South China agriculture, particularly with modern technology, such as CA. This can address, to some extent, the inconsistencies of what Scott has heard and seen.

However, the most important and the most urgent task is to implement some kinds of extension or site-specific research in close cooperation with local farmers. South China agriculture does need external power and policy promotions to enhance its productivity and efficiency. I deeply realize that we, agricultural engineers, are left behind by the soil scientists, the agronomist and the biologists in helping and supporting South China agriculture.

Comments by Mr. R. J. Jeff Esdaile, agricultural consultant, Tamworth Australia

A further development of the ARC Gongli (as mentioned in the paper) is now under way. This is as a result of preliminary field testing in East Africa. Many African cropping soils have an uneven surface due to past tillage practice. As a result, many small CA seed drills do not have an even depth of planting, and an affordable and versatile arrangement of contour following tines (or discs) must be developed.

I have taken a lot of ideas for the contour following tine assemblies from Mark Stumborg (ex Canada Agriculture) who built a seed drill for Mongolia as part of a foreign aid project in 2004[4]. I have used a pair of down pressure springs from some Australian trailing press wheel assemblies.

We also found traction difficulty with the first Gongli Africa seed drill when testing on my recent East Africa trip. Once someone stood on the front section of the 2WT then tractive ability improved enormously.

As a three point linkage arrangement is not available, nor any hydraulic lift system, as on bigger tractors, either a manual lift or mechanical lift must be devised.

In a manual situation the operator requires an effort on the lever to lift the tines clear of the ground. When lowering the tines, one has to lower the static weight, plus more effort to compress the springs to the operating pressure to ensure that the tines penetrate properly. The lever would be latched at either end of travel to fix in the up or down position. A mechanical lift from an old seed drill from the 1950's was being used based on a 1930's 'power lift' design (Kovar J R, 1934)[5]. A system like

this has to be simple and capable of being repaired by local artisans. A disadvantage of this mechanical lift is that it takes at least 3-5 metres of forward motion to raise the tines-unlike a hydraulic or 3PL system which is instant.

Comments by Dr. Jack Desbiolles, agricultural research engineer, University of South Australia

A few questions:

• Can the manual lift system also disengage the seeder clutch at the same time? (a one lever 'end of run' action)

• How much 'break-out' force and tine jump height does the spring system allows at the tine tip?

• Is this met by a strong enough sub-bar locking mechanism when in work position?

• What is the load at the handle bar to lift the tines out of work? (Is this easy enough from the seat?)

• When will you be able to test its capability in the field?

I strongly agree with the comment made by John, especially because drudgery aspects often is at the source of mechanisation adoption failure and is particularly important for gender mainstreaming.

I wish to highlight the orientation taken in France with the recent appearance of OH&S sheets assessing the drudgery level of farm labour (fiches pénibilités), considering stress factors of manual lifting, repetitive actions, shift work, night work, ergonomics (poor postures), and exposures to excessive noise, mechanical vibrations, high heat, chemicals, dust/fumes. The incidence and exposure time per work day is quantified and forms the basis for identifying and applying controls.

A similar approach could be used to quantify the new drudgery level associated with the use of a particular mechanised equipment, perhaps if relative to a control method (e.g. the farmer practice) may be useful to compare changes in drudgery from various alternatives offered to the farmer.

In our Cambodia project, reducing drudgery – found to limit the farmer interest in using existing CA seeder options - was a primary factor considered in the development of our trailed rice seeder. In this context, it did not seem that an operator seat was required, but this might be quite different elsewhere.

With a bit of work (and may be a lot of luck), an integrating 'drudgery index' may express this in a single, meaningful value. In any case, I strongly suggest that aspects of labour drudgery evaluation should become a much more alive focus in CA machinery development.

Comments by Mr. R. J. Jeff Esdaile, agricultural consultant, Tamworth Australia.

The clutch to engage and disengage the seed drive is a relatively simple matter – connect the clutch yoke with the appropriate rod to the swivelling sub-bar.

The tine assemblies have a range of jump height from 100 mm up to 100 mm down. The spring 'break out' force system is adjustable.

The mechanical power lift method to raise and lower the tines has a satisfactory locking system to lock the sub-bar in position. At this time a mechanical lift is preferred to a manual method.

I will give it a run in the field at the local research station in a few weeks, using the manual lift, and then decide whether a mechanical lift is necessary.

There is another option which I have sometimes considered. Which drive is preferable- chain drive from the drive wheel of the 2WT, or have a separate ground wheel? The drive wheel option needs a clutch, and varies with wheel slip, whilst the ground wheel does not need a clutch as it lifts from the ground when the tines are raised. However that is another wheel with spokes on the ground to interfere with residue flow.

Comments by Mr. Saidi Mkomwa, executive secretary of African Conservation Tillage Network, Kenya

The paper has justifiably and extensively dealt with the technical constraints to the lack of suitable CA seeders for small to medium sized land-holding (SLH) farmers. Another dimension the paper might have elaborated is the physical accessibility of the equipment. We are finding in Africa, due to poor infrastructure and distribution networks, and more so with new innovations/unknown products, farmers are spending

substantial time and money (e.g. 1 day and 20 USD to purchase an 80$ jab planter). While "locally" developed equipment would partially address the problem, development of after-sales spares and repair services require policy support as the private sector awaits for the attainment of sales volumes that make business sense.

Due to access constraints to financing, SLH farmers' access to CA equipment services can also be enhanced, with clear lessons from Bangladesh, not through the buy-to-own equipment model but the hire mechanisation services model. Ownership costs are spread to affordable levels and only few service providers are expected to perfect equipment operating skills. We also have (but few) farmers who buy functional equipment but fail to use it due to not comprehending the operational skills aspects.

Comments by Dr. Allen David McHugh, Senior research scientist, CIMMYT-China

Although the document was broad in the machinery it covered, I agree with Professor Blackwell that the residue handling capability is a key determinate of performance. To that end different machinery is required for the variable residue conditions mostly because of cost, quality, weight and power consumption parameters. I say this, as disc based planter generally will work in all situations, but are beyond the reach of SLH due to cost and complexity. Therefore the ARC Gongli disc type combo and the new CIMMYT type based 2WT seeder are ideal for SLH in low residue conditions, single annual cropping regions. In high residue situations (rice) there are two inexpensive options for 2WTs. The strip tiller, like the Sichuan machine or the new Qingdao happy seeder. Both machines have seats (Scott), but the strip tiller will suffer from high blade wear in sandy soil conditions and soil degradation in wet heavy clay situations. Although the happy seeder will operate in all soils and all residue levels, it is over engineered for many situations and thus a site specific choice is needed. Therefore the choice or categorisation of 2WT seeders should be based on what is required to meet the agricultural objectives and CA principles with enough design flexibility in the machine to account for site specific variables, farm typologies, cropping choices and farm economics. In high technology farming, i.e., one without tillage, it is not enough to describe a planter simply as zero till or suitable for conservation farming, we must add the level of soil disturbance and residue handling volume to existing performance/operational parameters.

Comments by Mr. Theodor Friedrich, FAO representative in Cuba

The title of the paper was "Development of small/medium size no-till and minimum-till seeders in Asia: A review" and the paper was obviously focusing on seeders, which would allow to do a job within the CA definitions as set by FAO. The problem with the title is the term "minimum-till seeder", which includes a reference to "minimum tillage". In a strict sense, when we talk of the strip till seeders in Asia for example, the term would be right, and those seeders do comply with the 25%/15 cm maximum soil disturbance of the CA definition in most cases. Yet, the term minimum tillage is even less defined than the term conservation tillage (which refers to a minimum of 30% soil cover after the tillage operation). Minimum tillage can comprise a full set of tillage operations, when they are, for example combined into one machine. Minimum tillage can also be done by a rotary cultivator. Therefore the standard power tiller-cum-seeder unit as produced also in Asia, would also be a "minimum-till seeder", but it would not comply with the CA definition. Most "minimum-till seeders" actually on the market do indeed provide a full tillage at least for the seedbed preparation. For this reason I would suggest, to avoid such confusion and misinterpretations, not to use the term minimum tillage in the context of CA. The proposed wording is, that CA is a no-till system involving minimum soil disturbance within the defined limits, which allows for example for strip tillage in the seeding operation to open a seed or fertilizer slot. This kind of soil disturbance has not the primary function of altering the soil structure and hence is not tillage in the meaning of the word, but it reflects an imperfection of certain types of equipment, which for

good reasons, such as the cost of the equipment, sacrifice on the goal of minimum soil disturbance.

Comments by Mr. R. J. Jeff Esdaile, agricultural consultant, Tamworth Australia

I agree with Friedrich on his comment.

I dislike the terms 'minimum tillage' and 'reduced tillage' as they are subjective terms and there is no benchmark for comparison.

I prefer to use words such as 'inversion tillage', 'sweep tillage' or 'rotary tillage' as they more accurately define the type of tillage operation.

Similarly I prefer not to use the words 'conventional tillage' and call this as 'traditional tillage'.

Response and summary by authors

Authors' responses

The authors of the review article would like to express great thanks to the readers, with or without comments, for their concern and support for conservation tillage/agriculture. Particularly, thank those experts who provide their in-depth comments on the paper and good suggestions for the development of small/medium size no/minimum tillage seeders in Asia. These comments and suggestions involve the evaluation of CA machine performance, capacity and operability, CA developing strategy, etc. Authors' responses based on the comments are as follows:

1. **Machinery performance and capacity.** This is one of the most important factors that affects the application of CA machines. Generally, the working quality and efficiency of small/medium size no/minimum tillage seeder is not as high as that of large CA machines (widely used in USA, Canada and Australia, etc), so the research emphasis of small/medium size no/minimum tillage seeders needs to be concentrated on improving anti-blocking ability, seeding efficiency and quality, reducing fuel consumption, etc. Current study in Asian countries in this field is not enough and CA machinery performance still needs improvement.

2. **Machines' ease of operation and operator comfort**. The authors fully agree with the comments that small/medium size CA machines' ease of operation and operator comfort need to be improved, particularly no/minimum tillage seeders for 2WT. From the scientific aspect, the issues, such as traction ability, lift system, spring system for tine openers, and sub-bar locking mechanism (communications between R. J. Esdaile and Jack Desbiolles), but unlike plant residue handling capability (addressed by Allen David McHugh), these are not the main technical bottlenecks, but Asian agricultural engineers must consider these in the design, so as to improve machinery performance and overall operation.

Currently, many small/medium size CA machines used in Asia cannot meet the standard of operator comfort, although it is difficult to measure and quantify these factors in the operation. It is clear that the designs, such as seat for a two-wheel tractors, proper tractor vibration control, and other desirable operator features, can significantly improve the machine operators' working environment and comfort.

3. **CA developing strategy**. In Asia, many countries have been exposed to CA system for the past 10-15 years and some of them, such as China and Kazakhstan, have included this in their government policies. However, the adoption of CA across Asia is still low. The CA application strategy (e.g. Policy and financial support mentioned in our policy article by Kassam A, et al[3], scientific research, training, international cooperation) need to be developed based on each country's situation (details can be referred in Summary of the comments and authors' standpoints). For Asian CA scientists and engineers, it is the right time to suggest and 'persuade' the government to accept and extend CA in Asia, and help to train farmers/technicians for the application of CA and use of functional equipment as mentioned by Saidi Mkomwa. Some types of co-studies are also necessary, as suggested by Ding Qishuo.

Subsidies and financial support are very important for the adoption of CA, particularly in the areas with undeveloped economies in Asia. Regarding the Chinese purchasing subsidy for agricultural machine addressed by

Scott Justice, it was mainly for the subsidy of large agricultural machines during the past years. More subsidies are needed to shift the emphasis from large size machines to small/medium size machines. This is particularly significant for the development of CA in hilly and small farming areas in southern China.

4. The authors agree with John Blackwell's comment that more information (e.g. residue type and cover quantity) about the description of machine property and working conditions needs to be provided, so as to improve the readability of the paper.

Summary of the comments and authors' standpoints

1. CA is defined as a system that conserves land, soil and water resources and is economically environmentally and socially beneficial. However, the implementation of CA cannot be realized without properly designed machinery.

2. One key concept for CA-compatible machinery design is to avoid soil compaction and extensive soil disturbance. This may require that either excessive traffic be avoided, or lightweight and small scale machinery be recommended, or large-scale machinery be used with proper managed farming systems, such as compaction management farming.

3. Small scale machinery is beneficial when farming land is fragmented, or where small-holder farming is the main economy for rural sustainability.

4. CA not only brings forward new concept for crop production system, but has also shifted our mind toward exploring the advantages of small and light-weight machinery. The success of small machinery in South China and countries like Japan and South Korea is a proof that small machinery can be powerful in modern agriculture.

5. Small machinery is the wise mechanisation choice when rural economy is under-developed, and where farmland output is the main source for household economy. 2WTs equipped rotor strip tillers and seeders can help to relieve farmers from the drudgery of field work, and improve per capita productivity. This is true even today in some developing countries. However, when the rural economy is fully developed and rural labour force is extensively transferred to industry, (examples of the developed zone in South East China, Japan and South Korea), small machinery is still found to be valid.

6. Large machinery suits large farms, providing high productivity, reduced machinery cost per unit land area, which contributes to improved economies of scale in agriculture and competitive ability for a nation. China's agriculture has always experienced the threat from the North American low grain price on the world market, and even now is still under huge pressure to reduce costs. Developing large machinery (now 400 horsepower tractors are available) and land consolidation is, in some sense, a national-level game that has to be played in the modern world economy. However, it is the small mechanised farm sector that really drives the local food security and extensively utilises the local land, water and fuel resources and will continue to do so for many years to come.

7. Small machinery can also be powerful and productive, especially when a large fleet of machines is implemented. East China has many years of successful experience in small scale farming with small equipment for smallholder farming systems.

8. Some recommendations for the development of high-performance small/medium size no/minimum-till seeders have been addressed in "Conclusions" of the paper[2]. Here are some suggestions for fast adoption of CA in Asia:

Policy and financial support: The US Food Security Act of 1985 is a good example of how national policy can promote fast adoption of CA. Therefore, based on the successful experiences from the countries with developed CA system, Asian countries need to enact regulations to mandate the development of CA and provide the financial support for CA research and extension. Taking China as the example, the Chinese Central Government's 'No.1 Document' has continuously endorsed the development of CA over the past eight years. Also, the Chinese government has provided 30 million Yuan (1 Yuan ≈ 0.16 US dollars) to extend CA each year since 2002.

Scientific research: Asia's middle and small size farming system is different from the large CA farming system in USA, Australia, Brazil, etc., the constraints, such as the lack of suitable no/minimum tillage seeders and low yields in some cases, to adoption of CA need to be alleviated. The site-specific technical modes for hilly and middle/small farming regions must be developed according to agricultural features of each country.

Extension and training: The early CA adopters face many hurdles, so the high-efficiency extension mechanisms and CA expert group must be set up to provide training and technical support. In addition, the farmers should be subsidized during the application of CA based on each country's financial situation.

International exchange and cooperation, which includes international conferences, scientific exchange, joint research, etc., are helpful for the spread of CA in Asian countries.

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