Australian Government
Australian Centre for International Agricultural Research

Final report

Small research and development activity

project

Development of conservation farming implements for two-wheel tractors (power tillers) in Cambodia, Lao PDR and Bangladesh

project number CSE/2007/027

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Contents

1 Acknowledgments

Professor Richard Bell, Dept. of Environmental Science, Murdoch University, Perth Western Australia. Professor Bell encouraged me in the work, and has allowed field work in ACIAR project LWR/2005/001 to be used as the principal test site for evaluation of these implements.

Mr. Chris Holland, Principal of Spring Ridge Engineering, Spring Ridge, NSW. Chris did much of the design work, as well as the fabrication of the seed drills.

Mr. Sun Liangjun, Manager of Two Wheel Tractor Division of Dong Feng Agricultural Machinery Company, Changzhou, Peoples Republic of China. Mr Sun has assisted in the supply of various specialised parts for the seed drills.

Mr. Enamul Haque, Cropping Systems Agronomist, CIMMYT, Bangladesh and Mr. Israil Hossain, Principal Scientific Officer of Bangladesh Agricultural Research Institute (BARI), Bangladesh. These colleagues have given continued local support to the Bangladesh testing program for the seed drills.

2 Executive summary

Small farmers from South Asia and other parts of the world use two wheel tractors as the main means of land preparation and other farm operations, due to small farm and field size combined with price affordability. However no commercially available versatile seed drill exists for these tractors. Project CSE 2007/027 commenced in 2007 with the import of a 12HP two wheel tractor and a 2BG-6A rotary tillage seed drill from Asia. A total of seven seed drills were fabricated. Five drills are of the tyne type on a tool bar frame. They are modelled on the original CIMMYT two wheel tractor seed drill. The other two are modifications of the Chinese 2BG-6A rotary tillage seed drill, which is now being sold in Asia.

Spring Ridge Engineering of Spring Ridge NSW, a NW NSW agricultural implement manufacturer, has done much of the design and all of the fabrication.

The tyned drills are structurally sounder and more versatile than the original CIMMYT units. They are based on a tool bar concept and are fitted with seed and fertiliser boxes and press wheels. The seed metering system is adjustable and capable of handling practically all crop seeds from maize to mustard. Separate fertiliser placement is available as an option. Row spacing, frame layout, seed and fertiliser rate, and seeding depth are fully adjustable.

The rotary tillage drills have been modified to enable strip tillage planting if required. These units have similar seed and fertiliser boxes to the tyned implements and also are fully adjustable for row spacing and seeding depth. They also have press wheels fitted.

In September 2007, the first tyned drill was shipped to Bangladesh. This was assembled in October 2007, (with some local parts as well) and has been used since then in NW Bangladesh. A second tyned drill and a rotary tillage drill were shipped to Bangladesh in March 2008. One tyned drill was sent to Cambodia in mid 2008, and another went to Lao PDR at the same time.

Two units (one each of the tyned drill and the rotary tillage drill) remain in Australia. The tyned drill was also demonstrated to ACIAR staff and the media at the CSIRO Giniderra Research Station in January 2008.

Both the tyned and rotary seed drills have been intensively tested in farmer's fields in NW Bangladesh for most crops. They have proved to be successful and there has been considerable farmer interest. The tyned units supplied to Cambodia and Lao PDR are also being evaluated in these countries.

Both implements are suitable for traditional or conservation farming systems. The seeders are simple, and light in weight. The tyned drill can be adjusted for use as an inter-row cultivator, land leveller, bed shaper, or boom spray. Two Bangladeshi manufacturers fabricated local examples in late 2008 and have taken orders for more units.

The tyned drill was subjected to comprehensive testing at the Ag. Engineering Department of the University of Southern Queensland and was shown to be structurally capable of performing in the field as designed.

A promotional DVD and brochure for these implements has been produced, and a pamphlet on 'instructions for use' for each implement has been written and fairly widely distributed in Asia.

Full details of these seed drills were presented to the Fourth World Congress on Conservation Agriculture in Delhi in Feb. 2009, and there is moderate interest from nations where two wheel tractors are extensively used.

Australian agronomists and research workers who are associated with foreign aid projects have been exposed to this project and are now aware of the potential of these seed drills in small landholder agriculture.

The Agricultural Engineering department of the University of Southern Queensland has obtained valuable experience in the evaluation procedures for small seed drills.

A group of growers of intensive horticultural crops (vegetables etc.) from South East Queensland has shown interest in adopting parts of this technology for vegetable production in this area. This may be explored further in the future.

A short line Australian farm machinery manufacturer now has expertise in the development of small seed drills.

3 Introduction

Small farmers from South Asia use the two wheel tractor as the main means of traction for tillage and other farm operations. These units have become very popular, and over 500,000 are manufactured annually worldwide. There are over 350,000 operating in Bangladesh and over 2 million machines in Thailand.

Many small farmers in South Asia are aware of the benefits of conservation farming systems including minimum and zero tillage. However they lack the means to put into action these improved farming system practices due to the unavailability of a suitable seed drill.

These systems of farming have reached an advanced stage in many parts of the world. However the equipment to put this into practice has been principally designed for traditional four wheeled tractors and there are no commercially available conservation farming implements available for two wheel tractors.

Haque et al (2004) reported on the fabrication and testing of a power tiller operated zero tillage seed drill in Bangladesh. The development and testing of a prototype was conducted between 1999 and 2004. Results indicated considerable cost and time savings over the traditional system planting rabi crops into aman rice residue in October/November. This research was funded by a United States Aid program, and the United Nations Food and Agriculture Organisation, and carried out by CIMMYT Bangladesh and the Bangladesh Agricultural Research institute (BARI). However funding ceased in 2004, and no commercially available implement has been produced.

Justice et al (2004) also reported on an associated project in Bangladesh where a commercially available Chinese Power Tiller Operated Seeder (PTOS) was modified for strip tillage. This also was used to plant rabi crops into aman rice residue in October/November. One pass full tillage was compared to strip tillage. In the strip tillage treatment, half of the tiller blades were removed and the seeds placed into the tilled strips. Field capacity of the seed drill was increased, fuel consumption was reduced, and overall planting cost reduced compared to the full tillage treatment.

In 2006 it was realised that the ongoing research and development of seed drills for two wheel tractor was effectively at a standstill. Also it was realised that this technology, although developed for Bangladesh, could also be applied to other South Asian countries where two wheel tractors are the main farm traction units (Eastern India, Cambodia, Laos PDR, Vietnam, Indonesia, and Mainland China).

An application for funding was made in mid 2007 and ACIAR funds were provided to develop seed drills for two wheel tractors. These would be based on the existing prototypes, and development of both tined seed drills and rotary tillage seed drills was carried out.

4 Seed Drill Development

Following ACIAR approval of the project a Chinese made (Dong Feng brand, 12Hp) two wheel tractor was imported into Australia in mid 2007, along with a rotary seed drill. This tractor and seed drill was used as the test module for further prototype seed drill fabrication. Improved examples of the two seed drill types were fabricated at Spring Ridge Engineering. This company is very experienced in the manufacture of larger zero tillage seed drills in Australia. The improved examples are as follows:

Tyned Type Zero Till Drill (Tool bar mounted) – see picture in Appendix 2

This implement is essentially an improved model of the original tined type ZT drill as described by Haque et al (2004). A much improved three bar tool bar frame that is 1000mm. wide has been made up from 50mm x 4mm thick square tube. There are two side rails, of 75mm wide x 10mm thick x 825 mm long flat steel. Holes have been drilled in the side rails every 90mm. The tool bars can be fitted at various points to allow adjustable bar spacing. The resultant frame can be set up as a one bar, two bar, or three bar implement at bar spacing of up to 700mm.

Up to four tynes can be fitted to the tool bar. The tynes are made of 50mm x 12mm high tensile steel. Each tine is 700mm long, and is fitted with a non-detachable point (which is tungsten tipped) and a seed tube. Each tine is in a holding bracket and is clamped to the bar by 50mm square “U” bolts. Tynes can be adjusted both vertically and laterally along the bars. Mounted 250mm diameter x 50mm wide press wheels are fitted to a 25mm axle at the rear of the implement. Press wheel spacing is adjustable, and the number of press wheels can be varied to suit the number of tynes being used for sowing.

A set of double disc soil openers, and a set of cutting coulters are also available. These also can be easily fitted to the tool bar as required.

Dual two row bi-compartment boxes are fitted, with the front compartments for seed, and the rear boxes for fertiliser. In order to ensure good seed drop, and allow good clearance for the tynes and tool bar, the boxes are mounted either side of the handlebars of the tractor. Box position is adjustable vertically and laterally to allow for suitable fitting to different types of two wheel tractor. The front box is fitted with Asian made dual system fluted roller seed meters. These meters can measure out seed of all sizes from maize to mustard at variable rates. A second set of fluted roller meters is in the rear box. These meters deliver fertiliser also at variable rates as required. Toolbar frame is also suitable for fixing different types of other implements. Drive to the seed and fertiliser boxes is by a chain drive, from the main drive wheel of the tractor intermediate shaft above the front bar and hitch. A clutch is fitted to the intermediate shaft. External chains then drive the metering shafts.

Modification to Rotary Tillage Seed Drill – see picture in Appendix 3

In the standard commercially available arrangement this Asian made seed drill is set up for one pass seeding with 100% rotary tillage. The seed box is set up above the tillage unit, and the seed delivered by tubes and lightweight soil openers to the soil immediately behind the tilled zone. A steel long roller then lightly firms the soil behind the seed drill. No fertiliser box is available. We noted that seed positioning into the tilled soil behind the unit was poor. Some seeds were on the soil surface, some at intermediate positions in the tilled zone, and some were at the bottom of the tilled layer. Seed pressing was also poor. This setup may be satisfactory in optimum moist soils, or where the new crop is to be ‘watered up’ by irrigation, or where follow up rain to germinate the seeds is assured. However in dry soils, or rabi crop planting with no follow-up rain, seed placement is unsatisfactory.

Fertiliser application is by a separate operation, and fertiliser cannot be positioned in the seed row with the seed. The seed box was removed and an add-on tool bar, the width of the tiller (1200 mm.) was made up. This tool bar is also of 50mm x 50mm x 4mm square bar, with similar tynes to the tined unit described earlier. The bar is positioned immediately above and behind the tiller. It is attached to the main frame of the tiller. Tine type openers are positioned so that all the seeds can be delivered to the bottom of the tilled layer, and into the untilled subsoil if required. The steel roller was removed, and replaced by a 25mm axle with press wheels similar to the tined unit.

5 General Field Performance

Bangladesh

A prototype of the Australian made tyned drill was sent to Bangladesh in late 2007. A second tyned unit and the rotary drill modification were sent to Bangladesh in mid 2008. They have been exhaustive evaluated behind a Chinese made (Dong Feng) two wheel tractors.

The tyned seed drill generally has excellent penetration when used for rabi planting in Bangladesh. The two machines sent, along with some locally made variants, have been extensively tested in NW Bangladesh. Performance has been excellent in lighter soils. However in some cases, field performance has been mediocre in poorly structured clay soils. Due to the characteristics of these soils, it is difficult for a tyned implement to produce a satisfactory environment for plant establishment. Practically no soil 'fines' are created by the action of the tynes, and seed cover is often poor.

The modified rotary drill has proved to be successful under practically all field conditions in Bangladesh. This seed drill generally produces a satisfactory environment for crop establishment, with good seed placement at the bottom of the slots and a fine tilth of soil over the seeds, except under very wet conditions. It has been evaluated both as a 100% tillage unit, and as a strip tillage machine. It is superior in performance to the tyned drill in poorly structured clay soils, as the rotary tillage action produces more soil 'fines'. This results in better plant establishment on these soils.

With both drills the addition of press wheels has been very positive. Loose disturbed soil is considerably compacted over the seeds in the planted rows. Increases in crop establishment rates have been observed. Both of these drills have been extensively used in ACIAR project LWR/2005/001 "Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh"

Cambodia

One tyned drill was sent to Cambodia to the Cambodian Agricultural Research Institute (CARDI) in mid 2008. Mr. R.J. Esdaile visited CARDI after the arrival of the seed drill, and supervised the assembly of the implement. This drill was fitted to a 12 HP Siam Kubota two wheel tractor previously supplied from ACIAR project – ASEM/2006/130 "Enhancing production and marketing of maize and soybean in north-western Cambodia and production of summer crops in north-eastern Australia"
He also gave some instruction in the field operation of the drill to CARDI Ag. Engineer Mr. Pao Sinath and Ph.D student Ms. Rowena Eastick. Such items as seed and fertilizer calibration, tyne adjustment for varying field conditions, and other operational matters were explained. The drill was also demonstrated in one of the fields at CARDI

Lao PDR.

Another tyned drill was sent in mid 2008 to Lao PDR for use in ACIAR project CSE/2006/041 "Increased productivity and profitability of rice-based lowland cropping systems in Lao PDR" This project supports an expatriate Australian Ph D student Mr. Leigh Vial who was previously a rice farmer in the Riverina. He is experienced in the operation of seeding equipment, and has been able to successfully set up this drill for operation in Lao PDR. This unit has also been fitted to a Siam Kubota two wheel tractor.

A rotary tillage option is not readily available for the Thai built Siam Kubota two wheel tractor and thus the strip tillage unit is not being considered in Cambodia and Lao PDR.Enter text

6 Computer stress analysis of the tyned seed drill

The Dong Feng tractor, along with the tyned seed drill, was evaluated in the Agricultural Engineering Department of the University of Southern Queensland, in Toowoomba Queensland in 2008.

A final year undergraduate student, under the supervision of Dr. Guangnan Chen undertook a project to evaluate the implement by stress analysis and computer simulation. The implement was found to be structurally adequate for the tasks for which it was designed (Fraser, 2008).

As well as validating the strength of the implement that had been designed by Spring Ridge Engineering, this exercise has been productive as it has been a useful project for an undergraduate Agricultural Engineering student, which has been undertaken at minimum cost.

7 Results and discussion

Both the tyned drill and the rotary tillage seed drills have been extensively tested over two seasons in NW Bangladesh. They have been used as the principal seed drill types in the field experiments associated with ACIAR project LWR/2005/001 “Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh”

Crops planted have included wheat, chickpeas, lentils, maize, mung beans, and rice.

These drills offer the possibility of a quantum leap forward from the traditional farming systems being used in South Asia. Many field experiments planted as part of project LWR/2005/001 in Bangladesh have been planted with these drills. Other experiments as part of associated CIMMYT research programs have also used these drills.

Field performance of these seed drills for wheat, maize, chickpea and lentil establishment and comparisons with the standard tillage system in many farmers’ fields indicate that these crops can be established immediately after rice using these drills.

Many benefits have been shown when the change is made to these seed drills.

- Crop yield and profitability are 10-30% higher than comparable systems. (Hossain et al 2009)
- Turnaround time between crops is drastically reduced resulting in timelier planting.
- Fertiliser in now positioned in the seed row with the seeds.
- Costs of crop production greatly reduced.
- Fuel use in crop production greatly reduced.
- In many cases, there is only ‘one pass’ operation to establish the new crop.

Full crop data related to the sowing with these drills, including crop establishment figures, crop vigour, yield, and other parameters will be available in reports from other ACIAR projects in Bangladesh.

No data is available from any field trials in Cambodia or Lao PDR. The drill was for use by projects as a tool for machine planting of field trials by others.

8 Promotion and other marketing activities

Full details of these seed drills were presented to the Fourth World Congress on Conservation Agriculture in Delhi in Feb. 2009, Mr. Israil Hossain, Principal Scientific Officer with BARI Bangladesh made the presentation. There has been moderate interest from nations where two wheel tractors are extensively used.

A promotional DVD and brochure for these implements was produced in early 2009, and a booklet on 'instructions for use' for each implement was also written. Copies of the DVD and brochure were given to interested delegates at the Congress; and also distributed in partner countries.

Also, since that time, there has been some interest from Africa. A senior agricultural engineer (Theodor Friedrich) from FAO Rome has been given copies of all of the relevant material. As a result, copies of promotional material have been requested by various affiliates of the African Conservation Tillage Network (ACT).

As part of the Bangladesh project LWR/2005/001 being co-ordinated by Professor Richard Bell, funds were made available for the construction of samples of each of the drills in Bangladesh in mid 2008. Two manufacturers, Mahbub Eng. Works of Jamalpur, and Khairul Eng, Works of Doshmile, Dinajpur made units, using the Australian made implements as a pattern. These are currently being used in NW Bangladesh.

In mid 2008, a commercial farmer from Kenya in East Africa visited NW NSW and viewed the seed drills. As a result he ordered one each of the drills, which were manufactured by Spring Ridge Engineering. Finance for these drills was supplied from other sources. These were shipped to Africa in late 2008 for local evaluation in Kenya.

9 Operator training

The seed drills are satisfactory in performance and can be easily set up and adjusted by farmers who are experienced with machine planting. However many Asian smallholder farmers as well as many of the field research workers have little or no experience in machine planting of crops.

The introduction of seed drills such as these has indicated that most farmers who may use a two wheel tractor seed drill need a lot of basic instruction in the operation of a seed drill. The basic principles of correct seed placement, covering, and pressing need to be simply communicated to potential owners of these implements.

This has been partly addressed by the production of a handbook. However this handbook is at present only in English. Perhaps translation into other languages could be considered.

Also I would consider it necessary that all potential purchasers of these drills, as well as associated extension officers, research workers, and NGO officials should attend a basic course in the operation of these drills.

10 Conclusions and recommendations

10.1 Conclusions

These two seed drills have considerable potential to greatly increase productivity in South Asia, and other countries of the world where the two wheel tractor is the main traction unit in farming.

The main task now is to promote this technology and have these drills readily available to farmers at an affordable price. The tyned drill can be readily made from local components in most workshops. Most of the steel for fabrication is simple in design, and tynes can be made from old automotive leaf springs. The only specialized items required are the seed meters, which can be sourced at an inexpensive price from a Chinese manufacturer or local promoter.

There is now a machine seed drill readily available for manufacture by others. It is hoped that it will be at an affordable price. I pose the following questions.

Should ACIAR be involved in a training program for new owners of this technology?

To what degree should ACIAR be involved in a marketing campaign?

If so, how much effort and/or finance should be expended?

Do we encourage manufacture in Third World workshops? If so do we target specific countries?

10.2 Recommendations

Tyned Seed Drill

Although the tyned seed drill generally operates well, there are avenues for further research that could be contemplated. These include:

Varying press wheel materials, weight, and profiles to suit different soil types and conditions.

Different point types on the tynes to suit different soil types and cultural operations. (This implement can also be set up as an inter-row cultivator)

Design and fabrication of a mounted boom spray for power tiller using the seed drill frame.

The design and fabrication of a small land leveller/road grader for two wheel tractor.

Rotary Tillage Drill

This drill, both in 100% tillage and strip tillage modes, as learned in the field performance, is more suited to clay soils, which are hard and dry on the surface. The action of the rotary blades pulverises the soil and clods, and there are more small aggregates available in the seed zone for better seed cover and pressing.

However depending on tractor blade shape and position, some soil is thrown out of the tilled slots and into the inter-row spaces and this can result in insufficient soil being available for adequate seed cover. Further work on the development of shielding to alleviate this problem could be done.

Tiller blade shape and number at each seed row position can also affect vibration throughout the whole machine as well as the overall quality of the seeding operation. Re-arrangement of blade position and number as described by Lee et al (2003) could be a

fruitful area of further development of this seed drill. In the last two months, Enamul Haque of CIMMYT Bangladesh has made up a prototype along these lines using CIMMYT funds.

The Asian manufacturers of the rotary tillage drill should seriously consider the modification to the implement that has been designed and built as part of this project.

Both Drills

Both seed drills also have potential for direct seeding of rice at the beginning of the monsoon (kharif) season. This could be the subject of further work.

Both seed drills, with little modification, can be used in bed planting systems.

The optional disc opener options have not yet been tested in Asia. (However they may be unaffordable to most small farmers).

As indicated in the rationale, these drills offer the possibility for a quantum leap in Asia smallholder farming systems. This is particularly true of rice based farming systems, which are being rapidly commercialized in many locations and often face severe labour and water shortages. Other ongoing ACIAR projects are undertaking related seed drill development. Therefore it is recommended that an Asian direct seeding rice mechanization workshop be held to compare equipment from this and other projects and to disseminate results more widely through other countries which did not participate in this project. Ideally workshop participants should be able to view a range of equipment in action.

Publicity and marketing

Although most of the basic engineering work with these seed drills has been done, there still remains the challenge of publicity and marketing of these seed rills to the farmers of the world who farm with a two wheel tractor.

11 References

11.1 References cited in report

Haque E.M., Meisner C.A., Hossain I., Justice C., Sayre K. (2004). Two-Wheel Tractor Operated Seed Drill: A Viable Crop Establishment and Resource Conservation Option. *Proc.Int. Conf.• Beijing Sponsored by CIGR, CSAM and CSAE Beijing, China 11- 14 October 2004.*

Justice, S., Haque E.M.,. Meisner C.A., Hossain I., Ganesh Sah, Tripathi, J, Rashid, M.H. Amin, M.R.. (2004). Giving South Asia Farmers a Choice: A Single Drill for Reduced and Strip Till Crops for 2-Wheel Tractors",

Proc.Int. Conf.• Beijing Sponsored by CIGR, CSAM and CSAE Beijing, China 11- 14 October 2004.

Lee, K. S., Park S. H., Park W.Y., and. Lee C. S. 2003. Strip tillage characteristics of rotary tiller blades for use in a dry land direct rice seeder

Soil and Tillage Research 71 (1) pp 25-32.

11.2 List of publications produced by project

Research reports and conference presentations

Hossain I., Esdaile R.J., Bell R.; Holland C.; Haque E., Sayre K., and Alam M. (2009)

"Actual Challenges: Developing Low Cost No-Till Seeding Technologies for Heavy Residues; Small-Scale No-Till Seeders for Two Wheel Tractors."

Proceedings Fourth World Congress on Conservation Agriculture Delhi pp 171-177

Fraser M.J. (2008). "Development of a No-till toolbar for a two wheeled power tiller."

Bachelor of Engineering project thesis. Univ. of Southern Qld. Toowoomba, Australia.

Promotional material and Instruction books

"Seed drills for two wheel tractor" - promotional brochure

"Seed drills for two wheel tractor" A video presentation of the features of two seed drills suitable for power tillers (two wheel tractors) – DVD

Power tiller rotary tillage seed drill- Instructions for use - booklet

Power tiller tined seed drill –Instructions for use - booklet

12 Appendixes

12.1 Appendix 1:

TOTAL COSTINGS SUMMARY CSE/2007/027

R.J. Esdaile	Credit
	$2,500.00
	$19,000.00
	$25,000.00
TOTAL	$46,500.00
Supplies & Services	$46,500.00

12.2 Appendix 2:

The ACIAR tined drill planting rabi crop in Bangladesh in October 2008

The ACIAR tined drill outside the CARDI workshop in Cambodia.

12.3 Appendix 3:

The ACIAR modified rotary tillage unit ready for testing in NW NSW Australia.

A locally made example of the ACIAR modified rotary tillage unit being tested in NW Bangladesh on October 2008