FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

USA00008

Weed seed termination method at harvest

PROJECT DETAILS

PROJECT CODE:	USA00008
PROJECT TITLE:	WEED SEED TERMINATION METHOD AT HARVEST
START DATE:	15.09.2009
END DATE:	28.02.2013
SUPERVISOR:	JOHN FIELKE
ORGANISATION:	THE UNIVERSITY OF SOUTH AUSTRALIA
CONTACT NAME:	JOHN FIELKE

Summary

Firstly, the project focused on understanding the performance characteristics of the Harrington Seed Destructor (HSD). Instruments were set up on the HSD Mark 2.1 (green unit). The findings provided information on the power requirements of the cage mill and ancillary equipment, harvester fan characteristics and limitations of the chaff chart type transfer of chaff from the harvester to the tow-behind mill. Information gained guided the design of HSD Mark 3 HSD (blue unit) which was subsequently commercialised by de Bruin Engineering.

Secondly, the project supported the PhD studies of Nick Berry who developed and patented an impact mill that was able to be fitted to a harvester.

Report Disclaimer

product registrations listed in PUBCRIS for current information relating to product registration.

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Old or Archival Reports (Projects that concluded in 2007 or earlier)

The information contained in these older reports is now several years old, and may have been wholly or partially superseded or built upon in subsequent work funded by GRDC or others. Readers should be aware that more recent research may be more useful for their needs. Findings related to agricultural chemical use are also potentially out of date and are not to be taken as a recommendation for their use.

Conclusions

This project has provided several major engineering improvements that will allow for mechanical destruction of weed seeds as they exit a grain harvester.

Firstly, the work has provided design improvements that have allowed reliable capture and transfer of chaff and weed seeds into the HSD.

Secondly, the work has shown, using fundamental studies of what level of impact kills a seed and how a machine applies impact to seeds, that a new generation of mechanical seed termination devices can be developed that are small enough and energy efficient so that they can be fitted into and powered by a modern grain harvester.

Recommendations

This work has shown the benefits that can be achieved by applying rigorous engineering to a problem to find an appropriate solution. Subsequent funding has been provided by GRDC through project USA00010 to further develop the concepts developed in this project.

Outcomes

Grain production around the world is continually under threat by competition from in-crop weeds. In Australia, controlling weeds costs some $1.2 billion annually ($571 million (M) chemicals, $380 M loss of yield, $206 M tillage and $25 M contamination) (Jones, 2005). In modern grain production systems, weeds are controlled through the annual use of herbicides, which have helped enable conservation agricultural practices based on minimum soil disturbance and maximum residue retention (Yu, Cairns and Powles, 2007). However, targeting weeds with herbicides provides selection pressure for weeds to evolve herbicide resistance (Powles and Yu, 2010). Herbicide resistant weeds are now widespread and threaten global food security (Powles and Yu, 2010).

An effective strategy to control the evolution of herbicide resistant weeds has been to either collect or mechanically devitalise the weed seeds in harvest residues, thus preventing viable seeds returning to the soil (Walsh, Newman and Powles, 2013). Collecting harvest residues has been a widely adopted strategy in Australia to control weed seeds through burning windrows of chaff and straw material left by a combine harvester, burning piles of chaff left by a chaff cart towed behind a combine harvester or directly baling chaff and straw that is then exported off the farm (Walsh, et al. 2013). The problem with these methods is that they remove some of the soil protection and nutrients that the residues provide and they require a post-harvest operation to burn or remove crop residues (Walsh, Harrington and Powles, 2012). An alternative method is to mechanically devitalise seeds as they exit a combine harvester by pulverising the chaff residue material.The seeds are devitalised concurrently with harvest and all residues are returned to the soil. Mechanically devitalising seeds concurrently with harvest has been a long term goal for Roy and Bailey, 1969, Reyenga, 1991, Zani, 2001, Harrington, 2009, and researchers, Balsari, Airoldi and Finassi, 1994, Hauhouot, 1998, Hauhouot, Solie, Brusewitz and Peeper, 1998, Hauhouot-O'Hara, Solie, Whitney, Peeper and Brusewitz, 1999, and Walsh, et al. 2012.

Economically, herbicide resistance is becoming such a major problem that growers are finding that the purchase of weed seed termination equipment for use during harvest is now economically viable. Hence, this project was undertaken to improve on past approaches to mechanical weed control so as to provide growers with another viable option to help control herbicide resistant weeds.

Achievements/Benefits

Objectives
The project had two objectives. The first was to study and understand the self powered tow behind HSD so as to improve upon its performance. The second was to understand what is required to devitalise (reduce its vigour or kill) annual ryegrass seeds and apply this knowledge to design an impact mill that can be integrated within and be powered by a modern large combine harvester.

Research
The University of South Australia (UniSA) commenced involvement in the HSD project in 2009 and has been focused on understanding the performance characteristics of the various versions of the HSD. The project set up instruments on the HSD Mark 2.1 (green unit) in preparation for the 2009-2010 harvest season and has collected operating data for each season since. The findings have provided information on the peak and average operating power requirements of the cage mill and ancillary equipment, fuel use of the dedicated engine in litres/hour, harvester fan characteristics and limitations of the chaff cart type air transfer of chaff from the harvester to the mill. This information was used in the design of the Mark 3 HSD (blue unit) for appropriate sizing of components and further improvements, particularly in relation to a new style of chaff transfer. This machine was subsequently built in the second half of 2010 and commenced operation in the 2010-2011 harvest. During 2010, the instrumentation on the HSD Mark 2.1 was further developed. The data collected in 2010 were able to verify the design assumptions for HSD Mark 3 and provide further information to aid in the improvement of the design and operation of the HSD as a tow-behind and trailed machine that destroys weed seeds entrained in the chaff stream that exits a grain harvester.

Parallel to this work, the project also supported the PhD research undertaken by Mr Nicholas Berry who established key parameters to mechanically terminate weed seeds such as ryegrass. These parameters were then used to understand the characteristics of the HSD cage mill and then to propose a new mill design which is suitable to be fitted on board a grain harvester. With funding being provided through GRDC Project USA00010, two Integrated Seed Destructor mills were fitted to a Case 9120 harvester and demonstrated that the concept worked. Following this work, a patent has been filed. Further work is still being undertaken to develop the concept into a commercial design.

Outcomes
The outcomes of this work were multi-faceted.
Firstly, it provided design improvements to the HSD Mark 3, particularly with respect to improving the chaff transfer into the mill. This machine has subsequently been commercialised under licence by de Bruin Engineering.
Secondly, it provided knowledge of both seed devitalisation characteristics and impact mill characteristics and developed a method to combine these factors so as to be able to predict impact mill performance.
Thirdly, it used testing to validate the HSD and impact mill performance with theoretical predictions. This has allowed optimisation of mill design to reduce size and power consumption to such a level that it can now be fitted internally to and powered by a large modern grain harvester.

Implications
Growers now have several new options to help them with controlling weeds.
- Firstly, they have an improved version of HSD that has reliable chaff transfer.
- Secondly, there is an option for an integrated weed seed terminator that can be fitted to a grain harvester.

Other research

The project has highlighted several other questions. Many with regards to the design and operation of an on-board Integrated Weed Seed Terminator are being addressed in the project USA00010. Other questions outside of the scope of the project are:
- The design of a smaller version of the on-board unit appropriate for smaller harvesters.
- The study of impact response for other weed varieties to allow predicting of their destruction by an impact mill.
- Improving the capture of more weed seeds in the front of the harvester.

- Understanding the threshing of weed seeds to ensure they are not leaving with the straw unprocessed.
- Removing the bulk of the chaff (without weed seeds) to reduce the power requirement of the impact mill.

Finally work must be undertaken to see the benefits of the developed machines in a range of farming systems and regions.

Intellectual property summary

Managed under subsequent project USA00010.

Additional information

Attachments

1. Thesis.

2. Conference proceedings article 2011.

3. Conference proceedings article 2011.

4. Conference proceedings article 2013.

5. Conference proceedings article, Spain 2012.

6. Publications and Patents list.