DEVELOPMENT OF STRIPPER HARVESTING TECHNOLOGY FOR CHICKPEAS

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Abstract. *Harvesting rain-fed chickpeas (Cicer arietinum* L.*) from fallow fields in developing countries is currently a manual process performed by laborers in a tedious manner at a low level of efficiency. A tractor-pulled harvester was built in which a chain conveyor transfer harvested material. A tractor-mounted harvester was then redesigned, which incorporated a modified stripper header to detach pods from the anchored plants together with a pneumatic conveyor mechanism. The resulting machine benefitted from being light-weight and having good maneuverability. Reduction of total losses from over 50% to close to 25% over a seven-year period confirms the potential of the prototype for commercialization.*

KEYWORDS. *DESIGN, LOSSES, MODELING, PNEUMATIC CONVEYOR, STRIPPER HEADER*

Introduction

Developing an appropriate mechanical harvester for harvesting chickpeas can be an important way to improve production. Both conventional and stripper headers (Haffar et al., 1991; Bansal & Sakr 1992; Behroozi-Lar and Huang, 2002; Siemens, 2006) was used for chickpea harvesting, but their success has been limited. Harvesting equipment contends with many challenges, including low yields, irregular and small fields, uneven ripening, low plant stature, and a high probability of shattering losses. In addition, the sparse literature concerned with chickpea harvesters reveals previous efforts to redesign the existing mechanisms for solving harvesting problems. The main aim of this article is to design a tractor-mounted stripper harvester for chickpea harvesting with acceptable performance.

Materials and Methods

Machine development

A tractor-pulled stripper harvester designed and fabricated, in which passive fingers with V-shaped slots removed chickpea pods from the anchored plant; then a batted reel sweeps the pods across the platform; and finally a chain conveyor handled the harvested material. The reel presses the anchored crop against the passive fingers and onto the platform. An adjustable screw sets the working height of the header, which glides on shoes 3-15 cm above the ground. The low stripping height is advantageous in harvesting chickpeas, which often pod close to the ground.

The harvester consists of a material handling system and a modified stripper header consisting of a platform and a ground-driven reel (Fig. 1). The header is attached on pivot points to the frame on a side at the front. A gauge wheel is used to reduce machine vibration to produce smooth movement of the header. This floating mechanism allows the header to follow the topology of the ground and reduces shattering losses. The machine width, length, and height are 270, 150, and 140 cm, respectively. The harvester was made more maneuverable by folding the header to reduce the machine width to 140 cm.

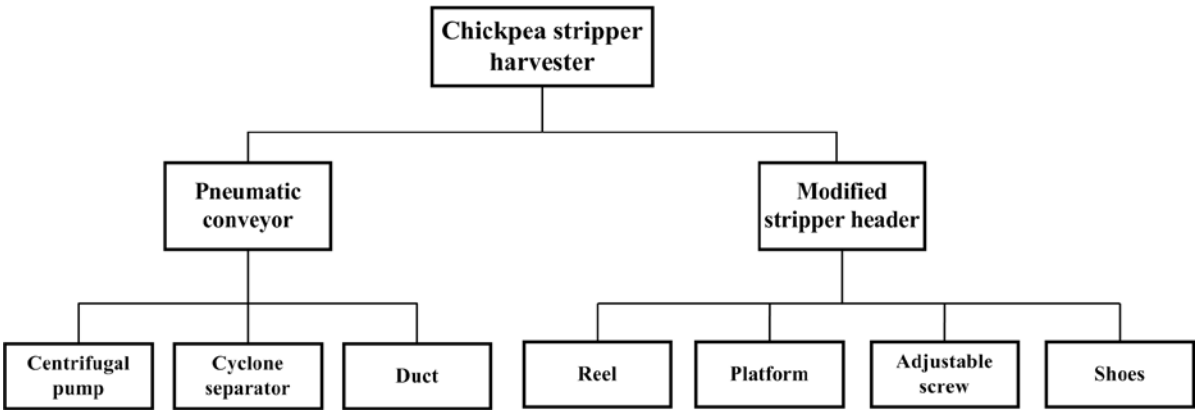

Figure 2. *Diagram for the demonstration of harvesting system for chickpeas.*

To improve machine performance, a negative pressure pneumatic conveyor was designed and constructed for dilute phase conveyance of the harvested material away from the platform to a cyclone separator (Fig. 3). This mobile vacuum conveyor was an innovative open system designed to handle grain, pods, and small pieces of straw. A fan transfers the harvested material, which falls onto the header and into the cyclone separator. A reverse engineering approach was taken to fabricate the gas-solid disengaging system based on the parameters of a conventional vacuum cleaner.

Figure 3. *Three-point hitch, rear-mounted chickpea harvester.*

The prototype's functional components were designed and improved based on machine element design, computer aided design, and a combination of trial and error and/or reverse engineering methods. The design of the harvesters (Golpira et al., 2013; Golpira, 2013) and related improvements are not discussed here.

Evaluation

Four headers, a hand-carriage experimental harvester, and two prototypes were fabricated for the evaluation of the new harvesting method over a period of years, from 2007 to 2013. The final design was tested to determine the machine performance for losses, maneuverability, and field capacity. The experiments were conducted during the summer of 2013 using a very common chickpea variety, Kabuli, on typical fallow fields. Grain was sowed using a mechanized planter with a row spacing of 35 cm and a distance of 35 cm between individual plants. Evaluation of the prototype harvester was conducted at two sites: the Dooshan farm at the Kurdistan Agricultural Research Center and the Saral farm at the Agricultural Research Station, at altitudes of 1200 and 2200 m, respectively. These two sites provided different ripening times and as a result allowed approximately two months for evaluation and improvement of the harvesting procedures.

Discussion

The low weight (350 kg) of the tractor-mounted harvester, the flexibility of the pneumatic conveyor, and the folding mechanism of the header provided good maneuverability and permitted tight turns and the ability to easily follow the crop rows. The field capacity was 0.25 ha h^{-1} and harvesting cost (excluding the operator and tractor) was 2.46 \$ ha^{-1}. Field losses during the harvesting were reduced from over 50% in 2008 to close to 25% in 2013 (Fig. 4). During this period, the pods remaining on the anchored plants were reduced from 40% to close to 10%. Losses are due to a number of causes, including lying material passed over by the platform, grain falling from the platform front-edge, and grain shattered on the ground by the reel. The former was affected largely by the platform design, while the latter depended on the reel performance.

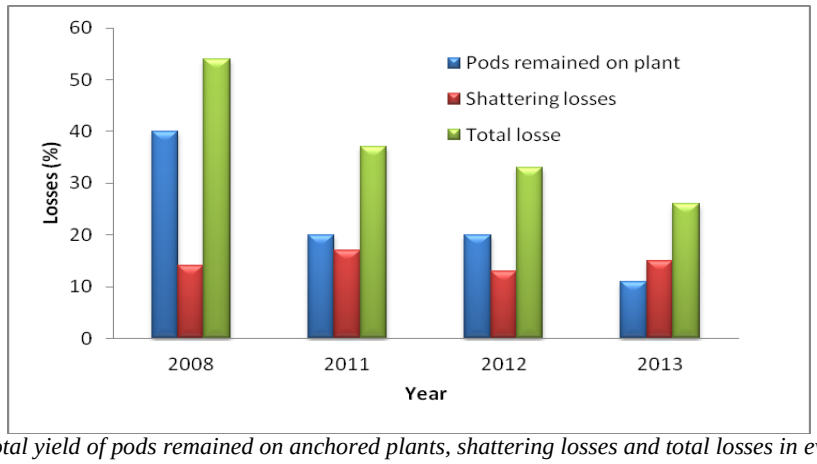

Figure 4. *Percentage of total yield of pods remained on anchored plants, shattering losses and total losses in evaluation procedure of the modified stripper harvester for chickpeas.*

Weed-free fields should allow satisfactory performance. Up-rating the conveying system, especially the feeding system and discharge port, may reduce shattering losses, which were approximately unchanged during the redesign procedure. Changing the cyclone separator to a gravity-settling chamber is also being considered in the next stage of redesign in order to reduce the weight of the machine. In addition, the continuing design enhancements suggest the potential for commercializing the new mechanism. Fabrication of the machine based on the available technology in the area gives low repairing and maintenance cost. Optimization of the header functional operators of reel and platform would enhance grain pick-up efficiency and performance.

Conclusion

A modified stripper harvester was designed and developed for harvesting chickpeas with minimal grain loss. The prototype demonstrates the potential to improve chickpea harvesting by reducing cost and time and provides a viable alternative to manual harvesting. Good performance and a low purchase price indicate the potential for commercializing the new methodology and machine.

However, care must be taken to evaluate the impact of machine harvesting on the social organization of the farming system. The displacement of people by mechanization needs to be carefully evaluated. This important issue makes the author reluctant to continue this line of research and forces him to conclude that the best overall method for harvesting chickpeas in the study areas may be a manual.

Acknowledgments

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