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STRAW YIELD MONITORING SYSTEM: A PRECISION FARMING TOOL

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ABSTRACT
Straw mass assessment to quantify the variations in crop yield within a field is viewed as an important element in understanding the farming process. Yield monitoring is one of the most important operations for efficient management of agricultural fields. This yield is found to spatially vary within the same field, where mapping this variation is considered as one of the fundamental elements of precision agriculture. This understanding can greatly help improve farming practices, productivity and in the reduction of negative environmental impacts. The traditional way of assessing straw mass is laborious and time consuming. Several manufacturers of forage harvesting machines are presently implementing mass flow sensors and bale weighing system in their machines to serve as yield monitoring systems. But these methods will give only yield of the total field. In order to obtain variation of yield data within the field, a GPS mounted yield monitoring system is got much scope in the area of straw yield monitoring.

Introduction

Straw is agriculture by-product; the dry stalks of cereal plants, after the grain and chaff have been removed. Straw makes up about half of the yield of the cereal crops such as barley, oats, rice, rye and wheat. Straws are essential for the support of ruminant animals during winter when grass growth and field conditions preclude grazing. It has many uses, including fuel, livestock bedding and fodder, thatching, basket, paper and rope making, packaging, etc. Straw is usually gathered manually or mechanically from the field and stored in stacks (loose straw) or in a straw bale (if straw is gathered mechanically), which is a bundle of straw tightly bound with twine or wire. A baler is a piece of farm machinery used to compress a cut and raked crop (such as straw, hay, etc) into compact bales that are easy to handle, transport, and store. Bales may be square, rectangular, or round, depending on the type of baler used. High-density big balers have been commercially available for 25 years for the baling of crop residues after combine harvesting (Maguire *et al*., 2007). Knowledge of bale weights would provide a measure of variability in weight; the mean bale weight, the total field crop weight and yield; the possibility of a closed-loop bale density control system; and the production of yield maps showing the crop distribution throughout the field.

Precision agriculture (PA) is a process or technique which involves collecting, interpreting, planning, and use of data about a field and crop. This requires the use of various technologies, including yield monitoring systems. A yield monitoring system can be considered a logical first step in precision agriculture because it provides the farmer information about the yield of a crop as it is harvested in real time. This yield was found to vary spatially within the same field, where mapping this variation (yield mapping) is considered as one of the fundamental elements of PA. A yield monitoring system for straw and forage will allow a farmer to identify areas of his fields that are productive and other

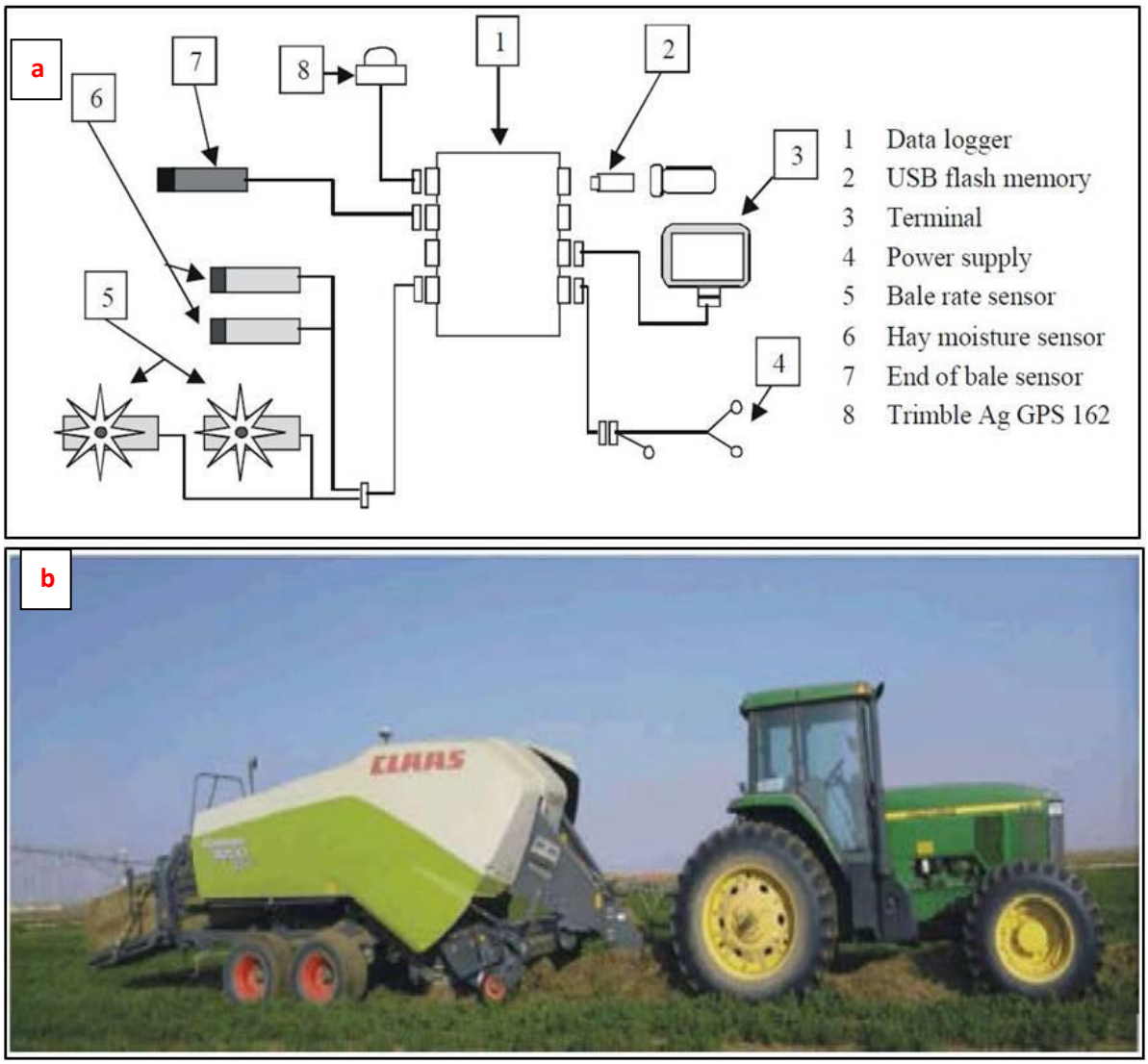

Fig. 1. a: Schematic diagram of yield monitoring system; b: Straw baler mounted with yield monitoring system (Kayad *et al*., 2015)

areas that are not. The farmer can then gather soil nutrient and topography information, fertilizer and chemical input information. By combining all this information using computer software, he can develop prescription map that will show him the areas of the field where he needs to apply less fertilizer and chemicals to optimize his crop yield, and other areas where he have to avoid application to reduce the chance of the chemicals and fertilizers leaching into water sources. In this way, a yield monitor becomes a management tool that helps a farmer to become a better environmental steward, and he can demonstrate his social responsibility. The traditional way of assessing biomass of forage crops is laborious and time consuming hence baler with yield monitoring systems is projected as an alternative to the traditional one.

Types of straw yield monitoring system in baler

The fundamental pieces of yield monitoring system are mass flow sensor, moisture sensor, GPS receiver and yield monitor (one such system is shown in Fig. 1). The load cells and instrumented trailers are used to accumulate and record the weight of crop bale continuously as straw being baled and thrown to the trailer. In this instance, trailer follows the baler and is most common practice in case of small balers. Straw yield on the large square baler is being estimated by plunger force pulse width, bale displacement velocity through bale chamber (by measuring feed roll displacement using load cells with springs, vertical displacement transducer and linear potentiometer) and weight of bale on the bale chute. Directly weighing the

bale on the chute is the most successful approach among the others. This mechanism isolates the current bale weight as it passes over the centre of a pivot. The bale is then held briefly by a braking mechanism before being released to the ground and uses load cells on a bale receiving structure at the rear of the baler, which weighs individual bales (Kayad *et al*., 2015). Round balers are equipped with a load cell based weighing system to form crop yield monitoring system during baling process. A star wheel encoder to measure bale displacement inside the baler chamber, which will be correlated to the straw mass flow rates are developed for straw yield monitoring in large square balers. The moisture content of the straw being baled also important to record as it affects the quality of the feed and its capability to be stored. It is also necessary to determine dry matter (DM) yields as straw is usually composed of large and variable amounts of moisture. It is very essential to have differential GPS (example: Trimble Ag GPS 162) with yield monitoring system for geo-referencing the bales and to record yield spatially so that yield of crop can be mapped (yield mapping).

Conclusion

Yield monitoring is an aspect of PA that helps to provide farmers with adequate information to make educated decisions about their fields. Straw yield monitoring system work in three very simple steps: measurement of straw moisture content, total number of bales and weight of individual bales by using sensors. As both of these sensors works, the information is sent to the driver cab and is displayed on a screen, as well, the information is geo-referenced so it can be mapped as well as closely investigated on a later time or date.

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