Monitoring of the Combine with Smart Devices in Soybean Harvesting

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Abstract. GIS technology based on real-time smart devices, including GPS devices and sensors will be widely used in agricultural technology. Therefore, this technology is being expected in crop harvesting process. One of the most important processes in soybean cultivation is the efficient use of combines and harvesting without loss of harvest. The grain harvester combine Dominator-130 equipped with GPS receiver and grain level sensor was researched in harvesting the soybean. According to results of experiments, during the harvesting of soybean the grain cleanness in a tank of the combine harvester Dominator-130 made up 95.9 per cent, grain loss in a thresher of combine made up 0.7 per cent, these indexes answer to the demands, however in a reaper of combine harvester the grain loss and damaging of grain were higher than demand. Therefore, it is important to define the optimal technological parameters and working regimes that give opportunity to decrease the loss of grain in the reaper of combine and damaging of grain in the thresher of combine for harvesting the soybean.
Keywords: GIS, soybean harvesting, GPS, combine, grain sensor, real time, working efficiency.

1 Introduction

Significant work is being done in Uzbekistan on large-scale cultivation of soybeans as a primary and secondary crop. However, there are still a number of difficulties in soybean harvesting due to the peculiarities of this crop and the methods and means of harvesting it at the required level, taking into account the conditions of different regions. One of the most important processes in soybean cultivation is the efficient use of combines and harvesting without loss of harvest. At present, in Uzbekistan, the use of combiners is Dominator-130, New Holland TS-5060 and many others, but most are Dominator-130 combines. Recently, agricultural technology has been widely used in GIS technology based on real-time Smart devices, including GPS devices and sensors.

In Japan, several agricultural robots had been developed, the tractor robot working autonomously using RTK-GPS and FOG [1], the tractor robot that followed the path by D-

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GPS and Geomagnetism Sensor [2-3], the paddy trans-plant robot using RTK-GPS and IMU [4-6], the weeding robot based on the paddy trans-plant robot using RTK-GPS and IMU on paddy field [7], the head feeding type combine robot that able to go straight and turn using GPS, and the rice combine harvester robot using CAN Bus network with RTK-GPS and GPS compass [8]. Each operation like cultivation, planting and harvesting are developed to work autonomously on the field. An automation of agricultural machinery has been studied in the world in the same way.

However, the sensors used in these agricultural robots are very expensive and it is necessary to find cost-effective ways to develop these robots. According to this M.Saito studied that a robot combine harvester for beans was developed using a conventional bean combine harvester adopting a CAN Bus network, handheld sensing devices. The harvesting efficiency was also developed by harvesting and unloading crops simultaneously [9].

As a result his work a robot combine harvester for beans was developed using CAN Bus network. Two sensors are connected to the CAN Bus; a RTK-GPS to locate the position, and a GPS Compass to detect the heading direction. This robot is programmed to perform autonomous operation such as moving forward, backward, and turning in right angle. When the robot was tested in harvesting soybeans on a 100 m × 30m rectangular field, the deviations between the target path and the robot's traveling path was approximately 0.07m RMS, and the yaw angle error was approximately 1.82° RMS along the long side of the field. Therefore this robot can work autonomously along the target path without overlapping and shortening. In addition, this robot can unload harvested grain to adjacent transport truck during harvesting operation, which improved harvesting capacity to approximately 10% [10].

Much research has been done on soybean harvesting and new methods and techniques have been developed. Nowadays, in world practice, combines are used as grain harvesters equipped with headers that are not adapted for soybean harvesting.

Although there are developments and recommendations on the quality of soybean harvesting worldwide, there are no studies on the quality of soybean harvesting with the GIS technology-based smart combine. That is why it is important to study this combine in soybean collection and to identify performance indicators.

2 Materials and methods

The experiments were carried out in the fields of Agrobioholding LLC, located in Yangiyul district of Tashkent region.

The threshing and cleaning components of the grain harvester remain unchanged and are used only with their technological parameters adjusted and operating modes adjusted. Where soybeans are cultivated in small areas, small techniques have also been developed for its collection [11-13]. Although soybeans are ripe, their stems are high in moisture, making it difficult to harvest from the combine. Therefore, a method for decontamination is recommended [14-15].

The field size where experiment performed was larger than other regions, the moisture of the crop was not higher. Therefore, there was not need to use small technics and desiccation plants.

During the experiments, the width of the Dominator-130 combine was 4.2 m, the drum rotation frequency was 1200 rpm, the hole inclination between the drum and its deck was 13 mm, the exit angle was 3 mm, and the open angle 30 cm. The number of ventilation cycles was 800 rpm. Harvest height was 5-10 cm depending on the mass of the stem and the working speed was 4-5 km/h.

The key performance indicators were the combine's real-time performance, grain losses, grain cleaning and damage in the bunker. The combine's real-time performance was determined by subtracting salts and stops on the GPS receiver and grain level sensor data. Grain losses were obtained separately by combine harvester and crusher. Grain purity and damage were extracted from the grains in the bunker, separating the whole grain and the damaged grain and foreign impurities and found by their ratio.

In experiments at first the condition of crops before harvesting, namely description of the agro background was defined.

According to experiments the height of the soybean stalk that harvested is average 85 cm, average quadratic declination is 13.6 cm, diameter of the stalk in bottom cutting part is average (7.1 ± 0.37) mm. There are average 29.8 pieces of pod on a plant, the lowest pod is located on average 6.2 cm height from the land, there are 2-3 pieces of grain that is 6.3 gram in one pod and the ratio of grain than stalk consists of 1:1.8.

After defining the harvesting condition in the field where combine works, it was started to harvest the soybean (fig.1) and according to research method its work quality indicators were defined.

Fig. 1. Process of harvesting soybean with combine Dominator-130.

Fig. 2. GPS receiver Teltonika FMB920 installed in combine Dominator-130.

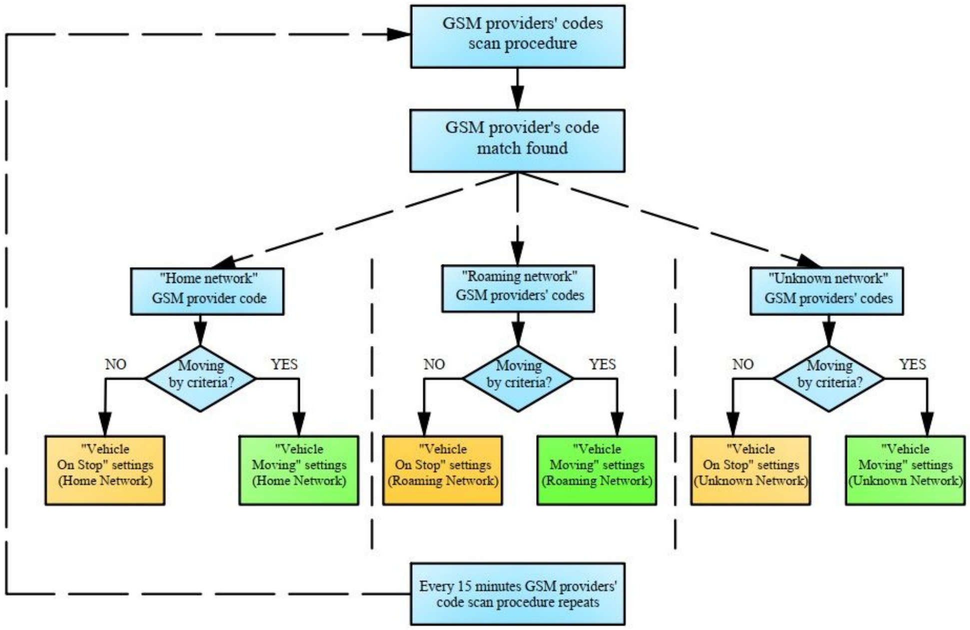

Fig. 3. Regime of GPS recording date.

3 Results and discussion

According to analyzing the results of experiments, work indicators of the combine in soybean harvesting were more different than indicators for harvesting other sorts of crops (look at the table). It was known that from experimental results, the work efficiency of combine Dominator-130 for harvesting the soybean in mainly time consists of 1.1 ha/hour.

The grain loss was observed only in cutting unit of the combine and made up 5.34 per cent. Grain losses on the Dominator-130 combine occurred mainly in the form of legumes that were not cut below the harvest height, resulting in a larger grain loss index.

Table 1. Quality indicators of work on soybean harvesting of combine Dominator-130

Work quality indicators	The amount of work quality indicators
Capacity in main time (ha/h)	1.1
Grain loss (%) - in combine header - in combine thresher unit	 5.34 0.7
Grain cleanliness in grain tank (%)	95.9
Grain losses (%)	7.8

It is also important to pay attention to the period of harvesting soybeans, and studies have also shown that early or late harvest can have a significant impact on grain and its quality [16-19].

Worldwide, soybeans are harvested mainly in combines, with the most common loss being grain spills [20, 21]. Grain loss depends on many factors, and one of the main ways to prevent it is to develop appropriate harvesting techniques for each crop. Therefore, every soybean in the US has appropriate recommendations for its harvesting [15].

In addition, the mechanical damage caused by combine harvester blades was revealed as a result of grain spills and death. Grain clearance in the bunker was relatively good at 95.9%, despite the presence of weeds in the field. Grain damage was also significantly higher than the target and was 7.8%.

4 Conclusion

According to the results of experimental studies, grain harvester combine Dominator-130 equipped with GPS receiver and grain level sensor was tested in soybean harvesting showed that grain cleanliness in tank is 95.9 %, and the loss of grain in combine thresher unit is 0.7%. However, the loss of grain in the header combine harvester is 5.34 % and the grain damage is 7.8 %, which is higher than the set requirements. Therefore, further research will need to identify parameters and modes of operation that reduce grain loss and damage to combine harvester and crusher.

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