



## Determine Sugarcane harvester field efficiency using global positioning system (GPS) data

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### ARTICLE INFO

#### Article history:

Received: 27 December 2012;

Received in revised form:

18 November 2015;

Accepted: 23 November 2015;

#### Keywords

Sugarcane,  
GPS,  
Energy,  
Machine.

### ABSTRACT

Population growth and increase need greater utilization of resources such as food, water, soil, energy, machinery, manpower and other inputs lead to use them more than last era for earn more production. And better management methods; minimize operational cost to reach maximum profitability more attention is placed on agricultural systems. Since sugar cane is one of the major plants under cultivation in the septet agro industry reach to 84000 hectares in Khuzestan province and a case study is Karun agro industry that has total area 40000 hectare which currently 25000 hectare is arable. On the other hand one of the most expenses in each agricultural production systems is machinery cost, increase in efficiency of farm machinery can affect on production costs. As regards in most cases manager of agricultural mechanization unit don't know exactly how can use the machinery in different farm operation (tillage, planting, intercultural and harvest) at optimum condition and detect factors that lead to decrease in field efficiency. So consideration of farm machinery field efficiency is necessary. Between farm Operation, sugar cane harvesting is more important because have high volume of work. The purpose of this article is to show how Global Positioning Systems, or GPS data, can provide very useful information about the efficiency of sugarcane harvester. In the past, calculation of field efficiency was very difficult, time consuming, and required someone with a stopwatch on-site during operation. But now by combining GPS data in other software like: Garmin Map source, Google earth and Arch map can be used to produce maps of navigation and obtain farm machinery management factors like field efficiency, material capacity and field index that were calculate for this study 69%, 51.5 ton/hour and 63% respectively.

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### Introduction

With the development of agricultural mechanization, agricultural machines as well as management's renewed focus on agriculture, It has proven experience in the management of agricultural machines with capital, land and labor in order to gain the benefits of these three factors, it is important (randal et al, 2002) Given the increasing world population need to optimize production, increase production per unit area is more important and decisive factor is considered. Climatic constraints, time and labor are the main obstacles in the production path are generated Sugarcane is also not the exception to increase the area under sugarcane cultivation and the use of farm machinery for agricultural operations likes land preparation, planting, interculture, rationing, harvesting and material handling is essential. Harvesting operation done with Austoft Case IH 7000 Series.

Quantity of sugarcane harvesting in first year of plant field reached to 130 ton.ha<sup>-1</sup> and in normal situation should not less than 70 ton.ha<sup>-1</sup>. First year of harvesting sugarcane fields named as plant farm and 2<sup>nd</sup> year far 6<sup>th</sup> named as ratoon farms Sugarcane handling to the factory by cane transporter after harvesting (Lowenberg et al, 2006). Between sugarcane farm operation, harvest is very important and have high workload. Aims of this study are methods of using global positioning

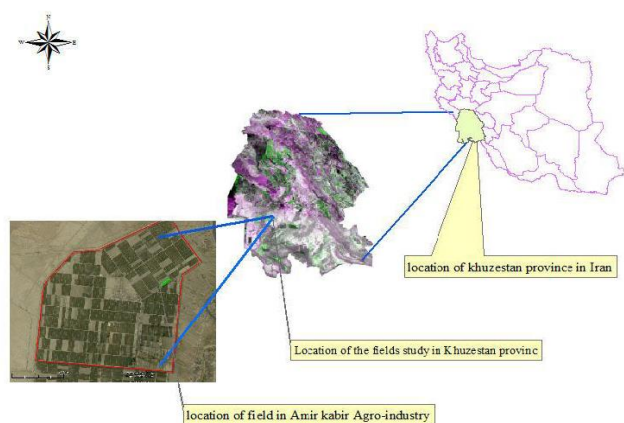
system data which can provide usable information to calculate field efficiency of sugarcane harvester machine. There are three factors that affect how a machine is utilized in the field: operator, machine, and field characteristics (such as field size, shape, topography, layout, row length, row-end turning space and field conditions that affect how fast one can drive in the field). In the past, calculating factors such as field efficiency was very difficult, time consuming, and required someone with a stopwatch on-site during operation. Now, GPS can be used to obtain this information much faster and simpler (Ehsani, 2010). Also Ruiz et al 2011, use Correction system of differential global positioning system to map the planting row crops on transplanting tomato seedlings was used. Topakci et al, 2010, are examined Improving farm efficiency measurement using GPS systems to apply precise inputs in agriculture.

### Material and methods:

#### Description of study area

This field study was conducted in Amir kabir Agro-industry (31°03'N, 48°14'E) 45 km south of Khuzestan province, Figure 1 shows the location of the field study in Iran, Khuzestan province and Amir Kabir sugarcane Agro-industry. This region has a mean annual rainfall of about 147.1 mm, air temperature is 25 C, soil temperature at 50 cm depth is 21.2o C and Average elevation is 7m above sea level.





**Fig1. Location of the study fields in south of Ahvaz, Khuzestan province, Iran**

The site has been under sugarcane (*Saccharum officinarum* sp.) monoculture during the last 14 years. Each sugarcane field represents a rectangular of approximately 25 ha (250 m width × 1000 m long). Sugarcane is harvested from November to March each year by using the Case IH-Austoft series 7000 harvesters. Photograph (Figure 2) shows the sugarcane ratoon field (during harvesting operation).



**Fig 2. Sugarcane harvesting operation**

#### GPS receiver with cable

Oregon550 series used in this study is manufactured by Garmin Company (figure 3). With features like touch screen to switch apps, Digital compass, Trip computer (which can be completed quickly, departure time, stop time, the place and time of origin and destination to calculate etc.), barometric altimeter, Images taken with a resolution of 3.2 MP, map of the whole world and Iran, Also have the ability to calculate the area of an irregular polygon, the ability to record the time intervals of arbitrary memory locations which some of this feature has been used in research.

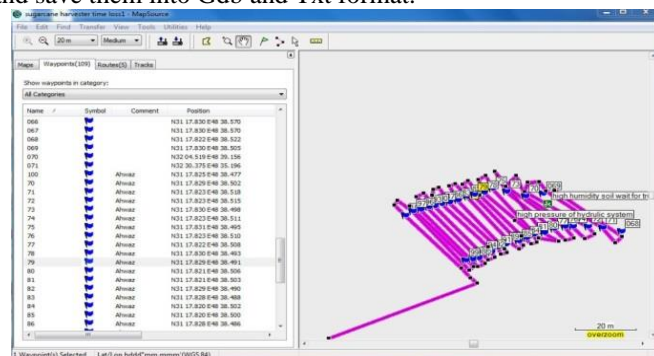


**Fig 3. Oregon 550 Garmin series GPS which used in research**

#### Garmin Map source software

After recording the GPS waypoints interval in each 5 second within the farm during harvest, Garmin map source

software needs to be processed points (Figure 4). By cable to connect the device to the computer input port to the discharge port information through the "received information from device" and save them into Gdb and Txt format.



**Fig 3. Discharge waypoint along Routes**  
**Transfer waypoints from Garmin map source into Google earth software**

After connecting the USB cable from the computer to the GPS device, Google earth software setup and GPS options from tools tab and immediately select the Import option. After input recorded waypoints and routes we can clearly track of sugarcane harvester machine in during operation between furrows, delay time for receiving cane transporter, time of Stuck in the mud due to high humidity, Troubleshooting and servicing time and at finally we can use them to evaluate machine work rate at determining accurate field efficiency and delay times.

#### Using trip computer page

Work time study is a basic technique for the measurement of time is because it is derived from direct observations. When working directly study the best option for repeatable operations such as tillage, disk, harvesting, loading and transportation of sugarcane. This technique to study the various factors involved in the operation, is cumulative time. At the beginning and end of each farrow is recorded as given in the form of time (for example, Table 1, Appendix). Trip computer using a stopwatch and time intervals during the harvest period in each row around the farm, waiting for the basket (time off), remove the retention and destruction of records and the process is compiled in Table 1. In addition to the data shown in Table 1, the product belongs to the study of field conditions and is generally viewed as the interpretation of the observation is recorded. After extracting data into computer by Microsoft excel version 10 percentage of time when each factor is also calculated. Also spatial data and map the movement of farm machinery on the Map source software and can be seen on Google earth. Sugarcane harvest machine performance by using the information listed and also obtained information on the farm, such as planting distances between rows, the rows and yield per hectare is evaluated. Harvester Operations by using GPS data during the study are shown in Figure 4.

#### Field efficiency

Field efficiency (ASAE S495) ratio of effective field capacity to theoretical field capacity, expressed as decimal value. Calculating field efficiency to failure (exhaustion) or failure in applying the theory of working within machine delay times due to operator ability, habits, and use methods and properties of the field. Move to the field and back to the farm, major repairs, preventive maintenance, and daily maintenance activities in the field can be computed efficiently and are not involved. Field efficiency of a machine is not a constant factor but the size and shape of the field pattern field operations,



product performance, product moisture content and other conditions are changing.

The increased loss time involved in the following activities in the field and is measurable

- move around freely
- Material Handling
- Seed
- Fertilizer
- Chemicals
- Water
- Material harvested
- Cleaning equipment hunk
- Set the machine
- Lubrication and refueling (except for daily service)

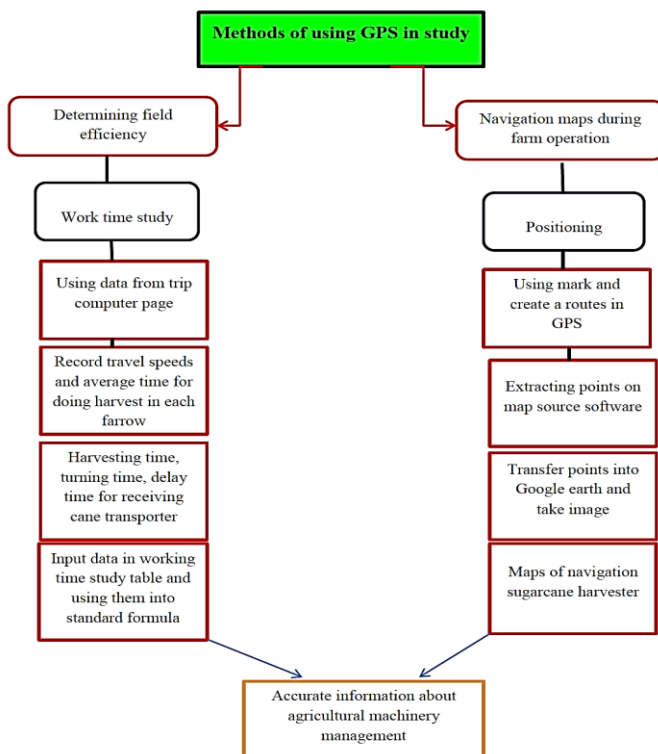


Fig 4. Flow chart of methods using GPS data into study

#### Theoretical field efficiency

$$Cat = \frac{v \cdot w}{10}$$

Where:

Cat= theoretical field efficiency (ha.h<sup>-1</sup>)

V= travel speed (km.h<sup>-1</sup>)

W= width of work (m)

$$Cat = \frac{6 \times 1.83}{10} = 0.78$$

#### Requirement theoretical time

$$Tt = \frac{A}{Cat}$$

Where:

Tt= theoretical time for field operation (h)

A= area under cultivation (ha)

Cat= theoretical field efficiency (ha.h<sup>-1</sup>)

$$Tt = \frac{1}{0.78} = 1.28$$

#### Effective time for farm operation

$$Te = \frac{Tt}{Kw}$$

Where:

Te: effective time for farm operation (h)

Tt= theoretical time for field operation (h)

Kw= effective width of work that used (m) which about sugarcane harvester equal 1.83m

$$Te = \frac{1.28}{1.83} = 0.69hr = 41min$$

#### Sugarcane harvester field efficiency

$$\eta f = \frac{Tt}{Ts + Th + Ta} \times 100$$

Where:

□f= field efficiency (%)

Tt= theoretical time for field operation (h)

Te: effective time for farm operation (h)

Th: delay time which are not proportional area under cultivation (h)

Ta: losses time are proportional with area under cultivation (h)

$$\eta f = \frac{78min}{59 + 29 + 24} \times 100 = 69\%$$

#### Machine field index

$$FI = \frac{Ts}{Ts + Tr} \times 100$$

Where:

FI= machine field index (%)

Tr= turning time of machine (h)

Te: effective time for farm operation (h)

$$FI = \frac{59}{41 + 52} \times 100 = 63\%$$

#### Sugarcane harvester effective material capacity

$$Cm = \frac{v \cdot w \cdot y \cdot \eta f}{10}$$

Where:

Cm= material capacity of machine (ton.ha<sup>-1</sup>)

V= travel speed (km.h<sup>-1</sup>)

W= width of work (m)

Y= yield of crop (ton.ha<sup>-1</sup>)

□f= field efficiency (%)

$$Cm = \frac{6 \times 1.83 \times 68 \times 0.69}{10} = 51. \frac{5ton}{hr}$$

#### Result and discussion:

The ability to improve yield is an important step in improving farm management, agricultural machines is considered. There are several reasons why a machine must be having certain field efficiency. Some of the time losses that occur during the operation another casualty of the planning and management can be eliminated. The factors that could cause the time losses can cited to do not have enough experience and skill sugar cane harvester operator, Filling cane transporter and lack of coordination between tractor drivers and sugarcane harvester operator, evacuation procedures, and conditions around the farm, troubleshooting and fixing and servicing machine, time for rest. This study was conduct on burned sugarcane farm and sugarcane was having in lodge situation. Factors that had an impact on the performance sugarcane harvester:

By surveying of gain results from work time study and consider the views of management factor and research in the field which agrees with the findings of Meyer (1999) has also been Several factors influencing the sugarcane harvester performance was taken that these factors respectively:

- Terrain features (slopes, terrain)
- Soil type and moisture
- Varieties of sugarcane (being brittle, have fewer leaves)



**Table1. Sugarcane harvester work time study sample data**

types of machines: Austoft 7000						Study location: Amir Kabir Agro-Industry						Date: 2011	
Crop condition: lodge						types of soil: silt-clay-loam						Field number: ARC3-20	
distance between rows: 183 cm						Soil humidity: between 14-%18						Sugarcane variety: CP 69	
Length of farrow: 250meter						Slope: 1%						Average yield: 68 ton/ha	
Different times which records in field												Evaluate factors	
sec	min	sec	min	sec	min	sec	min	sec	min	sec	min		
15	4	03	4	30	8	48	3	03	5	02	5		Harvest cane
30	1	58	1	53	1	26	1	17	1	06	1		Turning time
54	2	24	3	22	1	30	1	20	3	04	3		Delay time for cane transporter
50	40	04	12										Troubleshooting and servicing time
*After finishing harvest operation in experiment field, average times of harvest, delay time of turning Calculated separately for each part of the field and get the value of farm output, the timing and terms are useful.													
*Bypass time (getting closer to finishing with the smaller radius around the farm level to start gradually declining) scratch work to the end of a downtrend.													
*Delays in carrying cane transporter cause to emptying system and vary distance between farms to factory.													

- Cane yield per unit area
  - The straw (harvested green or burnt standing or lying in the straw)
  - Field conditions (field size, distance between rows, the rows, and the space around the farm)
  - Distance transport and unload
  - Total capacity into straw baskets shipped farm
  - Operator Skills
  - Compliance status with the distances between rows during harvesting machine working width
- All these factors affect the sugarcane harvester performance by following titles:
- Harvesting time
  - Turning time
  - Losses time
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