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***Journal of Scientific and Engineering Research*, 2023, 10(9):35-41**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Mechanization of Wheat Growing in Thrace Region and Evaluation for Smart Farming Applications

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Abstract Aim of this research was to determine mechanization and agricultural inputs usage to suggest what smart farming applications can be used in wheat production in the Thrace Region, Turkey. Agricultural, machinery types, application time of field operations and amounts of inputs were determined. Fuel consumption, machine and human time requirements from tillage to harvest were evaluated for smart agriculture applications. Field operations in wheat growing generally start in August-September and continue until June-July of the following year in Thrace Region. Fuel consumption and time requirement of agricultural machinery operations were determined as 118.0 l/ha and 3.92 h/ha. It was determined that there are 15 field operations and 10 different agricultural machineries used from tillage to harvest. Agricultural machineries were plough, chisel plough, disc harrow, cultivator, fertilizer spreader, toothed harrow, sowing, roller, field sprayer, and combine harvester. When wheat production was evaluated in terms of smart agriculture; in particular, variable rate application of inputs such as fertilizer, pesticide with sensors, yield mapping, determination of NDVI by unmanned aerial vehicles and variable rate fertilization and spraying were the first possible applications. In addition, instead of map-based variable rate applications, sensor-based variable rate agricultural inputs determine input as real time by sensors and send the application command to the machine behind the tractor. Another suggestion is to make soil and plant analyses by using sensors. Combine harvesters used in wheat harvest are mostly rented. Yield and grain quality maps can be obtained when a location-based yield measurement system is installed on these combines.

Keywords precision agriculture, wheat, field operations, agricultural inputs

1. Introduction

Thrace Region is located of the European Part of Turkey (Figure 1). Instead of one of the well-developed industrialized area, Thrace Region has also important agricultural production.

A large portion of Thrace Region has been used for growing of field crops such as wheat, sunflower, canola, rice, maize [1]. Total sown area was 993 913.1 ha. In 2021 [2]. Agriculture is the one of the important income sources in Edirne, Kirklareli and Tekirdağ Cities of Thrace Region. Agricultural production value of the Region was obtained from plant production (79.13%) and animal production (20.87%). Wheat, sunflower and rice are the most important crops in this Region. In addition, canola, sugar beet, grape, apple have been growing. Mean size of farm area is approximately 7 ha. Instead of the mean size is higher than Turkey's average farm size 5 ha, 37% of farms are lower than 5 ha. in Thrace Region. Economic income of the farmers is small because of small scale farms and non-irrigated agricultural crop production [3].

Figure 1. Thrace Region of Turkey [2]

In this study, mechanization of the wheat growing in Thrace Region was evaluated for possible precision agriculture applications such as variable rate fertilizations, and controlled traffic farming. In addition, projects carried out in Tekirdağ Namık Kemal University, Department of Biosystems Engineering were explained.

2. Materials and Methods

Machine type and size, field size, crop, soil type and working conditions affect fuels consumption, effective machine capacity and labour requirement of field operations in field crops growing. Agricultural machinery type, size, application time of agricultural practices and amount of agricultural inputs were determined for wheat widely produced in Thrace Region. Field operations, machine type, time, speed, effective machine capacity, fuel consumption and human labour requirement were determined by using questionaries with farmers in Thrace Region. Fuel consumption of each procedure and time requirements of field operations were determined from research studies, articles and surveys [4]. Daily working hour accepted as 10 hour per day. Field efficiency data of the agricultural machines were taken from [5], [6], [7]. Collected data were used to calculate effective field capacity (h/ha), efficiency of effective field capacity field capacity (%), total fuel consumption (l/ha), fuel consumption percentage in total fuel consumption (%) for each operation, total man labour requirement (h/ha) and percentage of man labour requirement in total man labour requirement (%) for each field operations [8].

3. Results and discussion

Results of the wheat mechanization were given in Table 1 for wheat [4].

Table 1. Wheat mechanization

Field operations / Agricultural Machines	Time/Months	Working Width (m)	Speed (km/h)	Efficiency (%)	Effective Field Capacity (ha/h)	Fuel (l/ha)	Man labour (h/ha)
Plough	August- September	1.4	6	0.80	0.67	30.0	1.190
Disc harrow	September	3.0	10	0.85	2.55	12.0	0.333
Cultivator	September October	4.0	13	0.80	4.16	7.0	0.192
Centrifugal fertilizer spreader	October	16.0	14	0.70	15.68	3.5	0.045
Roller	October	4.0	17	0.80	5.44	4.5	0.147
Sowing machine	October	4.0	12	0.70	2.24	12.0	0.208
Roller	October	5.0	13	0.85	5.53	4.5	0.308
Centrifugal Fertiliser spreader	January-February	16.0	14	0.70	15.68	3.5	0.045
Sprayer	February	16.0	14	0.65	14.56	3.5	0.045
Sprayer	March	16.0	14	0.65	14.56	3.5	0.089

Centrifugal Fertiliser spreader	March-April	16.0	14	0.70	15.68	3.5	0.089
Sprayer	April	16.0	14	0.65	14.56	3.5	0.089
Sprayer	May	16.0	14	0.65	14.56	3.5	0.089
Sprayer	May-June	16.0	14	0.65	14.56	3.5	0.089
Combine	June-July	5.2	4	0.70	1.46	20.0	0.962
TOTAL						**118.0**	**3.920**

According to the results; field operation was started on August and finished on June. There were 15 field operations for soil tillage, fertilization, sowing, spraying and harvesting. Plough, disc harrow, cultivator, centrifugal fertilizer spreader, roller, sowing machine, sprayer and combine were used. Total fuel consumption was 118 l/ha. Man labour-hour requirement were determined as 3.92 h/ha. All field operations were realized by machine in wheat production.

Precision Agriculture Projects in Tekirdag Namik Kemal University

Precision Farming is the term given to a method of crop management by which areas of crop within a field may be managed with different levels of input. The benefits of so doing are three- fold: the economic margin from crop production may be increased by improvements in yield or a reduction in inputs, the risk to environmental pollution from agrochemicals applied at greater levels than those required by the crop can be reduced, greater assurance from precise targeting and recording of field applications to improve traceability, and it is an excellent example of where both economic and environmental considerations are working together [9]. Precision farming as a farm management system is very important for Turkey because Turkey has 23.473 million hectares of arable land and Turkish farmers used 12.546 million tonnes of fertilisers and 52 965 tonnes of pesticides for agricultural production in 2021 [2]. Optimal use of agricultural inputs is vital for environment, health and production cost. Precision farming technologies is to establish variable rate applications to protect environment and decrease production cost.

Research Projects carried out in Tekirdağ Namık Kemal University; Department of Biosystem Engineering Department were summarized below.

Soil Sampling

The soil sampling machine can take samples from the soil depth of maximum 30 cm in the resistance of 10 MPa. The depth can be adjusted between 10-30 cm by being changed with the help of limit switches. In order to take sample away from auger, a form of sonde was integrated with the auger. As a result of this, the soil samples taken from the adjusted hole were kept homogenous [10].

The machine can work with two different types of probes with 1,2 cm. and 2,4 cm inner diameter. Depending on the probe diameter, a sample with 34 cm^3 -136 cm^3 volume can be taken from one sampling. The required amount of sampling was reached by increasing sampling number. Parts of soil sampling machine were given in Figure 1 and general dimensions can be seen in Figure 2.

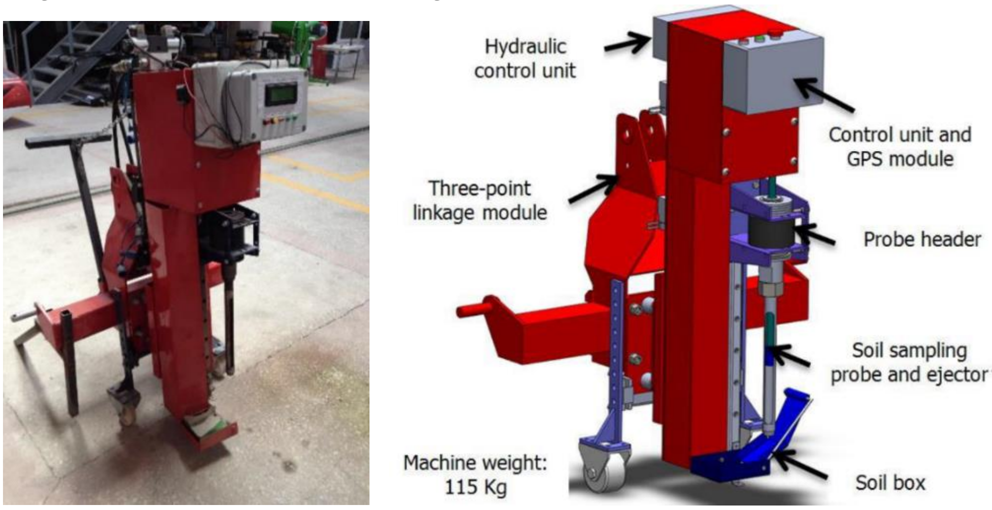

Figure 2. General view and important parts of soil sampling machine

Variable Rate Applications

Variable Rate Fertilization

A variable rate controller for centrifugal fertilizer spreader machine was developed by [11], In addition, different type variable rate controller was also developed by [12]. Step motors were used to realize variable rate application for these machines (Figure 3). A special electronic control system was designed for control step motors (Figure 4). A DGPS system was also used to determine positioning. Specific software was used to communicate variable rate system such as step motor, computer, DGPS (Figure 5). These systems were tested for determination of the performance [13].

Figure 3. Fertiliser spreader machine with double discs

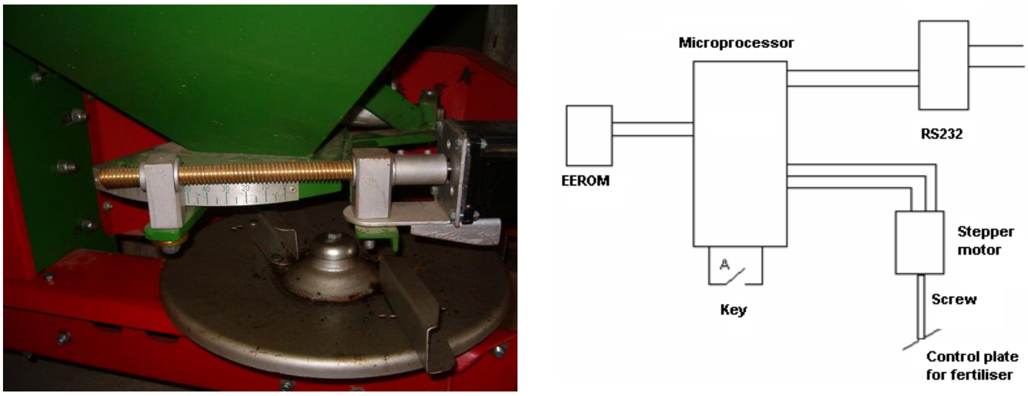

Figure 4. Variable rate controller for centrifugal fertiliser spreader

Map based variable rate control systems generally require a prescription or application map software.. A special application map software was developed by [14].

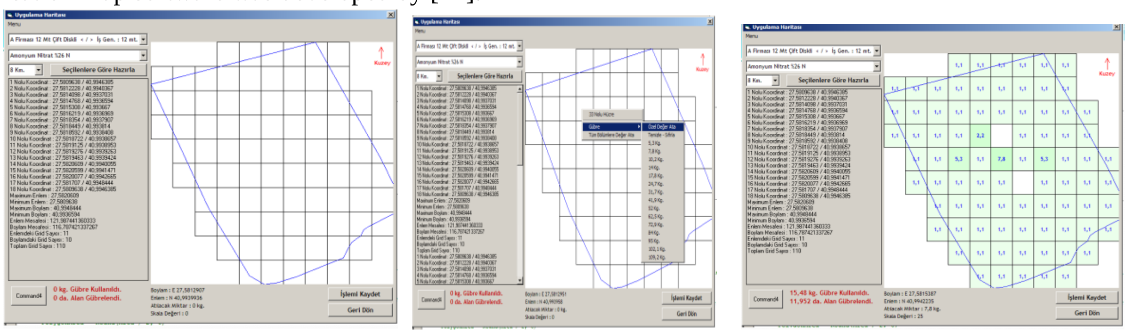

Figure 5. Screen views of the variable rate application software

A variable rate controller for combine cereal sowing machines was developed by [15]. This system controlled by step motors is an alternative instead of expensive and heavy technological variable rate application controllers, Stepper motors, Excel-based application map and GPS signals to be processed and controlled by the control unit (Figure 6). Elements of the modular variable rate controller system, stepper motors, GPS antenna, stepper motor control circuit and electronic control unit. During laboratory tests, the developed system did not create any problem for communication between stepper motors and electronic control unit.

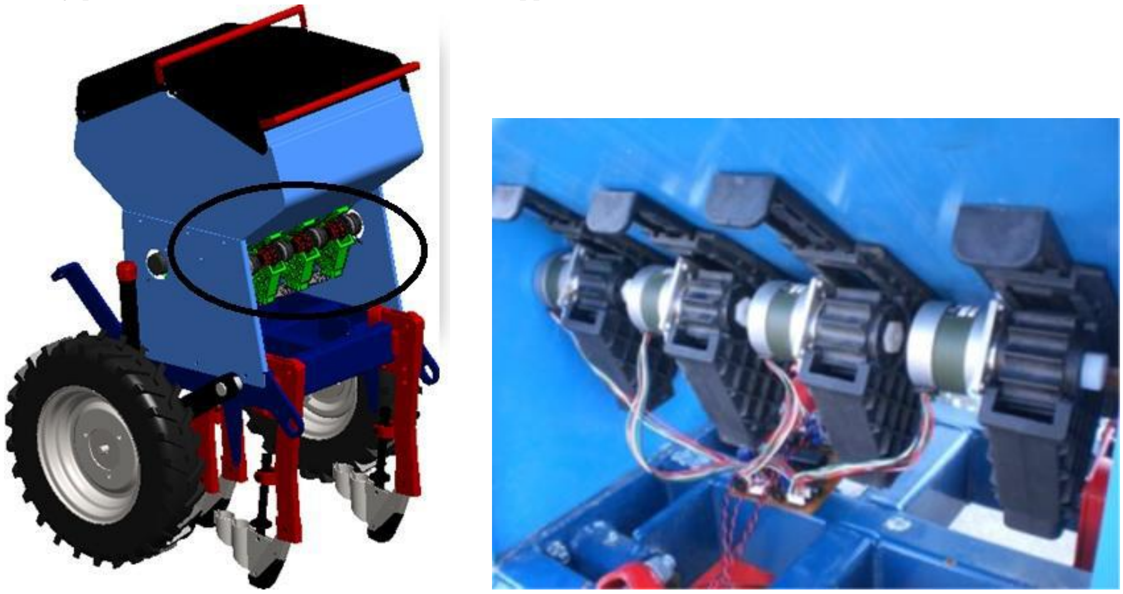

Figure 6. Variable rate controller for cereal sowing machine

Yield Mapping

The yield mapping systems in a combine includes global positioning system (GPS) and yield measuring system. The GPS and yield measurement system send data to the computer. Data file includes different data for geographical position, longitude; latitude and yield values for a field. Coordinate were converted from longitude/latitude projection to Universal Transverse Mercator (UTM) projection. These new coordinates were used to get yield map. Another software was used to create average yield map and standard deviation map for each field (Figure 7). The software was named as Yield Map 3.0 [16].

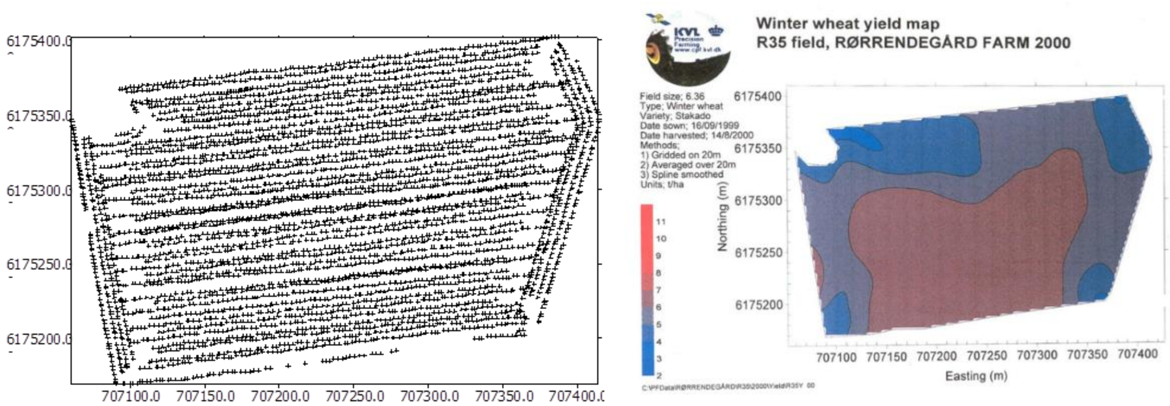

Figure 7. Yield data and yield map

Automatic Steering

An automatic steering system was developed by [17], The system consists of a central control unit, touchable user interface, positioning system, and electro-hydraulic control unit (Figure 8). These subsystems will be worked simultaneously and whole system will be worked by developed software. Steering control unit includes an electro-hydraulic valve and an electronic control circuit which controls the electro-hydraulic valve. The steering control system provides rotation of the steering wheel at required amount according to the order of the central control unit. The routes and maps of the tractor can be loaded on Touchable User Interface, and it can create commands to realize these routes. The Touchable User Interface gives information about system working. In addition, it undertakes a duty as control panel which some adjustments can be on it. Positioning system is a system that can takes coordinate data from RTK-GNSSS by using CORS-TR system which has 147 reference stations in Turkey and measurement errors will be approx. 2-4 cm. The positioning system will transfer data. The software consists of steering control software, graphic interface software, software for determination of positioning and motion, and system communication and integration software [18].

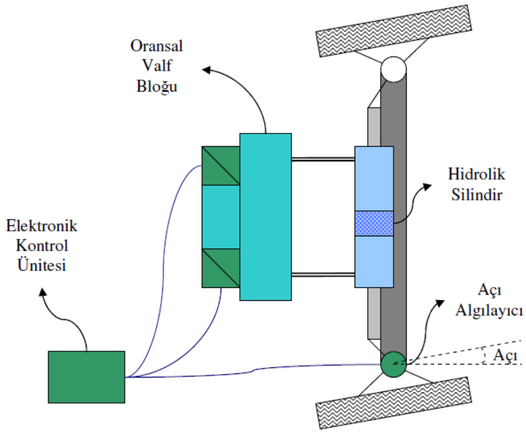

Figure 8. Automatic steering system

4. Conclusions

In this study, mechanization of the wheat growing in Thrace Region was evaluated for possible precision agriculture applications such as variable rate fertilizations, and controlled traffic farming. In addition, projects carried out in Tekirdag Namık Kemal University, Department of Biosystems Engineering were summarized.

According to the results; field operation was started on August and finished on June. There were 15 field operations for soil tillage, fertilization, sowing, spraying and harvesting. Plough, disc harrow, cultivator, centrifugal fertilizer spreader, roller, sowing machine, sprayer and combine were used. Total fuel consumption was 118 l/ha. Man labour hour requirement were determined as 3.92 h/ha. All field operations were realized by machine in wheat production.

A variable rate controller for centrifugal fertilizer spreader machine, automatic soil sampling machine, variable rate fertilization control system for cereal sowing machine and automatic steering system were developed in Department of Biosystems Engineering, Tekirdag Namik Kemal University.

Precision farming as a farm management system is very important for Turkey. Because Turkey has 23.473 million hectares of arable land and Turkish farmers used 12.546 million tonnes of fertilisers and 52 965 tonnes of pesticides for agricultural production in 2021. Precision agriculture is not only electronically controlled agricultural machines. It is also an approach to decrease agricultural input and to decrease environmental effect of agriculture.

Some of the problems for adoption of precision farming in Turkey are small scale farming and price of the precision farming systems. Control systems, machineries and software to enable precision farming in the field should be developed for agricultural machines manufactured in Turkey. In addition, development site specific strategies for agricultural sub-regions in Turkey is obligatory to apply precision farming to save agricultural production inputs and to decrease environmental effect of agriculture.

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