Decision Support System for Farm Mechanization

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Abstract
This paper describes a Decision Support System about farm mechanization with the use of GIS. The methodology consists of using a model of whole linear programming of machinery selection and planning that costs minimizes of farm mechanization. With the aim of avoiding absurd solutions the system carries out a study of the matching implement-tractor by means of the stability, slip and energy analysis. The DSS includes the natural factors (climate and soil conditions), plot geographic site (cadastre) and the crop and machinery data. Crop surface and farm machinery information is introduced into the system. A GIS is part of the system to carry out a spatial analysis of the farm results and be able to make machinery grouping. To execute the system a PC, the Agrisupport System programmed in C++ with Microsoft Foundation Classes 4.2 (MFC) is necessary. The data bases using Microsoft Access have implemented by means of Data Objects Access. Optimization is possible by means of an external product called CPLEX (software of iLog). El DSS is applicable for identification farm action, farm machinery selection, cultivation planning and to carry out machinery cooperative.

Key words: mechanization, optimization, GIS, cooperative.

1 Introduction

The farms mechanization is the introduction of the machines in the cultivation farm. The mechanization have for aim the set of actions for the improvement of farm mechanization giving priority to the profit, the costs decrease, the resources rationalization, the use of new techniques and environmental protection in structural and socioeconomic surroundings.

The farm rational mechanization needs of an optimum and selection machinery that carry out the actions preceding.

The agricultural modelling technologies are: Mathematics modelling, mathematics programming, dates table and knowledge engineering.

The Decision Support System is the process of data collection, obtained through perception means that are analyzed and linked with appropriate decision rules that identify actions to assist in producer decision-making.

2 Objective
Under these expositions, the objective is to develop a decision-making aid system about the farm mechanization, extended to farm numerous and with GIS applications.

The attainment of the objectives requires:

- Creation of the data bases
- Introduction of the farm data
- Selection of the economic and matching tractor-implement models.
- Selection of design and tools for the system
- Use of GIS

The uses of this system allow:

- Identification the farm actions
- Farm machinery selection
- cultivation planning
- machinery cooperative.

3 Review of literature

Various methods are available on selection farm machinery.

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### 4 Methodology

The mathematical model used to characterize of optimal way the mechanization cost is in [Rubio, 1999], and minimizes the total cost, which includes the variable cost of performing a task in a certain way and the fixed cost of the resources considered, where the decision variables are: the dates of tasks beginning and whole variables that they indicate that task is made under which farm machinery (tractor and implements) and that resources are used. The model this subject to restrictions that ensures that each task is performed in a unique way, that the precedence conditions are satisfied, that the fixed cost of all resources used in planning is considered and that each task is completed within its time window and the incompatibility conditions that they prevent tasks using the same resource in the chosen mode from being carried out at the same time, being necessary intercalary auxiliary variable that make the model logical.

The resolution of precedent models requires of a previous development in that duration and total costs for farming operation (denominated task) are determined with each one of the farm equipment available (denominated mode) in data base within the period available for the execution of the tasks.

The resolution of the model determines the mode to make cultivation to later calculate the total cost of each mode.

With the aim of avoiding absurd solutions the system carries out a study of the matching implement-tractor by means of the stability, slip and energy analysis.

**Tractor-implement matching.** The tractor-implement matching compatibility is analyzed by means of stability, adhesion and power compatibility.

**Stability.** The stability is determined by means of dynamic wheel reaction that prevents the lodging, assures the guide function and it allows the work without an excessive load that makes the movement sufficiently expensive. The equipment does not comply with the stability condition when dynamic wheel reaction has certain values with respect to the weight tractor.

The stability calculation is made according to dynamic balance of tractor.

In order to solve the stability problems a tractor ballasting is suggested in the system or to change the implement. In the case of load excessive to consider take off ballast or another implement.

**Tractor adhesion.** The tractor adhesion is defined as tangential resistance to slip of wheel with respect to ground. An equipment does not comply with the condition of adhesion if $s < 20$. Different models, with different precision and number of variables are used. [ASAE;1994]

In order to solve the adhesion problems it is recommended to tractor ballast, to change the tires by others of different dimensions or to remodel the implement.

**Oversize structural.** Implement oversize exists if the drawbar pull is greater than a certain proportion of tractor weight.

The analyses of power compatibility come determined by power requirements and energy efficiencies.

**Power requirements analysis.** The power requirement is the sum of implement power (ratio between drawbar power and traction and mechanical efficiency, hydraulic power, power-take off power and electric power).
The power requirement must be smaller than a determinate proportion of nominal power for accelerate, overcome changes in topography, soil and crop condition, and work in engine speed of specific fuel consumption minimum.

Energy efficiencies analysis. The power balance can be used to determine energy efficiencies tractor-implement matching.

Fuel use degree is ratio between drawbar power and total power requirement and specific fuel consumption.

Power use degree is ratio between total power requirement and total engine power.

The tractor-implement matching is inefficient if fuel and power use degree are smaller than a coefficient determined.

When an inefficient fuel and power use degree exists can be decided between implement changing or working with higher cost.

All the models are calculation for 2 WD and 4 WD

The data is obtained by surveys and engineering data of farms implied in the planning. The necessary data for the system are structured in three data types. Farm: plots, texture and index of cone, crops and machinery. Crops: cultivations technique, operation and date. Machinery: technical and cost data.

All the information and the results can be represented spatially by means of GIS.

5 DSS structure

The complete implementation of the DSS requires of AgriSupport use, programmed in C++ (Microsoft Fundation Classes-MFC), that makes all functions, coordinating and connecting data bases (Microsoft Access), data bases tools (Data Objects Access), optimizer (Cplex) and SIG (Arcview).

6 Results

The execution of the system allows:

To determine farm mechanization actions already expressed in the methodology. (Figure 1)
To determine the farm mechanization costs obtained by resolution of the whole linear programming model. (Figure 1)

To use the SSD for equipment selection that farm optimizes obtained by execution of the system introducing a varied number of machines. (See right side of figure 1).

A later version expresses all the selected machines and not solely the tractors. In the traditional version the system provides the machinery selection in a table of the data base.

The results can be exported to a GIS for to observe spatially the results and to determine actions for to constitute cooperative machinery.

7 Conclusion

The system has been validated at different places in Spain and it has been effective.
References


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