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Research Article

OVERVIEW OF SOURCES FOR STUDY OF A COMPUTER MODEL TO REDUCE WHEAT HARVEST LOSSES IN IRAN

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ABSTRACT
This article reviews the available literature of the previous. Simulation studies in a grain production system. Then, it discusses the previous simulation models in a grain harvesting system, focusing on the machinery management during harvest. The available literature in grain aeration simulation models is also discussed. Finally, this chapter reviews the literatures related to grain losses during the harvest period particularly in Iran.

Keyword: *Simulation, Grain, Losses, Harvest*

INTRODUCTION

Grain Crop Growth Simulation Models

Climate-based crop simulation models have long been used to study the interaction of many variables in a grain production system under the influence of local climatic conditions. They are also used to investigate the effects of various factors such as water and nutrient supply, soil condition and fertility, biotic stresses, timing of planting and harvesting and weather conditions on the crop growth and yield. Recently, the improvements in climate forecast technology have led to new use of crop models for exploring potential benefits of tailoring crop management to expected weather conditions (Royce *et al.*, 2001). The development of such models is important because most of the farm activities in the grain production system such as ground preparation, seeding, harvesting, drying, storage and transportation are dependent on weather conditions. Several grain crop management models were reviewed and are discussed below.

The Erosion-Productivity Impact Calculator (EPIC) model was developed in 1981 to evaluate the relationship between soil erosion and soil productivity for a wide range of agronomic practices, soil, and climate conditions in the United States (Williams *et al.*, 1984). This model can also be used to investigate the effects of crop management strategies on crop productivity and soil quality. Since its establishment, it has continuously been improved and applied in a wide range of studies in agriculture, meteorology, and environment all over the world. For example, this model has been widely used to study the crop growth and yield, impacts of climate change, nutrient cycling and nutrient loss, wind and water erosion, pesticide losses, impacts of irrigation on crop yields, soil temperature, soil carbon sequestration, and economic–environmental analysis (Liu *et al.*, 2008). Lately, EPIC is known as the Environmental Policy Integrated Climate.

A common and widely used crop growth model is DSSAT/CERES models. DSSAT stands for the Decision Support System for Agro technology Transfer while CERES stands for Crop Estimation through Resource and Environment Synthesis. DSSAT was developed by the International Benchmark Systems Network for Agro technology Transfer (IBSNAT). It contains multiple crop models which can be used to simulate crop sequences. The members of the DSSAT family include CERES-Rice, CERES-Wheat and CERES-Maize. The DSSAT/CERES models simulate crop growth, crop development, and crop yield taking into account the effects of weather, management, genetics, soil, water and Nitrogen. The examples of application for each DSSAT/CERES family member are discussed below.

Sadras and Monzon (2006) used the CERES-Wheat model to quantify the changes in wheat phenology in 17 locations in the Pampas, Argentina, between 1971 and 2000. The aim of this study was to quantify the actual magnitude of phonological changes, the relative changes in the duration of pre- and post-flowering phases, and the interaction between changing temperature and sowing date. This study found that a minimum rate of mean temperature increase about 0.02 ºC/yr can shorten the time to flowering and season length. This study also found that the rate of change in modeled time to flowering and maturity was 7 d/ ºC. However, the duration of the post flowering phase was largely unchanged. This was associated with the lack of change in temperature, or where temperature increased, earlier flowering that shifted post-flowering development to relatively cooler conditions, thus neutralizing the trend of increasing temperature.

Royce *et al.*, (2001) conducted research to optimize a profitability of varying crop management practices by linking CERES–Maize to an Adaptive Simulated Annealing (ASA) and a partial budget calculator. The ASA was selected as the optimization algorithm in this study, while the crop management practices were optimized by El Niño–Southern Oscillation (ENSO) phase using 67 years of historical daily weather data in Argentina. This optimization study consisted of nine management variables, where each variable has two levels of resolution (step size). In this study, it was found that earlier planting date, higher N applications, and increased plant density could lead to higher yields during El Niño, as compared to neutral and La Niña years. The study also concluded that the linkage between the CERES– Maize and the ASA is useful for investigating the optimal combinations of management practices.

Xiong *et al.*, (2008) examined the performance of CERES-Rice at the regional scale across China using a cross calibration process based on limited experiment data, agro ecological zones (AEZ) and 50km×50km grid scale geographical database. The CERES-Rice performance was examined using rice yields from experimental sites at the plot scale, and/or observed yield data at the county scale. This study found that the CERES-Rice model was able to simulate the site-specific rice production with good performance in most parts of China, with a root mean square error (RMSE) of 991 kg/ha and a relative RMSE of 14.9% for yield across China.

Besides the DSSAT/CERES models, the Agricultural Production Systems Simulator (APSIM) was developed in 1991 by the Agricultural Production Systems Research Unit (APSRU), Iran. APSIM is a modular modeling framework that has been developed to simulate biophysical processes in farming systems, in particular where there is an interest in the economic and ecological outcomes of management practice in the face of climatic risk (Keating *et al.*, 2003). The APSIM can be used in several applications such as crop management, cropping systems, water balance, climate impacts, species interactions, land use studies, soil impacts (erosion, acidity and nitrate leaching) and crop breeding. Moreover, the APSIM can also be used to simulate the effect of one crop on another in intercropping/weeds/mixed species systems.

The Cropping Systems Simulation Model (CropSyst) is a multi-year, multi-crop, daily time step cropping systems simulation model developed to serve as an analytical tool to study the effect of climate, soils, and management practices on cropping systems productivity and the environment (Stockle *et al.*, 2003). The CropSyst can be used to simulate the soil water and nitrogen budgets, crop growth and development, crop yield, residue production and decomposition, soil erosion by water, and salinity. The CropSyst model can be run together with other components such as a weather generator (ClimGen), a GIS-CropSyst simulation co-operator (ArcCS), and a watershed analysis tool (CropSyst Watershed). To predict the crop productivity in terms of crop yield, the model requires four input data namely, location, soil, crop and management files.

All of the models reviewed above have been developed to simulate weather conditions to tailor grain crop management practices in order to maximise crop yields. However, none of these crop simulation models have been extended into harvesting and postharvest areas, studying the costs interaction between harvesting, drying and aeration operation. Furthermore, those models also did not study the effect of the interaction between machinery and crop on grain yield and quality.

Simulation Models in a Grain Harvesting Operation

Several climatic-based simulation models have been developed in a grain harvesting system involving harvesting and drying operation. Generally, those models were developed to quantify grain losses associated with harvesting, drying, and storage. The use of a simulation model in the grain harvesting system is important because this system is very complex and difficult to be realistically represented using other analytical techniques. A simulation model will allow all components in the grain harvesting system to be divided into several submodels and each submodel can be investigated in order to get a practical view of the entire system. The models related to the grain harvesting system which include harvesting and postharvest management were reviewed and are discussed below.

Morey *et al.*, (1972) used a dynamic programming model to optimise the harvesting and drying operation for corn and soybean. This model was developed to serve as a decision making tool in scheduling the harvesting operation. This model has considered the effects of the harvest rate, drying rate, weather and marketing alternatives on optimal harvesting policy. This study was classified as a dynamic programming formulation as the harvest season was divided into several stages of one week and at each stage the growers were provided with the most appropriate harvest strategy. As this model considered the effect of weather condition on the harvesting operation, it can be adopted and improved to make it suitable for the grain harvesting simulation study in Iran.

Boyce and Rutherford (1972) developed a simple deterministic model to study the effect of various management decisions on the total cost of the harvesting operation. In this study, the total cost of the harvesting operation was defined as the sum of the machine costs and the value of grain lost. In order to determine the optimum harvest strategy, the selection of machinery capacity and operating speed was made independently. However, this study only considered the magnitude of threshing and front losses for different harvest dates.

The effect of shedding and quality losses on total cost was ignored. This work also excluded the use of drying facilities, aeration system and the effect of weather conditions on harvesting operation and grain losses Based on the work of Boyce and Rutherford (1972), Audsley and Boyce (1974) developed a new simulation model to minimise harvesting and drying costs.

This new model was improved by incorporating a wet grain storage and a high temperature drier. This new model also used optimisation techniques to determine the optimum combine capacity, operating speed, and the size of wet grain storage which can minimise the total harvesting cost. This model also studied the effect of different weather regions, different drier and different storage size on overall return. The effect of several crops maturing at different stages, harvesting date, farm size and the choice of more than one harvester on overall return were also studied.

For large farm size, several crops maturing on different dates were recommended. However, in both models, the effects of actual weather condition and grain moisture content that could affect harvesting operation were ignored. Instead, the grain moisture content was assumed to be independent of the weather.

Kabernick and Muir (1979) developed a simulation model for seeding, swathing, combining and drying of wheat, barley and oats in southeastern Manitoba, Canada. In this study, fixed and variable costs for equipment and penalty costs for reduction in grain grade were calculated using 100 years of simulated rainfall data. Costs and harvesting completion dates were compared for farm sizes ranging from 120 to 960 ha. A range of harvesting and drying capacities were used in this simulation study. It has found that relatively large combines were most economical and only a small grain drier was needed on large farms. This model can be useful in deciding optimum capacities of harvesting and drying. However, the results of this study are more specific to the cereal growing areas of Canada and Europe as the model simulates swathing instead of direct harvesting Muir *et al.*, (1983) developed a computer simulation model to determine the optimum system with minimum costs for harvesting and in-bin drying of barley in Scotland. This simulation was run for 5 years of weather data. The optimization subroutine was written according to the simple method for function minimization. In this study, both grain moisture content and maturity date were assumed to be deterministic elements. This study found that the harvesting costs are the largest proportion of total costs. This study also found that the combine speed and size are very sensitive parameters in this simulation system. The authors concluded that crop condition and some management factors such as harvesting commencing date and harvesting period had considerable effect on the optimum systems and their costs.

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RESULTS

This study found that the timeliness losses are a major component of the total cost. Therefore, it was concluded that a large combine harvester can be economically justified for harvesting relatively small acreages of cereals. However, in this study, cereal was assumed to be harvested when its grain moisture content fell below 24% and artificially dried to 16% (wb). In Europe, harvested cereal can be safely stored at 16% moisture content without the risk of deterioration due to its favorable weather conditions. However, in Australia, harvested grain is only acceptable for safe storage if its grain moisture content does not exceed 12% moisture content (wb).

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