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Cultivation-time recommender system based on climatic conditions for newly reclaimed lands in Egypt

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Abstract

This research proposes cultivation-time recommender system for predicting the best sowing dates for winter cereal crops in the newly reclaimed lands in Farafra Oasis, The Egyptian Western Desert. The main goal of the proposed system is to support the best utilization of farm resources. In this research, predicting the best sowing dates for the aimed crops is based on weather conditions prediction along with calculating the seasonal accumulative growing degree days (GDD) fulfillment duration for each crop. Various Machine Learning (ML) regression algorithms have been used for predicting the daily minimum and maximum air temperature based on historical weather conditions data for twenty-five growing seasons (1990/91 to 2014/15). Experimental results showed that using the M5P and IBk ML regression algorithms have outperformed the other implemented regression algorithms for predicting the daily minimum and maximum air temperature based on historical weather conditions data. That has been measured based on the calculated mean absolute error (MAE). Also, obtained experimental results obviously indicated that the best cultivation-time prediction by the proposed recommender system has been achieved by the M5P algorithm, based on the seasonal accumulative GDD fulfillment duration, for the coming five growing seasons (2016/17 to 2019/20).

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Keywords: climate conditions, recommender system, regression, growing degree days (GDD), Farafra oasis, Western Desert, Egypt

1. Introduction

Food security has become a pressing challenge due to rapid population growth, climate change, and water shortages, especially in developing countries [1,2].

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Despite the fact that wheat production in Egypt for the current season of 2015/16 is estimated to 9 million tonnes, it remains the world's largest wheat importer with wheat imports estimated at 11 million tonnes [1,3,4,5]. Moreover, growth ratio of Egyptian imports of other cereal crops, such as barley, for the same season reached around 96.08% compared to the previous season [3,6]. It is noteworthy that climate change is a major reason that causes large variations in crop yields from decade to decade. Also, as plant development is tightly aligned with weather conditions, especially temperature, uncertainty in weather creates a risky environment for agricultural production.

Therefore, the cultivation area of winter cereal crops increased in the newly reclaimed lands under various irrigation systems. Both crops are suitable to be widely grown in the rain-fed areas of the north coastal region. In addition, the newly reclaimed lands with saline soils in Egypt, such as the newly reclaimed lands in the western desert, are appropriate to grow both crops [7].

Commonly, people often count on a calendar to predict plant development for making management decisions. However, as plant development depends on temperature that can vary greatly from year to year, it's hard to depend on the calendar days that can be undeniably misleading for predicting plant growth, especially for early stages of crop growth [8]. Therefore, weather forecasting is very important to determine the suitable cultivation dates of various crops for agricultural development in the newly reclaimed lands, especially the Egyptian western desert.

This paper proposes a cultivation-time recommender system for predicting the best sowing dates and cultivation times for cereal crops in the newly reclaimed lands. A case study considered two strategic cereal crops in Egypt, namely winter wheat and barley, has been presented. The scope and focus cultivation location of this research is the newly reclaimed lands in Farafra Oasis, The Egyptian western desert. The main goal of the proposed system is to enable the best utilization of farm resources and to support the farmers as well as governmental authorities and decision makers via predicting the best sowing date for a certain cereal crop during a given (future) cultivation season.

The proposed recommender system consists of two main phases; namely *weather prediction* and *Growing Degree Days (GDD) based sowing date prediction*. In this paper, various Machine Learning (ML) regression algorithms have been used for predicting the daily minimum and maximum air temperature based on historical weather conditions data. The predicted daily minimum and maximum air temperature have been used to calculate the seasonal accumulative GDD fulfillment duration, and to accordingly predict the best sowing dates for the aimed crops.

The rest of this paper is organized as follows. Section 2 presents a brief review of related recent research work. Section 3 describes the different phases of the proposed recommender system along with briefing the details of the used prediction methods. Section 4 introduces the tested weather conditions data and the case study location in addition to depicting and discussing the obtained experimental results. Finally, section 5 presents conclusions and discusses future work.

2. Related work

Numerous studies have been conducted on cultivation in the Nile delta, however, few researches have addressed cultivation in the desert region, especially oasis. Moreover, very limited research studies have proposed computational intelligence based recommender systems for predicting the best planting dates, especially for the newly cultivated lands, based on the required temperature for crops growth stages. For example, in [1], authors proposed a recommender system, based on the rough mereology theory, for predicting best cultivation dates for wheat in Egyptian Sinai Peninsula according to the required mean temperature for germination stage.

However, several research works addressed the usage of crop growth models and weather conditions prediction software for studying the impact of related phenomena. For example, authors, in [9], studied the SIRIUS crop growth model program under Egyptian climatic conditions in order to investigate the effects of increasing temperature and Co^2 on wheat production and help the decision maker to set mitigation plans for facing climate changes. While, in [10], authors used the ArcGIS 10.1 software to create classified maps for presenting GDD at ten governorates in the Egyptian Nile Delta considering three selected base temperatures. Prediction equations were implemented to predict annual accumulative GDD for crop management decisions. In [11], CERES-Wheat simulation model in the DSSAT package has been used for describing daily phenological development and growth, in response to environmental factors (soils, weather and management), at three agroclimatic locations in in Nile Valley and Delta, in Egypt. Authors in [12] used CropSyst crop growth simulation model to quantify a range for calibration parameters for four wheat cultivars grown