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A Simulation Model for Planning of Hay Harvesting Machinery Systems and Management

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The thesis consists of this summary and the following two reports:

[1] Axenbom, Å. 1988. An integrated model of hay growth, harvesting and barn drying. Report 120. Dept of Agricultural Engineering, Swedish University of Agricultural Engineering. Uppsala. 79 pp.

[2] Axenbom, Å. 1990. A base model for discrete event simulation of field operations using Simula and DEMOS. Report 143. Dept of Agricultural Engineering, Swedish University of Agricultural Engineering. Uppsala. 49 pp.

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ABSTRACT

A model of the hay production and utilization system was developed and validated. The model is primarily aimed at analyzing machinery dimensioning and management problems with a high accuracy.

The model consists of several sub-models of growth, field operations, management, field drying, barn drying, field losses and conservation losses.

The validation procedure included validation of certain sub-models as well as of the model as a whole. It was demonstrated that the resolution of the model is generally satisfactory for thoroughly analyzing complex problems related to planning of hay harvesting machinery systems and management.

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SUMMARY

The thesis consists of the reports [1] and [2]. Report [1] covers the development and validation of a model of the hay production and utilization process. Report [2] describes the sub-model for simulation of field operations in general, and discusses its validity, usefulness and limitations.

In report [1] a background is given to the problems of optimizing the production apparatus in agriculture in general, and in haymaking in particular, due to the interactions between the man-machine system, the biological material, the weather and the manager when performing field operations.

It is concluded that the only means of appropriately considering these interactions is to include the entire hay production and utilization process in the calculation model. Furthermore, a high resolution is required. From this it was decided to develop an integrated model of the hay production and utilization process.

The remaining part of [1] describes the development and validation of the integrated model. It consists of three models, a growth model, a harvesting model and a hay-to-milk conversion model, of which the former two ones are interconnected. The growth model is a simulation model adopted from Torssell et al (1982), while the hay-to-milk conversion model is a Linear Programming model, aimed at calculating the economical potential of the harvested forage.

The model is primarily aimed at analyzing problems related to planning of hay machinery systems and management. Therefore the highest requirements of resolution and validity was set on the hay harvesting and conservation model. As one means of achieving this objective, the discrete event simulation technique was chosen for the model of field operations and management, whereas continuous simulation was used for the models of the biological processes.

The model of field operations and management is described in [2]. It was designed to be a "base" model, useful for simulation of most field operations. It is a discrete event simulation model built upon the discrete event simulation package DEMOS, utilizing the object-oriented programming language Simula.

The harvesting and conservation model is built upon the base model, and extended with dynamic models of the particular biological processes (field drying, field losses, barn drying, conservation losses).

The field drying model chosen was a multilayer one developed by Thompson (1981). It was chosen because it was assumed that only a multilayer model would have the necessary resolution. The model was validated against Swedish data, demonstrating a good correspondence between measured and simulated data.

The barn drying model as well as the conservation loss model and the field loss models were developed by Jónasson (1983). The barn drying model has been modified into a true multilayer model, and so has the loss models.

A demonstration run with the model showed that the parts of the model interact correctly with each other, so that an entire hay harvesting season may now be simulated with a high resolution.

The main result of the work is that problems, related to planning of hay harvesting machinery systems and management, which before could not be analyzed at all or only in a brief way, can now be thoroughly analyzed with a high resolution.

The work is expected to have an impact on future hay management research and extension service on several levels. On the research level, the work describes the state of the art, and where knowledge is missing or uncertain. The model is also useful to determine whether it is worthwhile to invest in more research to improve some knowledge. Thanks to its resolution, many experiments can be complemented or even replaced by simulation studies. Finally, the work defines an interface between the different parts of the model, which will simplify future inter-disciplinary work.

On the extension service level the work will not have an immediate impact since the model developed is mainly intended for research. It is however possible to further develop certain parts of the model in order to solve different specific problems. For example, with small modifications, the field drying and barn drying models could be used for forecasting.

One main contribution of the base model described in [2] is that similar applications as [1] for other types of field operations, such as combine harvesting, spring sowing or autumn sowing, can now be developed with significantly less resources.

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