A Weighted Goal Programming Model for Vegetable Production Planning in Republic of Macedonia

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Extended Abstract

Mathematical programming and optimization techniques provide significant decision-making support under various circumstances in which farmers operate. Traditionally, linear programming (LP) paradigm for optimising a set of interactive variables received a considerable importance in the production scheduling and the resource allocation (Charnes *et al.*, 1955). However, LP models might result in bias solution due to the limitations when optimising a single objective (Gomez-Limon *et al.*, 2003). Gasson (1973) and Cary and Holmes (1982) stressed the necessity for developing decision making models in farm production planning by recognizing the multiplicity of the objectives compatible with the farmer's preferences. Farmers decisions are influenced not only by economic incentives and resource allocation factors but also by environmental and policy requirements.

The application of goal programming (GP) as a multi-criteria decision making method proved to be an adequate tool for different farm planning problems (Jones and Tamiz, 2010), also applicable for solving cropping pattern problems that are multi-objective in nature (Sen and Nandi, 2012).

In this research we focus on Macedonian farms specialised in vegetable production. The aim is to develop an optimisation model for decision-making on Macedonian family farms, utilising mathematical programming techniques.

The optimal production plan is determined with weighted goal programming (WGP), optimising several conflicting objectives at once. Some of the objectives are considered as goals with different achievement levels; the distance between the aspiration and the achieved level is measured by the deviational variables, thus presenting the over and the under achievement of the goal (Jones and Tamiz, 2010). In its mathematical formulation, WGP minimises the sum of unwanted deviational variables into a weighted normalised single achievement function.

The constructed model was set as a spreadsheet application with 172 decision variables. The model is consisted of two sub-models, LP and WGP. Classic LP model is used for calculating the goal aspiration level as an input value in the second sub-model based on WGP. Four goals are currently set in the model: maximised farm gross margin, minimised working capital, minimised labour and minimum number of farm enterprises incorporated in the solution. For indicating the decision maker's preferences as well as for normalising the goals, priority weights were derived from the pairwise comparisons with integer values in 1-9 scale, using the Analytical Hierarchy Process (AHP) method (Saaty, 1980).

The activities in the model refer to the most representative vegetable crops thus reflecting the typically diversified production structure on Macedonian vegetable farms. Additionally, input related activities, farm infrastructure capacity and balance activities are determined. Farmers are expected to make decisions under a number of constraints, dealing with production factors scarcity, agronomic limitations and constraints capturing the external factors that affect the production.

The model is fed with data from enterprise budgets obtained by a panel of relevant experts, supplemented with the Farm Monitoring System (FMS) for the period 2005-2010. The model was applied on "typical vegetable farms" determined with cluster analysis. An agglomerative hierarchical clustering procedure using the Ward's algorithm and Squared Euclidean Distance was applied, in SPSS 17. The cluster analysis provided three different

groups of farms, regarding the farm size, farm gross margin, number of crop enterprises and number of vegetable enterprises.

The two stages optimisation approach (LP and WGP) proved to be useful in optimising the vegetable production and analysing the farm management problems in Macedonia. For all three clusters the findings reflect quite heterogeneous production plans, whereas the total cultivated area was devoted to 9 out of 17 vegetable enterprises in cluster A, 5 enterprises in cluster B, and 6 enterprisese are cultivated in cluster C. The production structure determined for the larger farms generates more working capital, i.e. the working capital in cluster A is overachieved by 10%, while the targeted level is reached in cluster B and C. The model revealed that the gross margin in all three clusters is maximised and on the targeted level. Compared to the single objective maximisation where the production structure required hiring of extra labour in peak seasons for all three clusters, the WGP model showed that the labour goal was underachieved, by 19% in cluster A, 63% in cluster B and 73% in cluster C.

The developed model is flexible; different crop enterprises can be added and different goals considered. It could be also applied for optimising the farm situation in the countries in the region, considering the similar structure of their agricultural production.

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