Analysing the energy balances of sugar beet cultivation in commercial farms in Germany

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Energy balances are increasingly used to assess the energy efficiency and productivity of agricultural production. In this study, energy balances for sugar beet cultivation in commercial farms in Germany were calculated. 109 farmers with 285 fields were interviewed about the sugar beet cultivation 2004. The energy input and the energy output were calculated with standardized balance-sheet approaches and energy equivalents. Calculated energy balance parameters were the energy gain (energy output less input), the output-input ratio (energy output versus input) and the energy intensity (energy input versus natural yield measured in Grain Equivalents). A factor analysis was performed to explain the variation of the energy balance parameters between the fields by crucial factors for energetic efficiency and productivity. Fields with similarly valued factors were grouped into common clusters by a cluster analysis and a discriminant analysis. The influence of specific growing conditions and cultivation methods on the energy balances were examined for the clusters.

Total energy input (median: 17.3 GJ ha^{-1}), energy output (261.7 GJ ha^{-1}), energy gain (244.6 GJ ha^{-1}), output-input ratio (15.4) and energy intensity (87.4 MJ GE^{-1}) revealed a significant variation. The total energy input was significantly lower and the energy yield was significantly higher than in previous studies. Thus, the energy gain and the output-input ratio have clearly risen compared to earlier studies. Today, sugar beet cultivation is energetically more productive and efficient than the cultivation of many other arable crops in Middle Europe.

The intensity of the cultivation measures irrigation, catch crop cultivation, tillage and N fertilisation as well as the management of all cultivation measures and the site were determined as crucial factors for energy efficiency and productivity. The intensity of the different cultivation measures influenced the total energy input significantly, but no influence on the energy output was determined. In contrast, the cultivation management (quality and adaptation of cultivation measures) was mainly responsible for the energy output. Whereas the cultivation management mostly explained the energy gain, the factor cultivation management and the factors representing cultivation intensity together were responsible for the output-input ratio.

Cluster and discriminant analysis resulted in the formation of 13 clusters. For clusters with an above-average energy gain and output-input ratio, the intensity and in particular the management of cultivation measures were essential for optimising the energy balance.

The study emphasises that in commercial cultivation energetic productivity and efficiency are influenced by many factors. In particular, the cultivation management has a great impact on the yield and thus on the energy balance. This dominating effect of the management does not become obvious in many scientific trials and calculations. Implication for agronomists comprise: Minimising the energy input for the cultivation is only one part of a strategy for optimising balances. The farmers also need support regarding an optimum cultivation management.

From the methodical point of view, the study shows how data from commercial farming can be utilised for agronomic research through a challenging statistical analysis. The results can be re-transferred directly into commercial farming and are well accepted by farmers and decision makers. For the scientific community, data from commercial farming offer the possibility to reflect results from previous trials or theoretical calculations. Furthermore, the analysis of the data can provoke new questions among the scientists.

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