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POSTER PAPER

THE ISO-GROUP CONCEPT AS A TOOL FOR OPTIMIZING CROP PRODUCTION AT FARM LEVEL

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ABSTRACT

Yield and quality of agricultural crops are influenced by a large number of factors. Some of these are inherent to the field on which the crop is grown. They define the intrinsic capacity of a field and cannot or hardly be modified by man. The so-called management factors can be adjusted or influenced as required for optimum production. In the present concept, the maximum attainable yield is considered to be the highest observed yield within a group of fields with comparable intrinsic value, further called iso-group. The grouping (positioning step) is based on a set of permanent characteristics determined mainly by the physical environment. Each unique combination of these characteristics, established by

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using a GIS-tool, gives rise to a new iso-group. After appointing each field to an iso-group, a ranking can be made within each group based on yield or quality. During the diagnosis step the contribution of each management variable to the observed variation in yield and/or quality within an iso-group, is determined. In this way the most relevant variables are selected and the relationship with yield and/or quality is established. Based on these relationships specific measures can be suggested to improve the yield and/or quality of the crop on a specific field (advising step). By applying these recommendations the farmer is expected to obtain yields that approximate the maximum intrinsic capacity of his plot.

INTRODUCTION

The iso-group concept allows a farmer to compare the results achieved on his fields with the results from anonymous colleague-farmers. Because the intrinsic capacity differs among fields, the concept "iso-group" is introduced. An iso-group is a set of fields with a comparable physical or financial production potential, as defined by inherent field characteristics.[1]

MATERIALS AND METHODS

Method

Positioning Step

Different fields having distinct production potentials, they need to be grouped in so-called iso-groups, each member whereof having a comparable intrinsic production potential. This grouping must be based on a set of permanent characteristics. Basically these are soil physical parameters such as soil zone, soil substratum, soil texture, drain class, slope and exposition. Each unique combination of these characteristics gives rise to a new iso-group. The fields are classified in iso-groups using a program developed for these purposes in Arc/Info. In this prototype program the field borders, achieved by digitization, are overlaid with a soil map layer and a digital terrain model to obtain the necessary soil physical parameters, as well as the average slope and exposition for each field.[2] An iso-groupcode is deduced based on the extraction of the permanent characteristics and written in a Windows Access database.

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After appointing each field to an iso-group, a ranking can be made within each group for a chosen result variable. From an agricultural point of view result variables relating to yield and quality are chosen. However the same concept can be used for variables concerning the financial return or the environmental pressure (e.g., soil nitrate residue after harvest).

Diagnosis Step

For each result variable, a list of influencing parameters can be considered. During the diagnosis step, the contribution of each parameter to the observed variation in yield and/or quality within an iso-group is determined. In this way the most relevant parameters are selected and the relationship with the result variable is established. For this purpose a prototype Windows Access application is developed.

Advising Step

Once these relationships established, specific measures can be suggested in an evaluation report to improve the yield and quality of the crop within an iso-group. By applying these recommendations the farmer is expected to obtain yields that approximate the maximum intrinsic capacity of his plot and improve its position within the iso-group. Meaningful and realistic recommendations can only be formulated for a given field within the limits of its intrinsic qualities. In this concept, the maximum attainable crop yield is considered to be the highest observed yield within the iso-group.

RESULTS AND DISCUSSION

During two years, nine Belgian arable farms were intensively reviewed and followed. All management practices were recorded for each field, including data on sowing, fertilization, crop protection and harvesting, completed by soil analysis results and field observations. Two criteria were used to select the farms: arable crop farming must be the main source of income and the fields must be located on loamy soils (to assure a relevant set of iso-fields).

The concept is further illustrated by an iso-group of 22 sugar beet fields (Beta vulgaris L.) harvested in 1999 with the following characteristics: loamy soil type with no substratum, a normal drain class and a slope between 0 and 8%. As slopes are small, the exposition is not taken into account.

Within the iso-group a ranking is made for the root yield and the sugar content. For the diagnosis of the root yield the following parameters are

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considered as most explicative: nitrogen fertilization, growing period, presence of nematodes and other plagues, sowing conditions and germination, and variety. To evaluate the effect of the nitrogen fertilization on the root yield, the difference between the applied and the recommended dose based on the expert system N-INDEX,[3] is chosen as a parameter, called N-surplus. The highest root yields were achieved on those fields with an N-surplus within the range of -20 to $+20\,\mathrm{kg\,N\,ha^{-1}}$. The growing period varies between 176 and 232 days, which makes a difference of eight weeks. From Fig. 1, it is clear that not every field achieves the yield as suggested by an imaginary growing curve. For those yields deviating from the curve, another explicative parameter must be searched for. The sugar beet variety did not appear to be explicative in this iso-group. Considering the field observations, it appeared that the deviations were mainly due to the presence of nematodes or bad germination (soil structure problems).

The sugar content on the other hand is diagnosed using the following parameters: nitrogen availability during the maturing stage, length of the growing period, disease pressure (e.g., rhizomany) and variety. The variety effect can be evaluated by plotting the observed sugar content against the sugar content attained in official variety trials. Deviations from the expected straight line indicate fields where the variety did not reach or exceeded its potential. Since the winter of 1998–1999 was very wet in the concerned region, the mineral N-stocks at the beginning of the season were very low. The N-apply exceeding the recommended dose negatively affected the sugar content. For those fields where organic manure is used, the applied N-dose is calculated estimating the N-availability from the manure using the expert system BEMORGEX.[4] In some

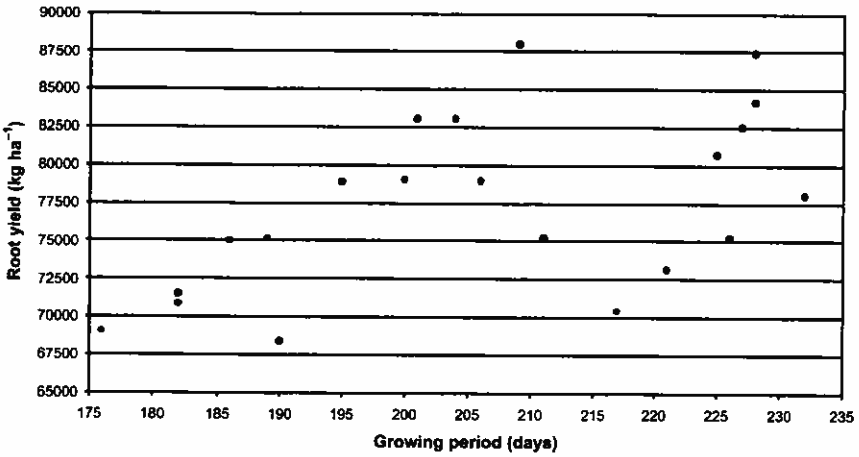

Figure 1. Root yield vs. length of growing period.

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cases the farmers clearly under-estimated the fertilizing value of the manure, resulting in a high N-surplus and a lower sugar content.

A ranking based on economic parameters can be useful as high physical yields do not necessarily correspond with high financial returns, especially when unnecessary or excessive costs have been made. Therefore positioning by gross margin, calculated as revenues minus assigned costs, might be helpful. The parameters that might offer an explanation for the observed variation in gross margin include root yield, sugar content and all cost categories that are relevant at plot level, such as costs for sowing, fertilization, crop protection and irrigation.

In the dataset, high root yields generally corresponded with high gross margins, this in contrast with the sugar content. Further diagnosis of influencing factors towards the sugar content, showed that the cost for sowing or planting did not appear to be explicative, neither did the fertilization cost. With regard to crop protection costs, a negative relationship can be noticed. The necessity of expensive treatments should always be in relation to the pressure of diseases and plagues. The net result of such a treatment is positive if the yield losses exceed the saved costs of not treating the crop. Costs for irrigation are irrelevant in this analysis as no fields were irrigated.

From an environmental point of view, the observed soil nitrate residue at harvest can be diagnosed. This residue is affected mainly by the nitrogen dose, the organic matter content of the soil, the use of catch crops, the achieved yield and the growing period. The iso-parcels where the nitrogen dose significantly exceeds the advised dose, display a rather high nitrate residue, as is visualized in Fig. 2. Generally the residue decreases with the length of the growing period, since N-uptake by sugar beets is expected to continue until harvest.

CONCLUSIONS

The iso-concept allows the farmer to compare the results achieved on his fields with results from anonymous colleague-farmers. By a diagnosis of those parameters that explain the greater part of the differences, recommendations can be formulated to improve the position of a field in the iso-group. The measures recommended can include, e.g.,

- a more accurate fertilization management corresponding to nutrient demands, including the choice of application period and the correct calculation of the fertilizing value of manure,
- the choice of a sugar beet variety, taking into account the expected harvest date (precocity), tolerance to drought and if necessary resistance to plagues (nematodes) and diseases (rhizomany).

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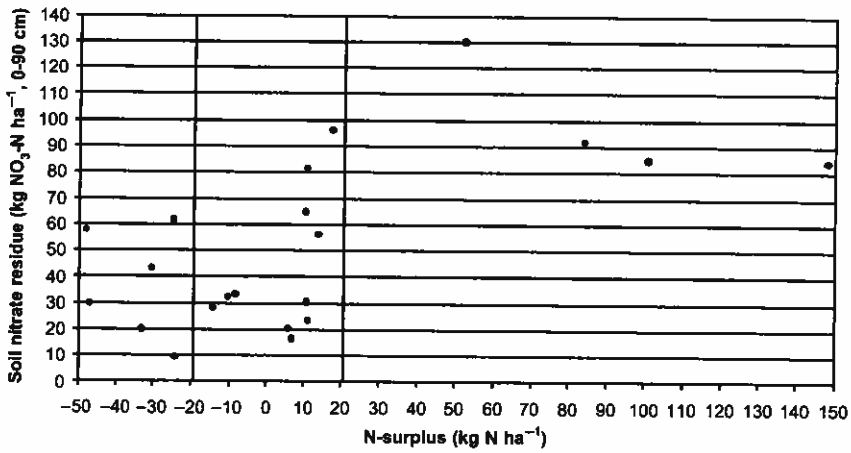

Figure 2. Nitrate residue (kg N ha^{-1}) vs. N-surplus = N-dose − N-recommendation (kg N ha^{-1}).

By implementing these recommendations in his farm management, the farmer is expected to obtain yields that approximate the maximum intrinsic capacity of his plot and to improve its position within the iso-group.

ACKNOWLEDGMENTS

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