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EVALUATION OF NITROGEN-FERTILIZER RECOMMENDATIONS FOR SUGAR BEET ON THE NITROGEN-INDEX EXPERT SYSTEM

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INTRODUCTION

Besides variety and environmental conditions, the nitrogen (N) fertilization is a major factor influencing the financial profit of the sugar beet crop. In Belgium, concerns about quality as measured by sugar content and extractability have led to increasing pressure from the sugar industry to promote fertilization systems which guarantee high crop quality.

N-INDEX is a N-advisory system, developed to calculate optimal N fertilizer rates that take into account the expected N supply by the soil itself throughout the growing season. The calculation of the available N is based on the mineral N content of the soil at sowing time as well as on a range of other factors estimating the N mineralization during the growing period (Vandendriessche et al., 1992; Geypens et al., 1994). N-INDEX is built empirically and is continuously refined both by new field trials and feedback from practice.

This poster presents the results of a study carried out in 1996 to evaluate the effectiveness of N fertilizer recommendations based on N-INDEX with respect to production levels, quality, and financial return of the sugar beet crop at farm level.

MATERIALS AND METHODS

The study area is situated in the Western part of Belgium (Flanders), a region with about 360,000 hectares of agricultural land, 21,000 hectares whereof are planted annually with sugar beet (data from N.I.S., 1993). In this region most sugar beets are grown on sandy-loam soils, loamy soils, or clay soils.

All sugar beet growers of this region who used N-INDEX based N recommendations on their sugarbeet crop were invited to join the project. A questionnaire was sent out to all farmers willing to participate. In this way, information was gathered on, among others, soil structure, fertilization practices, diseases, variety, and crop growth. In the course of the growing season, all participating farmers were visited twice to discuss the questionnaire and the condition of their fields. At harvest, yield and quality parameters for each of the sugar beet parcels were obtained from the sugar factories. In total about 60 parameters were collected (Table 1) for each parcel. The diagram (Figure 1) shows how the necessary data from the sugar beet grower, the sugar factories and the Soil Service of Belgium were gathered and put together into one database. In this way essential information became available for 208 parcels in total.

Table 1. List of the parameters collected from the parcels which were selected for the evaluation of the N-fertilizer recommendations.

Farmer Parameters	Parcel Parameters	Results Soil Analysis and N-Recommendations
name	parcel identification	NO_3-N soil layer 0-30 cm (kg N ha^{-1})
address	parcel surface	NH_4-N soil layer 0-30 cm (kg N ha^{-1})
postal code	soil analysis	NO_3-N soil layer 30-60 cm (kg N ha^{-1})
city		NH_4-N soil layer 30-60 cm (kg N ha^{-1})
distict		NO_3-N soil layer 60-90 cm (kg N ha^{-1})
telephone number		NH_4-N soil layer 60-90 cm (kg N ha^{-1})
fax number		soil texture 0-30 cm
client number SSB		soil texture 30-60 cm
client number sugar factory		soil texture 60-90 cm
		pH-KCl (0-30 cm)
		carbon content 0-30 cm (%)
		N-INDEX
		N-recommendation (kg N ha^{-1})

Parcel History	Sowing Parameters	Fertilizaton
previous crop	sowing date	*organic fertilization(s)*
green manuring	variety	-manure
	seed disinfection	-application rate (tons ha^{-1})
	distance between rows	-application date
	distance between the plants	
	number of plants (count)	*mineral fertilization(s)*
		-type of fertilizer
		-rate (kg ha^{-1})
		-application date
		recent liming
		-lime
		-rate (tons ha^{-1})
		-application date

Diseases/Problems and Fungicide Application	Yield Parameters
diseases/problems	load numbers
-yellowing diseases	delivery date (at sugar factory)
-bolting	for each load:
-wilting	-net weight
-rhizomania	-sugar content (%)
-stunting	-sugar extractibility (%)
fungicide application(s)	-*a*-N content (mg 100 g^{-1} beet)
-type of fungicide	-K content (mg 100 g^{-1} beet)
-rate (kg ha^{-1} of I ha^{-1})	-Na content (mg 100 g^{-1} beet)
-application date	-tare (%)
remarks	

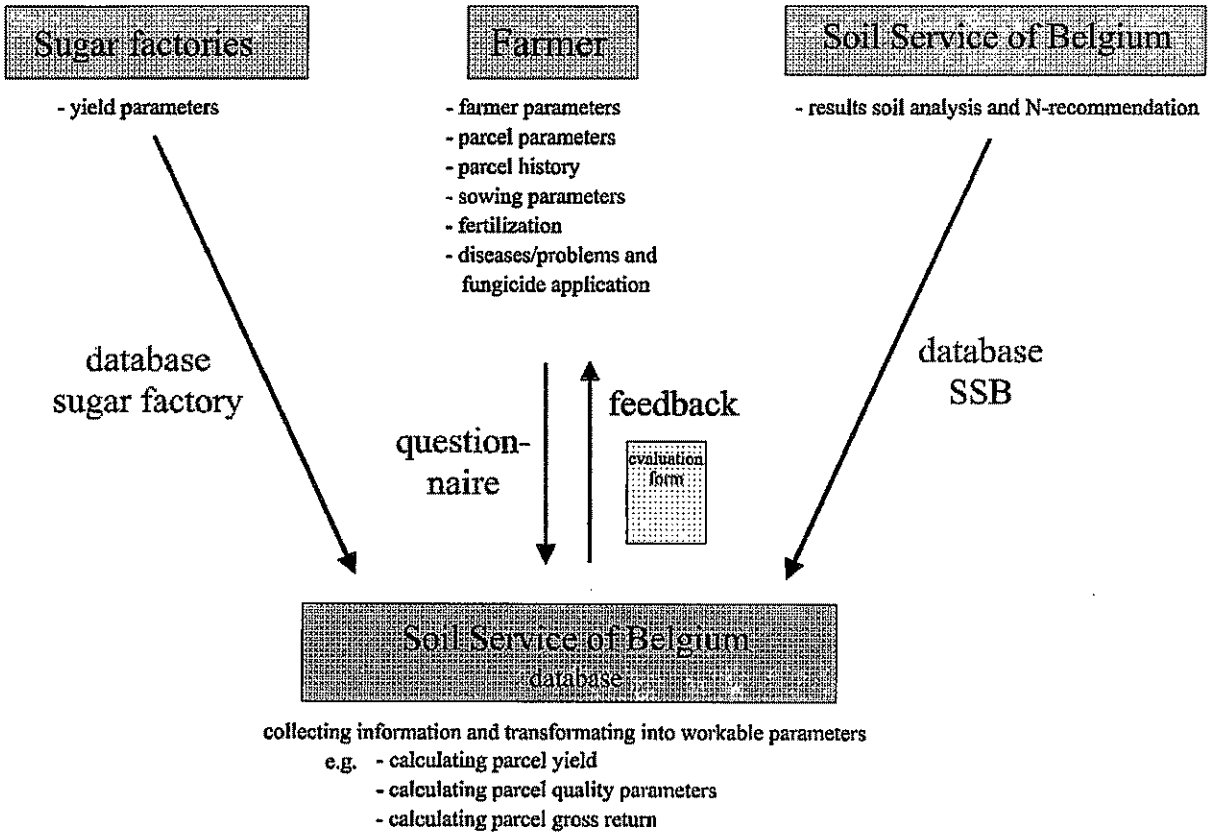

Figure 1 : Diagram indicating how the essential data were gathered and put together into one database

Table 2 : Mean value, standard deviation, minimum and maximum value of the most important parameters in the database.

database : 208 records	average	standard deviation	minimum value	maximum value
Mineral N 0 - 30 cm (kg N/ha)	62.6	41.0	10.1	237.5
Mineral N 30 - 60 cm (kg N/ha)	98.2	61.7	7.3	352.7
Mineral N 60 - 90 cm (kg N/ha)	80.4	54.4	8.4	402.2
Mineral N 0 - 90 cm (kg N/ha)	241.3	135.7	25.8	921.1
N-index	251.5	95.1	101.0	590.0
N-recommendation (kg N/ha)	71.6	51.9	0.0	185.0
sugar beet production (tons/ha)	61.3	9.2	39.0	87.1
sugar content (%)	16.9	0.7	15.0	18.7
sugar yield (tons/ha)	10.3	1.6	6.2	14.9
sugar extractability (%)	87.0	6.5	78.8	93.0

RESULTS AND DISCUSSION

Table 2 gives an overview of the most important parameters obtained from the 208 parcels. It provides for each parameter the mean value, the standard deviation and the minimum and maximum values observed. As these data were collected from production fields, it is not surprising to find a huge variation in the results. In particular the springtime mineral N reserve in the soil varies much from one field to another as a result of differences in organic manuring (use of animal manure, green manure), previous crop, soil type, etc. Table 3 shows that parcels which received animal manure have on average higher mineral N contents than those without organic manure. Climatic conditions during the winter period and also soil type explain the extent of N leaching. The use of green manure in the crop rotation appears to influence the distribution of mineral N in the soil profile which is one of the factors having an impact on the N recommendations for sugar beets.

For establishing the relationship between the mineral N content of the soil in the springtime on the one hand and the quality (sugar content) of sugar beets on the other hand, the following records were dropped from the database: parcels with an overdose of N, i.e. a N fertilization more than 50 kg N ha^{-1} above the recommended dose (calculated by the N-INDEX expert system); parcels which were harvested very early (September); parcels on which particular problems were encountered during the growing season (insects, nematodes, harvesting problems, etc.).

The relation between the mineral N content of the soil (0-90 cm of depth) in spring and sugar content of the beets at harvest is demonstrated in Figure 2 where N reserve (kg N ha^{-1}) is plotted versus sugar content (%). The large variation observed is explained by other factors having an important influence on the sugar content: variety, harvesting date, N-fertilization, soil type, etc. Nevertheless, it is interesting to note that high sugar contents were never recorded on fields with very high mineral

Table 3 : Average mineral nitrogen content of the soil profile, N-INDEX of the parcel and N-recommendation as a function of organic manuring

	without organic manure		with organic manure	
	without green manure	with green manure	without green manure	with green manure
mineral N 0 - 30 cm	56.3	40.8	65.2	61.3
mineral N 30 - 60 cm	94.9	59.1	102.9	79.8
mineral N 60 - 90 cm	75.8	41.3	83.4	60.0
mineral N 0 - 90 cm	227.0	141.1	251.5	201.1
N-INDEX	235.0	178.6	257.6	246.4
N-recommendation	87.5	117.6	67.6	76.6

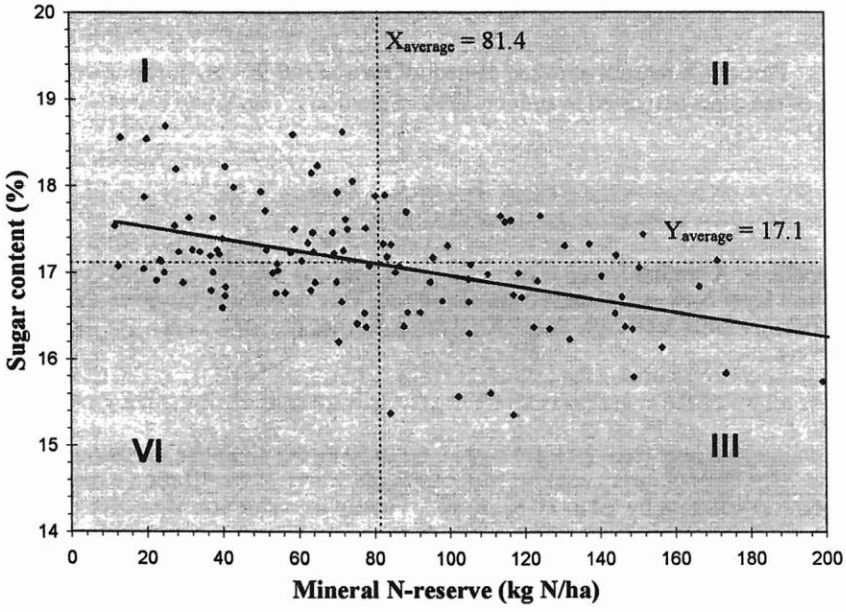

Figure 2 : Plot of the mineral nitrogen content of the soil (0-90 cm) in spring versus the sugar content of the roots harvested in autumn 1996. Significant regression line at 95%-confidence level ($R^2 = 0.12$).

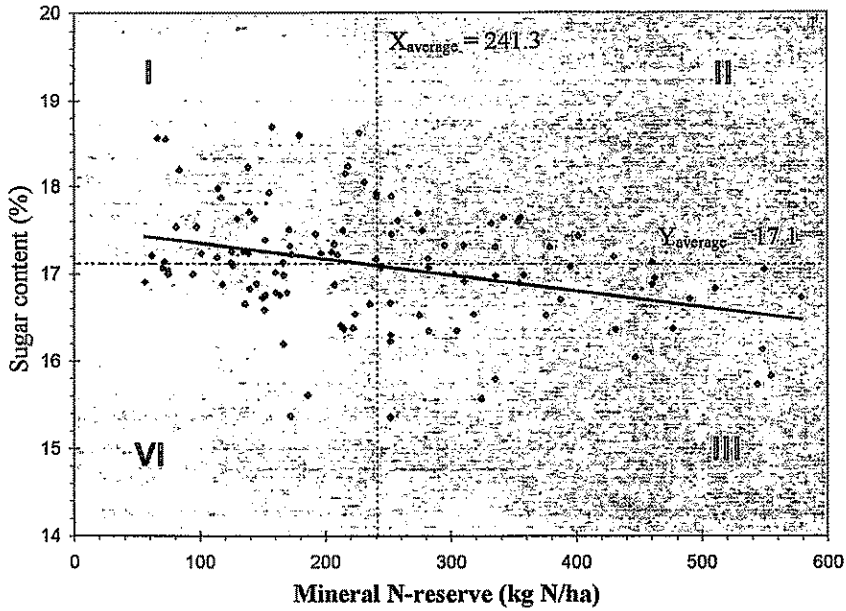

Figure 3 : Plot of the mineral nitrogen content of the soil (60-90 cm) in spring versus the sugar content of the roots harvested in autumn 1996. Significant regression line at 95%-confidence level ($R^2 = 0.23$).

N contents. A similar image is obtained when studying the effect of the N content of the soil layer between 60 and 90 cm (Figure 3). This shows that that even the mineral N content of this deep layer does effectively influence the sugar content of the roots at harvest.

In order to determine the influence of the N fertilization on the yield, quality, and gross return of the sugar beets, the 208 parcels were split up into three groups. The first group is made up of those parcels which received N fertilizer close to the recommended rate: from 20 kg N ha^{-1} under to 30 kg N ha^{-1} above the recommended dose. The second group consists of those fields where N fertilization exceeded the recommended rate by 30 to 80 kg N ha^{-1}. Finally the third group are those parcels with a N dose of more than 80 kg N ha^{-1} above of the recommendation.

For each of these three groups, the average yield (tons ha^{-1}), the average sugar content (%) and the gross return were calculated. The latter is a function of the yield and of the sugar beet price which in turn is determined by three factors: base price, a bonus for quality (sugar content), and the pulp price.

Figure 4 shows how yield increases only slightly with higher N rates. This means that pushing the N fertilization above the recommended rate will only have a minor effect on sugar beet yield as such. Overfertilized sugar beets may produce more leaves, though this parameter is hard to determine in field conditions. Sugar content on the other hand was clearly affected by the fertilization as it was indeed lower for

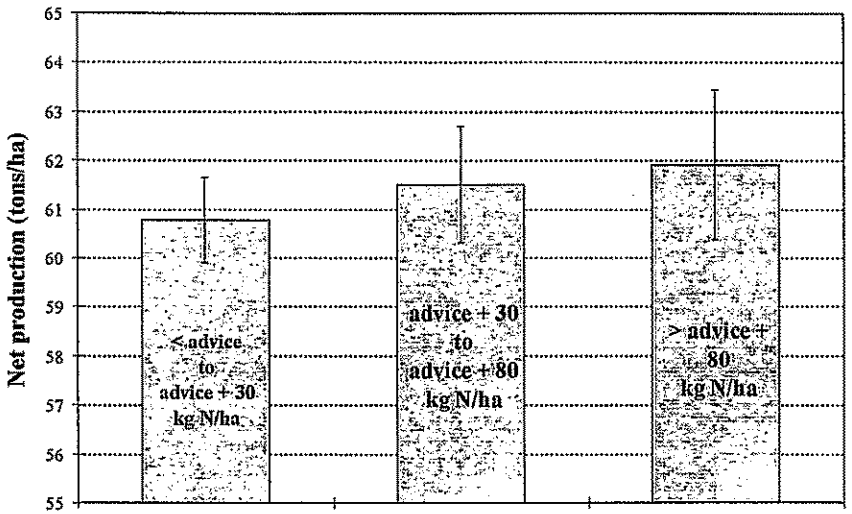

Figure 4 : Average net root production ($x \pm \overline{SE}$) related to the applied N-fertilization (in relation to the recommended dose) : group 1 = 60.77 ± 0.87 (n = 144); group 2 = 61.50 ± 1.19 (n = 63); group 3 = 61.91 ± 1.53 (n = 31)

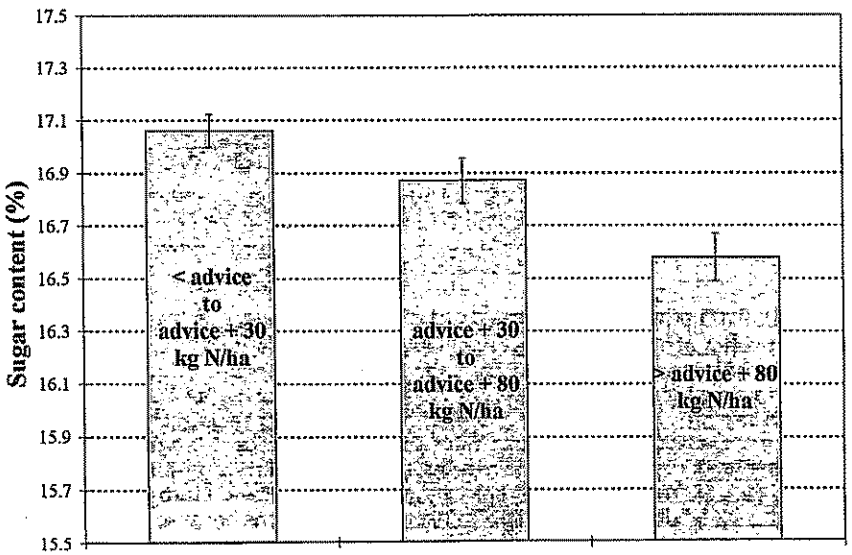

Figure 5 : Average sugar content ($\overline{x} \pm SE$) of the roots related to the applied N-fertilization (in relation to the recommended dose) : group 1 = 17.06 ± 0.06 (n = 144); group 2 = 16.87 ± 0.09 (n = 63); group 3 = 16.58 ± 0.09 (n = 31)

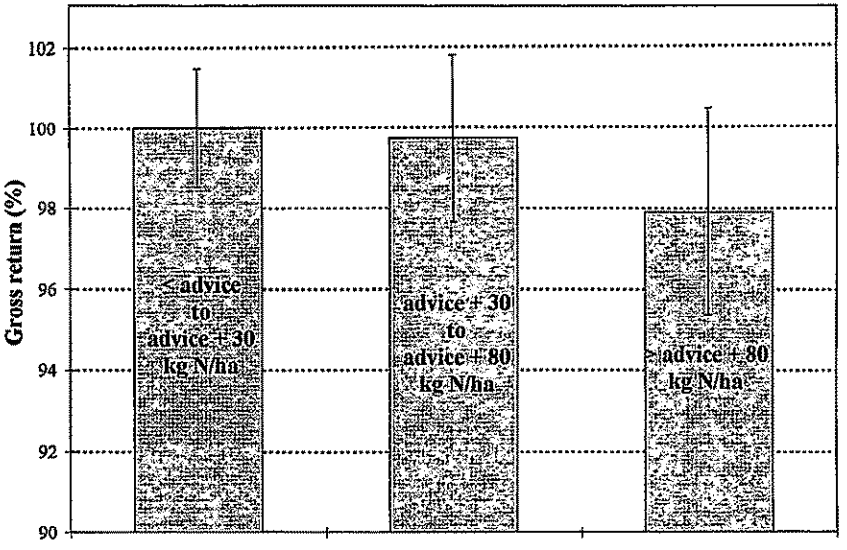

Figure 6 : Gross return ($x \pm \overline{SE}$) of the sugar beet crop (relative to group 1) related to the applied N-fertilization (in relation to the recommended dose) : group 1 = 100.0 ± 1.5 (n = 144); group 2 = 99.7 ± 2.1 (n = 63); group 3 = 97.9 ± 2.5 (n = 31)

beets grown on overfertilized fields (Figure 5). As the amount paid to the farmer reflects both crop yield and sugar content, a lower yield of high quality beets may be more profitable to the farmer than a somewhat higher yield of lower quality sugarbeets. This appears to be the case in practice as shown in Figure 6. It indicates that beets grown on overfertilized fields were less profitable than those harvested from parcels fertilized as recommended in spite of higher crop yields.

CONCLUSION

Results from production field can provide interesting data, besides data from field trials, to evaluate the accuracy of N-advisory systems like N-INDEX. From these results, the following conclusions can be drawn.

Due to differences in soil type, organic manuring, and previous crop, large variations can be expected in mineral N content of the fields in spring. Measuring this N content is essential for determining the optimum N fertilization rate for sugar beets. Results show that for growing high quality beets the N-rate needs to be adjusted in function of the expected N supply by the soil itself. Nitrogen rates above the recommended dose may lead to diminished gross returns because of lower sugar content.

ACKNOWLEDGEMENTS

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