Comparison of costs and yields of 'type top' and 'type average' growers in Dutch sugarbeet growing

Vergleich von Kosten und Zuckerertrag landwirtschaftlicher Betriebe in den Niederlanden

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The Dutch sugar industry and sugarbeet research initiated the project SUSY (Speeding Up Sugar Yield) as a reaction to the reform of the European Union sugar regime. The project was aimed at softening the reform's impact on grower income by improving their knowledge on raising sugar yield and identifying possible cost savings. From each sugarbeet growing region in The Netherlands, 26 pairs of 'type top' (high yielding) and 'type average' (average yielding) farmers were selected, based on their yield levels in 2000–2004. During three years, all aspects of sugarbeet production were investigated on 75 fields of 'type top' and 74 fields of 'type average' growers. Based on grower's crop management record, cost variables were calculated and analyzed in relation to yield and quality variables. The factors year and grower caused most of the significant effects on yield, quality and cost variables. The grower can compensate for the year effect of biotic and abiotic variables on yield.

The 'type top' growers had significantly higher sugar yields in each year compared to 'type average' growers, but the total variable costs did not differ. This makes the 'type top' growers more efficient in resource use. Costs for manure and fertilizer, 'other' and irrigation significantly increased the total variable costs. With higher fungicide costs, sugar yield significantly increased. There was no significant relation between the intensity of sugarbeet production and sugar yield. Based on this study, it can be concluded that the most profitable strategy for the growers is maximizing sugar yield and optimizing costs. The observed differences in sugar yield were not caused by economical constraints.

Key words: sugarbeet, variable growing costs, grower performance, SUSY pair study, yield, competitiveness

Als Reaktion auf die Reform der Europäischen Zuckermarktordnung initiierten die niederländische Zuckerindustrie und die Zuckerrüben-Forschung das Projekt SUSY (Speeding Up Sugar Yield). Ziel des Projektes war es, die Auswirkungen der Reform auf das Einkommen der Landwirte durch das Aufzeigen von Möglichkeiten zur Erhöhung des Zuckerertrages und zur Ermittlung möglicher Kosteneinsparungen zu mildern. Aus jeder Region in den Niederlanden, in denen Zuckerrüben angebaut werden, wurden 26 Paare von 'type top'-Landwirten mit hohem Ertrag und 'type average'-Landwirten mit durchschnittlichem Ertrag aufgrund ihrer Erträge im Zeitraum 2000–2004 ausgewählt. In einem Zeitraum von drei Jahren wurde der Zuckerrübenanbau auf 75 Flächen von 'type top'- und 74 Flächen von 'type average'-Landwirten untersucht. Basierend auf den vom Landwirt erfassten Daten wurden Kostenvariablen kalkuliert und in Relation zu Ertrags- und Qualitätsvariablen analysiert. Die Faktoren Jahr und Landwirt hatten die meisten signifikanten Effekte auf Ertrag, Qualität und Kostenvariablen. Der Landwirt kann den Jahreseffekt von biotischen und abiotischen Variablen auf den Ertrag ausgleichen.

Die 'type top'-Landwirte hatten in jedem Jahr signifikant höhere Erträge im Vergleich zu 'type average'-Landwirten, jedoch unterschieden sich die gesamten variablen Kosten nicht, d.h. die 'type top'-Landwirte waren effizienter in der Ressourcennutzung. Die gesamten variablen Kosten wurden signifikant durch die Kosten für organische und mineralische Düngemittel, sonstige Kosten und Beregnungskosten erhöht. Die Kosten für Fungizide erhöhten den Zuckerertrag signifikant. Kein signifikanter Zusammenhang wurde zwischen der Intensität der Zuckerrübenproduktion und dem Zuckerertrag gefunden. Basierend auf dieser Studie kann die Schlussfolgerung gezogen werden, dass die profitabelste Strategie für die Landwirte die Maximierung von Zuckerertrag mit Optimierung der Kosten ist. Die beobachteten Unterschiede im Zuckerertrag wurden nicht durch wirtschaftliche Einschränkungen verursacht.

Stichwörter: Zuckerrübe, variable Kosten, Leistung, SUSY-Paarvergleich, Ertrag, Konkurrenzfähigkeit

1 Introduction

Sugarbeet growers in Europe as well as in The Netherlands face the challenge of keeping up their financial yields. Due to the reform of the European Union sugar regime, the EU minimum price for quota beet fell from 43.63 EUR t^{-1} sugarbeets (CR (EC) 1260/2001, 2001; *Zeddies*, 2006) to 26.29 EUR t^{-1} from 2009 onwards (CR (EC) 318/2006, 2006), implying a 39.7% decrease. Growers have to raise their yield by the same percentage to compensate for this price drop, if the costs remain on the level of 2006. Another strategy is to reduce costs. Possibilities to save up to 20% of the costs without yield loss in Dutch sugarbeet production were identified by a previous study (*Pauwels*, 2006b). However, to compensate for the beet price drop by cost savings, costs should decrease much more to keep the absolute difference between costs and payment the same. Therefore, cost saving still leaves a need for raising sugar yield. A combination of both raising yield and saving costs would be profitable for the growers, too.

The potential sugar yield in The Netherlands was calculated at a maximum of 23 t ha^{-1} (*De Wit*, 1953), more recent research found 24 t ha^{-1} sugar for Germany (*Kenter* et al., 2006). However, the average sugar yield achieved by Dutch growers was 10.6 t ha^{-1} in the period 2002–2006 (*Van Swaaij*, 2007). There is an enormous difference in sugar yield between growers, even when the fields are located in the same region (Agrarische Dienst, 2007). That is to say, there is an enormous, unexploited gap in sugar yield by a large group of growers.

The aforementioned changed circumstances and the presence of a yield gap call for knowledge on how the sugarbeet growers in The Netherlands can improve sugar yields and make possible savings on their costs. The causes and costs of the difference in yield were studied in the project "Speeding Up Sugar Yield" (SUSY) (*Pauwels*, 2006a) in a pair-wise comparison of neighboring growers with high yields ('type top') and average yields ('type average'), encountering the same production prerequisites: soil and climate.

The aim of this paper was to analyze the yield, quality and costs of the different 'type top' and 'type average' growers in order to identify rules for improving the economic success of Dutch sugarbeet production. Therefore, the growers recorded all agronomic measurements in sugarbeet production, which formed the basis for calculations on the performance of 'type top' and 'type average' growers.

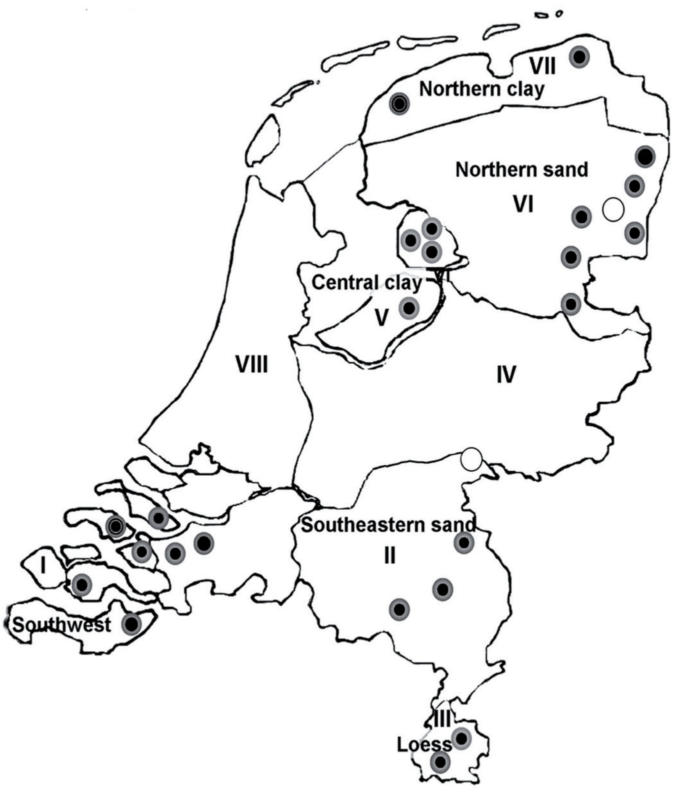

Fig. 1: The regions and location of the SUSY pairs in The Netherlands, each spot represents the location of a pair consisting of a 'type top' and a 'type average' grower; SUSY project 2006–2008. Open dots indicate two pairs of which the 'type average' grower sold the sugar reference in winter 2007/08, therefore these pairs were not included in the study in 2008.

2 Materials and methods

2.1 Data source

The data were obtained from the project 'Improvement of the competitiveness of the sugar beet crop' of the Dutch Institute of Sugar Beet Research, IRS, Bergen op Zoom.

The pair-wise comparison comprised 26 pairs (52 growers) in both 2006 and 2007. In 2008, data of 23 'type top' and 22 'type average' growers were available for costs calculation. This was due to the exclusion of two pairs from which the 'type average' sold the sugar quota and of three growers which did not fully complete the questionnaire in 2008.

A grower was considered 'type top' when the sugar yield on his farm in the period 2000–2004 was on average and in each single year among the 25% of the highest sugar yields in the region where the farm was situated. A grower was considered 'type average' when the sugar yields in the same period were among the 50% of average sugar yields in the region. Pairs were formed out of a 'type top' and a 'type average' grower, with at least 1.5 t ha^{-1} difference in sugar yield based on the 5 years average between those two growers. The location of the pairs in the different regions in The Netherlands is shown in Figure 1.

Data were collected on parameters of soil physics, soil fertility, soil health, rainfall, drilling (date, depth, distance), field establishment, canopy closure, pests and diseases, nutrient uptake, yield and quality, harvest losses and exact field size (Global Positioning System, GPS). All parameters were measured following the IRS internal protocols or the standard available protocols (*Pauwels*, 2006a). From these variables, yield, quality and field size are presented in this publication.

Additionally, the growers recorded all agronomic measurements, including application dates, prices, type and amounts of consumables etc. All data obtained were fed into a specially built Microsoft Access® database called 'Betapaar'. This database facilitates the calculation of the total variable costs based on the single cost components. Total machinery and contracting costs were calculated from the single cost components related to machinery use and contracting. Total direct growing costs were calculated from the single cost components for consumables. Root yield and sugar yield were used to calculate unit costs for root yield and sugar yield based on the total variable costs. The revenues were calculated from the yield and quality parameters and the beet price.

2.2 Calculation of total variable costs

Costs for chemicals, fertilizers, manure and contracting were taken from the growers' records. Costs for farmers' own machinery used, including labor, were calculated based on standard prices per hectare and only assigned to the farm for the measurements carried out (Table 1). This harmonized the costs for growers' own equipment, which are difficult to assess in practice as a lot of diverse types and brands of equipment with an enormous variation in age were used. If measurements were carried out by a contractor, the actual price paid to the contractor was obtained from the growers.

The basis was to value all inputs in growing sugarbeet and assess the total variable costs including labor, base materials, all machinery costs and contracting fees. The total variable costs exclude the fixed costs e.g. tenancy for the field and the overhead of the farm. The overhead encloses profit margin, costs of sugar quota, assurances for crop and grower, buildings, maintenance of fields, field

Table 1: Costs calculated for the use of own machinery by the farmers

Cost components farmers own machinery[1]	Tractor[2] (EUR h^{-1})	Fuel consumption ($L\ h^{-1}$)	Machine[2] (EUR h^{-1})	Treatment time ($h\ ha^{-1}$)	Total (EUR ha^{-1})	Taken in calculation (EUR ha^{-1})
Soil treatment						
Catch crop drilling	8	10.0	15.5	0.70	32	30
Main soil tillage	18	15.0	21.0	1.18	75	75
Equalization treatment	18	15.0	19.0	1.18	73	70
Drilling of wind erosion cover crop	8	10.0	15.5	0.70	32	30
Seedbed preparation	13	10.0	22.5	1.00	57	55
Cambridge rolling	8	10.0	5.0	0.50	17	15
Application of wind erosion protection compounds						20[3]
Drilling	8	10.0	52.0	0.85	69	70
Nutrient application	13	10.0	10.0	0.30	13	15
Foliar nutrient application	13	10.0	20.0	0.30	16	20
Herbicide application	13	10.0	20.0	0.30	16	20
Herbicide application with special equipment	8	10.0	17.0	0.50	23	25
Mechanical weeding	8	10.0	32.0	0.60	37	35
Pesticide application	13	10.0	20.0	0.30	16	20
Irrigation	18	from growers' records	106.0	0.50		95[4]
Harvest						
Harvester		40.7				350[5]
Transport to clamp	13	15.0	14.0	1.18	61	60

[1] All cost components include labor costs of 15 EUR h^{-1} and are based on average used equipment and fuel price 0.65 EUR L^{-1}. [2] The tractor and machine costs per hour are based on the yearly costs of these machines, including storage, maintenance and lubricants, depreciation, interest and assurance costs (*De Wolf* and *Van der Klooster*, 2006). For each treatment a suitably sized tractor is taken into account, e.g. a heavier tractor for ploughing than for drilling. [3] Taken without calculation from *Wilting* (2008). [4] To this amount the fuel costs per hectare were added. [5] Based on second hand 6 row bunker harvester, market price 50,000 EUR with depreciation to 0 in 4 years, including storage, assurance, interest, maintenance and lubricants. Calculation for an acreage of 100 ha a^{-1}.

and ditch edges, etc. The reason to compare only the total variable costs was that the fixed costs are very farm specific and depend on a lot of parameters which are not determined by the growing of sugarbeets. Above all, the level of the fixed costs is almost independent of the grown crop. Unit costs were calculated based on the net root and sugar yield per hectare, without harvest losses, because the harvest losses remain in the field, unpaid.

The sum of the costs of the use of growers' own machinery and the contractor costs makes up the total contracting and machinery costs. This cost component enclosed all the costs related to the machinery used in sugarbeet growing. This implies that also the fixed machine costs such as storage, depreciation, interest, maintenance (including the labor for maintenance) and assurance costs are included in the machinery costs per hectare (Table 1).

The sum of all costs for seeds, pesticides (herbicides, fungicides and insecticides), manure and fertilizers, hand weeding and the 'other' cost components makes up the total direct growing costs. These costs can be considered as the costs for the consumables in sugarbeet growing. The fuel costs are included in the total contracting and machinery costs.

Costs for application of fertilizers and organic manure were only assigned to the sugarbeet production if they were paid by the sugarbeet grower. They were neglected when the animal producer paid for these costs. In case the sugarbeet growers were paid to receive the manure, this payment is taken into the cost calculation as additional payments for the sugarbeets (*Van den Ham* et al., 2007).

'Other' costs include the costs for the seed of green manure crops, costs for covering the beet clamps, costs for wind and water erosion prevention. The costs for wind erosion prevention are the costs for the seed of barley (sown just before the sugarbeets), paper pulp or manure (both sprayed after drilling).

Total variable costs are obtained by the summation of the total costs of contracting and own machinery and the total direct growing costs. All cost components are calculated in Euro per ha.

2.3 Yield and beet price

The total sugarbeet quantity delivered to the sugar factory, including the quality parameters, was derived from the growers' records. Root yield, sugar yield as well as sugarbeet prices, based on the quality components, were calculated with the Betapaar database, taking into account the exact field size.

Root yield ($t\ ha^{-1}$) was corrected for top and soil tare and the basis for the revenues (EUR ha^{-1}), calculated from the sugarbeet price (EUR t^{-1}). Sugarbeet quality parameters formed the basis of the sugarbeet price (*Huijbregts* and *Tijink*, 2008). Sugarbeet quality parameters are: sugar content ($w_{S,B}$), potassium, sodium and α-amino nitrogen content ($w_{(K+Na)}$ and $w_{\alpha\text{-}N}$ in mmol kg^{-1}) of the sugarbeets, which determine the amount of sugar which remains in the molasses ($\hat{m}_{MS}$). The Dutch sugar industry uses a formula to calculate the sugar recovery (R_{WIN}, Winbaarheidsindex Nederland or beet quality index) based on quality parameters and the calculated quantity of sugar in molasses. The R_{WIN} is expressed as a percentage (*Huijbregts*, 1999):

$$R_{WIN} = 100 - 100 \cdot (\hat{m}_{MS}/w_{S,B}) \qquad (1)$$

The white sugar yield was not considered in the present study, because the growers only consider the sugar yield and beet quality. Sugar yield ($m_{S,B}$) is calculated as the product of root yield (m_B) and sugar content ($w_{S,B}$). Standardized prices were taken for quota beets (35 EUR t^{-1}) and for surplus beets (15 EUR t^{-1}), both at 16% sugar and R_{WIN} = 87. Sugar content and beet quality were fined with –8.40 EUR t^{-1} at 14% sugar and with –4.19 EUR t^{-1} at R_{WIN} = 80 and paid with 6.30 EUR t^{-1} at 18% and with 2.68 EUR t^{-1} at R_{WIN} = 92 per t root yield (*Huijbregts* and *Tijink*, 2008).

Since top tare is not fined (nor paid) by the Dutch sugar industry (*Huijbregts* and *Tijink*, 2008), the amount of top tare has no influence on sugarbeet payments. Soil and other (stones, wood pieces, weeds and rotten beets) tare is fined with 12.50 EUR t^{-1} (*Huijbregts* and *Tijink*, 2008). In the Betapaar database the fine was calculated per t root yield and subtracted from the sugarbeet price.

In this publication, all sugarbeets were considered being paid as quota beets for a transparent comparison of both grower types.

2.4 Statistical analysis

Data were analyzed using the statistical package GenStat, 11th edition (VSN International Ltd.). Linear mixed models were used to analyze the effect of year, grower, site and their interactions in the fixed model. The given pair number, region and their interaction were used as random terms to analyze the 'type top' and 'type average' within a pair directly with each other (*Thissen, J.T.N.M.*; Personal communication, 2009). Linear regressions were calculated to estimate the effect of single variables on sugar yield and total variable costs.

3 Results

3.1 Effect of grower and interactions with site and year

Sugar yield was not related to sugarbeet acreage per farm. The relation between total variable costs and sugarbeet acreage (on average 11.5 ha; range 2–40 ha) per farm was significant, but the coefficient of correlation was very low. Therefore, the sugarbeet acreage is not presented in the following.

The effect of site (S) was only significant for soil treatment and harvest costs (Table 2). Except for root yield, the effect of year (Y) was significant for all yield and quality parameters including beet price and revenues. Concerning the total direct growing costs, the significant effect of year was influenced by the significant effect of year on costs of fungicides and manure and fertilizer. The effect of year on total contracting and machinery costs was not significant,

Table 2: Significance of the effect of year (Y), grower (G), site (S) and their interactions on yield, quality and cost variables in Dutch sugarbeet production; SUSY project, 2006–2008. Grower 'type top' n = 75; grower 'type average' n = 74.

Variable[1]	Site (S)	Year (Y)	Grower (G)	Y × S	Y × G	G × S	Y × G × S
Root yield (t ha^{-1})	n.s.	n.s.	***	*	n.s.	n.s.	n.s.
Sugar content (%)	n.s.	***	*	n.s.	n.s.	n.s.	n.s.
Sugar yield (t ha^{-1})	n.s.	*	***	n.s.	n.s.	n.s.	n.s.
R_{WIN} (beet quality index)	n.s.	***	n.s.	n.s.	n.s.	n.s.	n.s.
Soil tare (%)	n.s.	*	n.s.	*	*	n.s.	n.s.
Top tare (%)	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.
Beet price (EUR t^{-1})	n.s.	***	n.s.	n.s.	n.s.	n.s.	n.s.
Revenues (EUR ha^{-1})	**n.s.**	*******	*******	**n.s.**	**n.s.**	**n.s.**	**n.s.**
Seed (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	***	n.s.
Herbicides (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Hand weeding (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*
Fungicides (EUR ha^{-1})	n.s.	***	***	n.s.	n.s.	n.s.	n.s.
Insecticides (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Manure and fertilizer (EUR ha^{-1})	n.s.	***	n.s.	n.s.	n.s.	n.s.	n.s.
Other (EUR ha^{-1})	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.
Total direct growing costs (EUR ha^{-1})	**n.s.**	******	**n.s.**	*****	**n.s.**	**n.s.**	**n.s.**
Soil treatment (EUR ha^{-1})	*	**	n.s.	n.s.	n.s.	n.s.	n.s.
Drilling (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Herbicide application (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mechanical weeding (EUR ha^{-1})	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Nutrient application (EUR ha^{-1})	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.
Irrigation (EUR ha^{-1})	n.s.	***	n.s.	***	n.s.	n.s.	n.s.
Pesticide application (EUR ha^{-1})	n.s.	**	***	n.s.	n.s.	n.s.	n.s.
Harvest (EUR ha^{-1})	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Total contracting and machinery costs (EUR ha^{-1})	**n.s.**	**n.s.**	*****	*******	**n.s.**	*****	**n.s.**
Total variable costs (EUR ha^{-1})[2]	**n.s.**	******	**n.s.**	*******	**n.s.**	**n.s.**	**n.s.**
Unit costs root yield (EUR t^{-1})[2]	**n.s.**	**n.s.**	*******	*******	**n.s.**	**n.s.**	**n.s.**
Unit costs sugar yield (EUR t^{-1})[2]	**n.s.**	*****	*******	*******	**n.s.**	**n.s.**	**n.s.**

[1] n.s. = not significant; *, **, *** = significant at $p \leq 0.05$, ≤ 0.01, ≤ 0.001. [2] Costs mentioned exclude the fixed costs e.g. tenancy for the field and the overhead of the farm. The overhead encloses profit margin, costs of sugar quota, assurances for crop and grower, buildings, maintenance of fields, field and ditch edges.

although it was significant for costs of soil treatment, irrigation and pesticide application. The year had a significant effect on the total variable costs and unit costs of sugar yield (excluding fixed costs), but not on unit costs of root yield.
The effect of grower (G) on yield and quality was significant for root yield, sugar content, sugar yield and consequently for revenues, but neither for the beet quality index nor top or soil tare (Table 2). The effect of grower was significant for fungicide, pesticide and nutrient application costs as well as for total contracting and machinery costs and both unit costs.
Compared to the main effects, there were only a few significant interactions: a year × site interaction for root yield, a year × grower and year × site interaction for soil tare, a grower × site interaction for seed costs, a threefold interaction of year × grower × site for hand weeding costs, a year × site interaction for 'other' costs, and interactions between grower and site respectively year and site for total contracting and machinery costs. Irrigation as well as all total costs and unit costs were significantly influenced by an interaction year × site (Table 2).
No significant relationship was found between root yield and sugar content (Fig. 2). The relationship of beet quality index and sugar content was highly significant. The influence of sugar content on beet price was highly significant while its influence on beet quality index was less strong (data not shown).

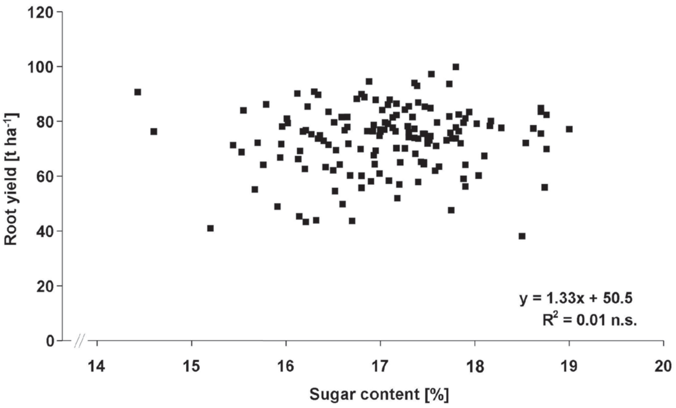

Fig. 2: Relationship of root yield to sugar content in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant.

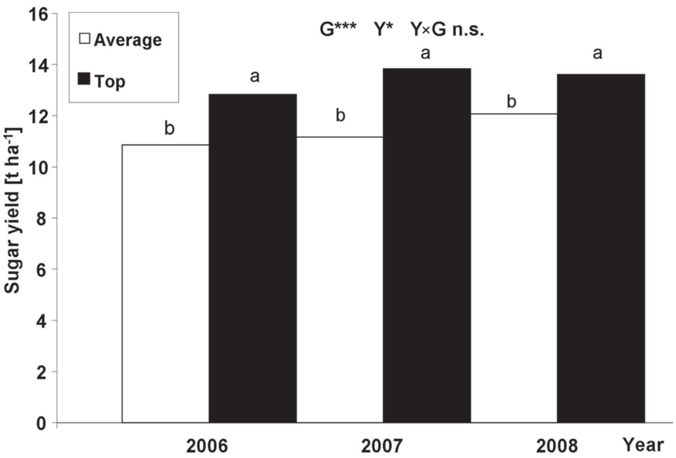

Fig. 3: Effect of year (Y) and grower (G) on sugar yield in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant; *, *** = significant at $p \leq 0.05$, ≤ 0.001. Different letters indicate statistical differences within years.

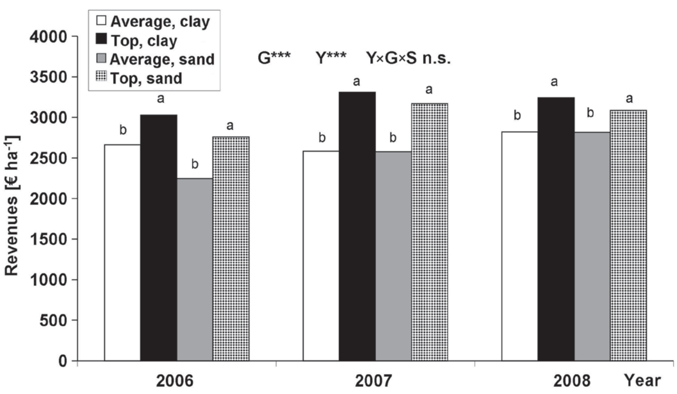

Fig. 4: Effect of year (Y), grower (G) and site (S) on revenues in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant; *** = highly significant at $p \leq 0.001$. Different letters indicate statistical differences between grower types within years.

3.2 Difference between grower types

The growers 'type top' had significantly higher root and sugar yield, resulting in significantly higher revenues (481 EUR ha^{-1} difference) compared to 'type average', although the difference in beet price was not significant (Table 3).
The 'type top' growers had significantly higher costs for fungicides, nutrient application and pesticide application, the latter two causing significantly higher total contracting and machinery costs for 'type top' growers compared to 'type average' growers. Both unit costs of root and sugar yield differed significantly between growers 'type top' and 'type average'. The total direct growing costs and total variable costs were not significantly different between growers 'type top' and 'type average'. For all variables considerably influenced by grower, the differences between 'type average' and 'type top' growers were significant, except for the difference in sugar content.
In the following, only data with significant main effects of grower and significant interactions of year and site (Table 2) are presented. However, if the main effect of grower was significant, the year × grower interaction is shown for these variables as well.
In all years, the 'type top' growers had a significantly higher sugar yield (12.8, 13.8 and 13.6 t ha^{-1}) compared to the 'type average' (10.9, 11.2 and 12.1 t ha^{-1}) (Fig. 3).
The effect of grower on revenues was highly significant, while the year × grower × site interaction was not significant (Table 2, Fig. 4). In all years and on both soil types, 'type top' growers had higher revenues compared to the 'type average'.
The effect of grower on soil tare was not significant, however, the year x grower interaction was (Table 2, Fig. 5). The 'type average' growers had significantly higher soil tare in 2007 (9.9%) compared to 2006 (8.4%) and 2008 (8.1%).
The grower × site interaction significantly influenced seed costs (Table 2). Seed costs were significantly lower on sandy soil for the 'type top' growers (195 EUR ha^{-1}) compared to the 'type average' (211 EUR ha^{-1}). The seed costs of 'type top' growers on clay soil (232 EUR ha^{-1}) did not differ significantly from those of 'type average' growers on clay soil (223 EUR ha^{-1}). The year × grower × site interaction had a significant influence on hand weeding costs (Table 2).
Fungicide and application costs of nutrients and pesticides were significantly higher for 'type top' growers in all years compared to 'type average' growers (Fig. 6). The differences between 'type

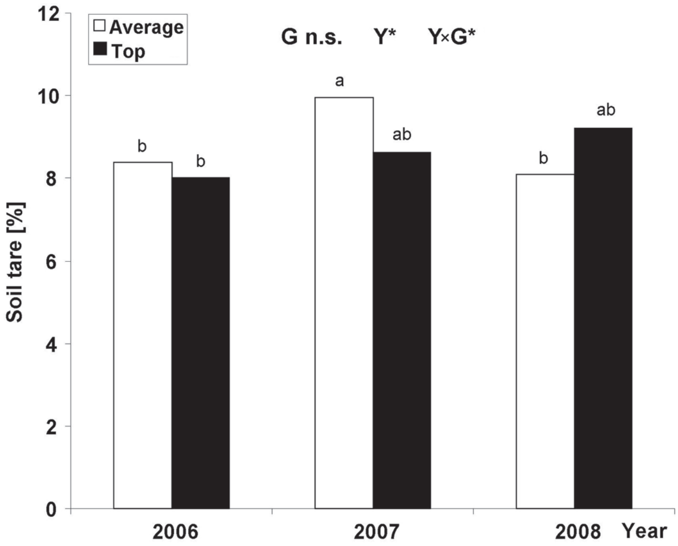

Fig. 5: Effect of year (Y) and grower (G) on soil tare in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant; * = significant at $p \leq 0.05$. Different letters indicate statistical differences between years.

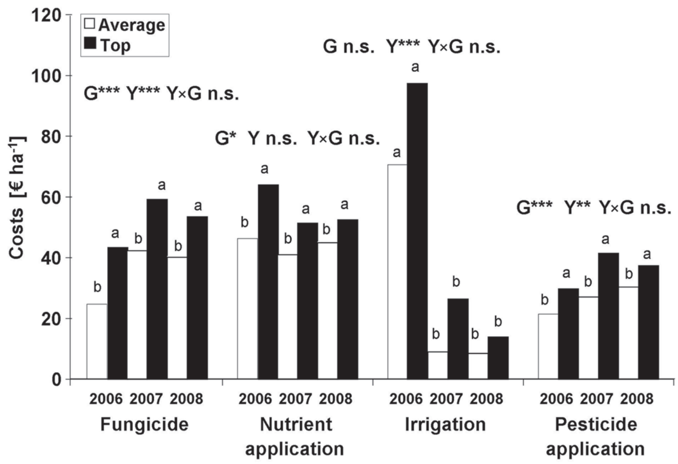

Fig. 6: Effect of year (Y) and grower (G) on costs of fungicide, nutrient application, irrigation and pesticide application in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant; *, **, *** = significant at $p \leq 0.05$, ≤ 0.01, ≤ 0.001. Different letters indicate statistical differences within each cost component and year.

Table 3: Influence of grower type on yield, quality and cost components in Dutch sugarbeet production; SUSY project, 2006–2008. Grower 'type top' $n = 75$; grower 'type average' $n = 74$.

Component	Significance effect[1]	Grower 'Type average'	Grower 'Type top'	LSD 5%
Root yield (t ha⁻¹)	***	66.7	78.1	2.89
Sugar content (%)	*	17.01	17.21	0.22
Sugar yield (t ha⁻¹)	***	11.4	13.4	0.51
R_{WIN} (beet quality index)	n.s.	91.1	91.1	0.29
Soil tare (%)	n.s.	8.8	8.6	0.87
Top tare (%)	n.s.	5.2	5.2	0.20
Beet price (EUR t⁻¹)	n.s.	39.08	39.75	0.86
Revenues (EUR ha⁻¹)	***	**2618**	**3099**	**128.80**
Seed (EUR ha⁻¹)	n.s.	217	213	6.53
Herbicides (EUR ha⁻¹)	n.s.	199	190	17.72
Hand weeding (EUR ha⁻¹)	n.s.	48	48	15.41
Fungicides (EUR ha⁻¹)	***	36	52	6.65
Insecticides (EUR ha⁻¹)	n.s.	1	2	1.66
Manure and fertilizer (EUR ha⁻¹)	n.s.	42	47	51.32
Other (EUR ha⁻¹)	n.s.	43	53	20.84
Total direct growing costs (EUR ha⁻¹)	**n.s.**	**543**	**564**	**59.19**
Soil treatment (EUR ha⁻¹)	n.s.	150	145	9.54
Drilling (EUR ha⁻¹)	n.s.	68	68	3.27
Herbicide application (EUR ha⁻¹)	n.s.	90	97	8.28
Mechanical weeding (EUR ha⁻¹)	n.s.	17	19	6.33
Nutrient application (EUR ha⁻¹)	*	44	56	9.56
Irrigation (EUR ha⁻¹)	n.s.	29	46	19.36
Pesticide application (EUR ha⁻¹)	***	26	36	5.04
Harvest (EUR ha⁻¹)	n.s.	345	342	10.73
Total contracting and machinery costs (EUR ha⁻¹)	*	**816**	**855**	**32.88**
Total variable costs (EUR ha⁻¹)[2]	**n.s.**	**1356**	**1416**	**73.35**
Unit costs root yield (EUR t⁻¹)[2]	***	**21.13**	**18.26**	**1.69**
Unit costs sugar yield (EUR t⁻¹)[2]	***	**125.1**	**106.8**	**9.92**

[1] n.s. = not significant; *, **, *** = significant at $p \leq 0.05$, ≤ 0.01, ≤ 0.001. [2] Costs mentioned exclude the fixed costs e.g. tenancy for the field and the overhead of the farm. The overhead encloses profit margin, costs of sugar quota, assurances for crop and grower, buildings, maintenance of fields, field and ditch edges.

top' and 'type average' growers for irrigation costs were not significant, but the year significantly influenced irrigation costs.

The 'type top' growers had significantly higher (49 EUR ha⁻¹) total contracting and machinery costs compared to 'type average' (Table 3, Fig. 7), the interaction grower × site being significant, too. On sandy soil, the total contracting and machinery costs were significantly higher for 'type top' (864 EUR ha⁻¹) compared to 'type average' growers (788 EUR ha⁻¹), while the effect was not significant on clay soil (847 and 844 EUR ha⁻¹) (Fig. 7). Neither grower nor the interaction year × grower × site had a significant effect on the total variable costs, although the non-significant differences were up to 200 EUR ha⁻¹ (Fig. 8 A, Table 3).

However, the grower main effect significantly influenced both unit costs root and sugar yield. The 'type top' growers had lower unit costs compared to the 'type average' growers in each of the three years (Fig. 8 B, C, Table 3).

3.3 Regression analysis

The relationship of total variable costs to costs of herbicide, hand weeding, insecticide, manure and fertilizer, 'other' costs, nutrient application and irrigation costs was significant (Table 4). However, the strength (R^2) was considerable only for the costs for manure and fertilizer, 'other' and irrigation costs. The total variable costs were significantly related to the total direct growing and the total contracting and machinery costs.

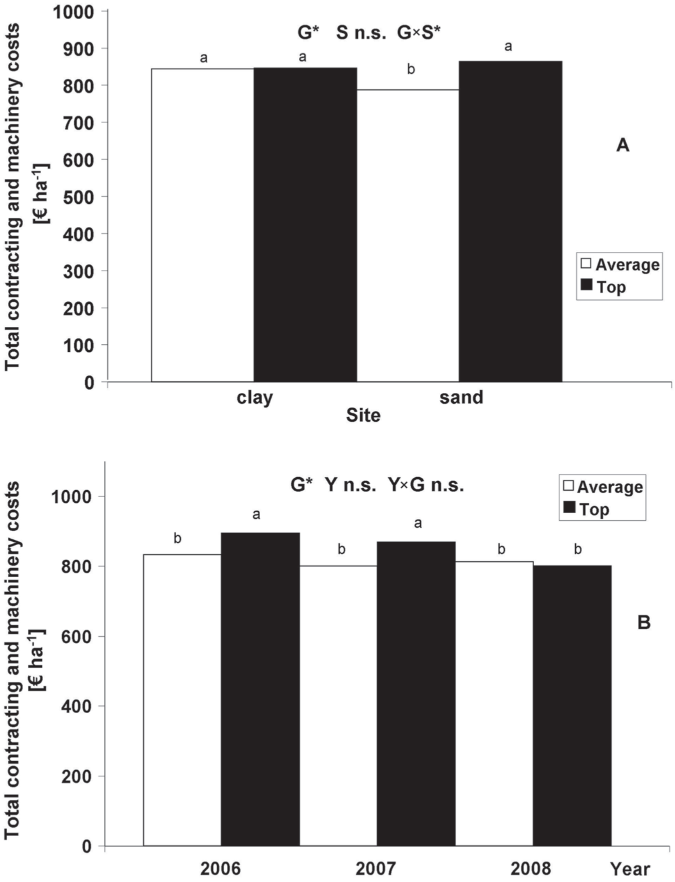

Fig. 7: Effect of grower and site (A) and year and grower (B) on total contracting and machinery costs in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant; * = significant at $p \leq 0.05$. Different letters indicate statistical differences between grower types.

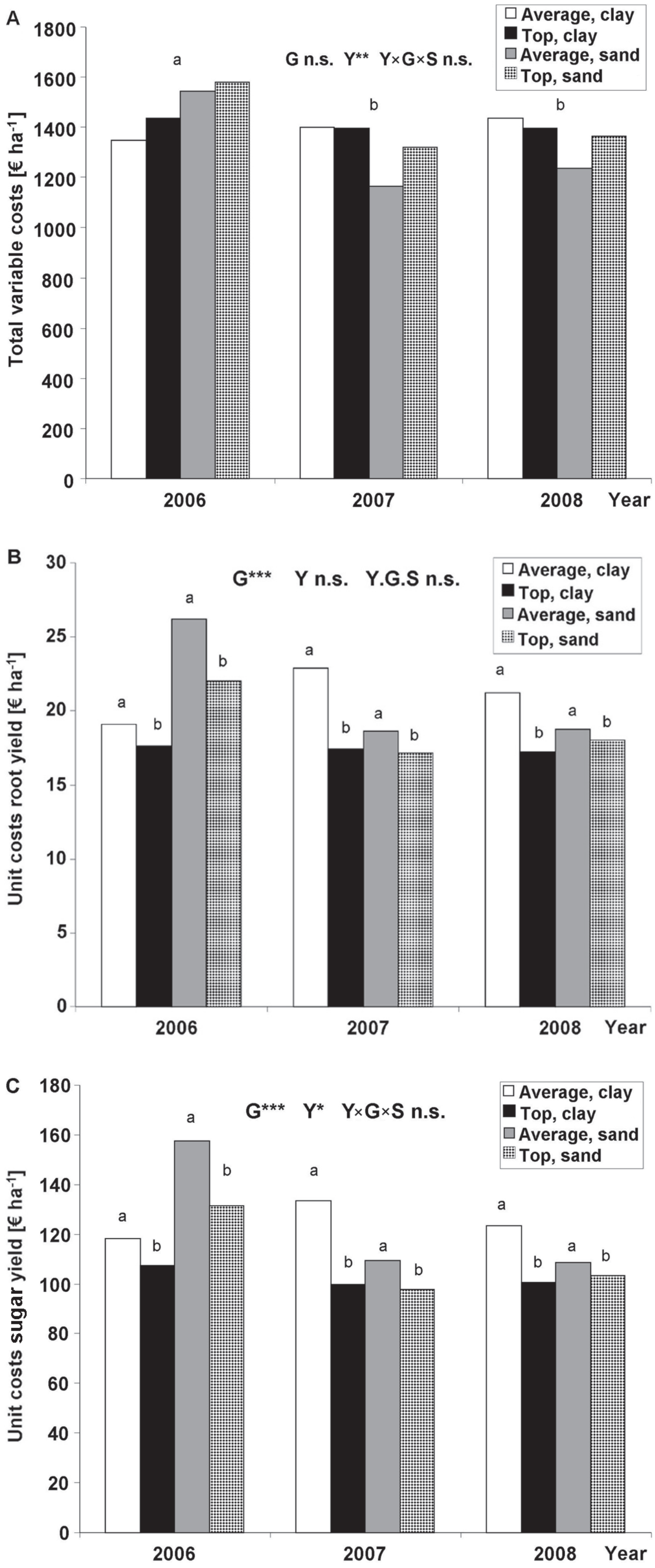

Fig. 8: Effect of year, grower and site on total variable costs (A), unit costs root yield (B) and unit costs sugar yield (C) in Dutch sugarbeet production; SUSY project, 2006–2008. Costs mentioned exclude the fixed costs e.g. tenancy for the field and the overhead of the farm. The overhead encloses profit margin, costs of sugar quota, assurances for crop and grower, buildings, maintenance of fields, field and ditch edges. n.s. = not significant; *, **, *** = significant at $p \leq 0.05$, ≤ 0.01, ≤ 0.001. Different letters indicate statistical differences between years (A) and between soil and grower types within years (B, C).

Sugar yield had a significant relationship only to seed, fungicide, drilling, and herbicide and pesticide application costs but with a very low R^2, except for fungicide costs. Finally, none of the cost components showing a significant correlation to sugar yield was significantly correlated to total variable costs and vice versa (Table 4). The non-relevant relationship of sugar yield to cost and cultivation intensity in sugarbeet is graphically demonstrated by two examples, the total variable costs and the fertilizer costs (Fig. 9, A–C).

4 Discussion

Many times in the history of Dutch agriculture, growers had to adapt to changing circumstances often initiated by economic impulses (*Bieleman*, 1992). For sugarbeet growers, the reform of the EU sugar regime was a recent economic pulse (CR (EC) 1260/2001, 2001) forcing them to decisions concerning the cost and yield level of sugarbeet production and even to decisions on continuing sugarbeet production or not. The SUSY (Speeding Up Sugar Yield) project aimed to provide growers with knowledge on how to handle the price drop in sugarbeet production. It investigated the causes and the costs of the differences in sugar yield, or growers' performance, in a pair-wise comparison. Farms in a pair were closely located to each other in all major sugarbeet producing regions in The Netherlands. The selection based on yields in 2000–2004 caused the 'type top' (high yielding) growers having higher yields compared to the 'type average' (average yielding) during the project. However, it

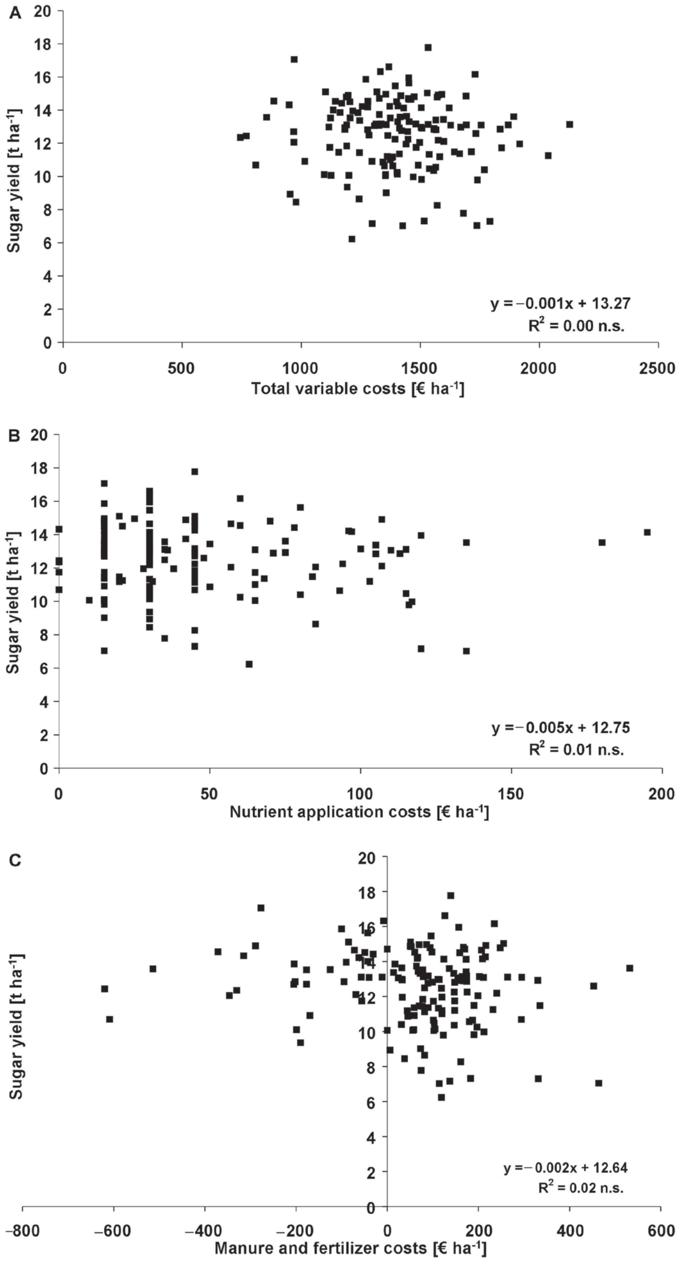

Fig. 9: Relation of sugar yield to total variable costs (A), costs for nutrient application (B) and manure and fertilizer (C) in Dutch sugarbeet production; SUSY project, 2006–2008. n.s. = not significant.

should be noticed that in each region at least one 'type average' grower was able to increase yield during the project, mainly due to a change in attitude towards sugarbeet production, not being pleased to be called 'type average'. On the other hand, not all 'type top' growers were excellent growers and had opportunities to raise their yields, too.

In the project, growers with a large sugarbeet acreage had no higher sugar yields compared with sugarbeet growers having a small acreage. Therefore, size of crop acreage cannot be used to measure growers' performance. In this study, there was no influence of sugarbeet acreage on the costs, either, since the costs were calculated for the treatments the farmers conducted themselves. These cost calculations were based on efficient equipment use in order to be able to compare farms with high and low contracting use. This methodology ignores the cost advantage of increasing farm size but allows for the comparison of the 'type top' and 'type average' growers on an equal basis.

Most of the significant effects on yield, quality and cost variables were found for year and grower. Year effects on yield are well known in agriculture (*Lobell* et al., 2009) and in sugarbeet production mainly determined by the weather (e.g. *Märländer*, 1991). However, since the weather is a given fact, the management by the grower becomes very important for crop performance. Independent of the year, the 'type top' growers harvested more sugar per hectare compared to the 'type average'. These results imply that the influence of the grower can compensate for yield losses by biotic and abiotic variance. This effect was also observed for growers with arable farms equal in size, similar in soil and with equal start of cultivation on newly reclaimed farmland in the Noordoostpolder (NL). Here the factor grower was also responsible for the difference in yield (*Zachariasse*, 1974). Other research found the same importance of growers' management in Germany (*Fuchs* et al., 2008) and its importance under the circumstances provided by the weather (*Märländer*, 1991).

The grower probably also influenced plant development. In breeding, a negative correlation between sugar content and root yield was observed on trial fields (*Hoffmann*, 2006), while no relationship was found in this study. The sugar content, although significantly influenced by grower, did not differ significantly between 'type top' and 'type average' growers. This implies that the 'type top' growers tend to achieve higher sugar content, but on average, the absolute difference between both grower types is not significant. So the general production management irrespective of grower type influences the relationship of sugar content and root yield. Next to this, the high yielding effect of 'type top' growers is mainly due to a higher root yield. This confirms the results of yield increase over 20 years, on the same farm, found to be mainly dependent on an increase in root yield (*Märländer*, 1991).

Sugar content is important in the sugarbeet payment and closely linked to beet quality (*Huijbregts*, 1999). Both sugar content and beet quality are positively rewarded by the Dutch sugar industry (*Huijbregts* and *Tijink*, 2008). Because the sugar content, although significantly influenced by grower, did not differ significantly between 'type top' and 'type average' growers, the beet price and the beet quality index did not differ, either. Since sugar content is a key factor for the calculation of the beet price, growers might focus on the sugar content. This could explain why there was a significant effect of grower type but no significant difference between grower types based on the least significant difference. This needs to be further investigated, because it is also possible that the sample size was too small to distinguish between a random or significant grower effect.

Due to their much higher sugar yield, the revenues of the 'type top' growers were 481 EUR ha^{-1} higher compared to 'type average' growers, while the total variable costs were equal for both grower types. This leaves a higher margin for 'type top' growers to cover fixed costs (which are not considered in this study) and might result in a higher income. A study on the total costs of 109 farms in Germany revealed the 25% highest yielding growers having lower costs compared to the 25% lowest yielding farms (*Starcke* and *Bahrs*, 2009). This difference can be due to the experimental set up. The German study selected the growers for an inquiry and divided them afterwards into high or low yielding groups irrespective of the region. In the SUSY project, the 'type top' and 'type average' grower of a pair were selected in the same region. As a

Table 4: Regression analysis for cost components to total variable costs and sugar yield in Dutch sugarbeet production; SUSY project, 2006–2008 (n = 149).

Cost component	Total variable costs[1]			Sugar yield		
	Slope	R^2		Slope	R^2	
Seed (EUR ha^{-1})	0.14	0.00	n.s.	0.02	0.06	**
Herbicides (EUR ha^{-1})	0.79	0.04	**	0.00	0.01	n.s.
Hand weeding (EUR ha^{-1})	1.20	0.06	**	0.01	0.02	n.s.
Fungicides (EUR ha^{-1})	1.40	0.02	n.s.	0.03	0.13	***
Insecticides (EUR ha^{-1})	8.60	0.03	*	0.05	0.02	n.s.
Manure and fertilizer (EUR ha^{-1})	1.00	0.52	***	0.00	0.02	n.s.
Other (EUR ha^{-1})	1.56	0.20	***	0.00	0.00	n.s.
Total direct growing costs (EUR ha^{-1})	**1.10**	**0.79**	*****	**0.00**	**0.00**	**n.s.**
Soil treatment (EUR ha^{-1})	0.44	0.01	n.s.	0.00	0.00	n.s.
Drilling (EUR ha^{-1})	1.75	0.01	n.s.	0.04	0.05	**
Herbicide application (EUR ha^{-1})	0.08	0.00	n.s.	–0.01	0.03	*
Mechanical weeding (EUR ha^{-1})	–0.39	0.00	n.s.	–0.01	0.01	n.s.
Nutrient application (EUR ha^{-1})	1.44	0.05	**	–0.01	0.01	n.s.
Irrigation (EUR ha^{-1})	1.39	0.23	***	0.00	0.01	n.s.
Pesticide application (EUR ha^{-1})	1.43	0.01	n.s.	0.03	0.08	***
Harvest (EUR ha^{-1})	–0.07	0.00	n.s.	0.00	0.00	n.s.
Total Contracting and Machinery costs (EUR ha^{-1})	**1.30**	**0.36**	*****	**0.00**	**0.00**	**n.s.**
Total variable costs (EUR ha^{-1})[2]	**–**	**–**		**0.00**	**0.00**	**n.s.**

[1] n.s. = not significant; *, **, *** = significant at $p \le 0.05, \le 0.01, \le 0.001$. [2] The costs mentioned exclude the fixed costs e.g. tenancy for the field and the overhead of the farm. The overhead encloses profit margin, costs of sugar quota, assurances for crop and grower, buildings, maintenance of fields, field and ditch edges.

consequence, both grower types encountered the same cost components specific for the region (e.g. extra soil treatment, irrigation and wind erosion prevention costs).

The costs for soil treatment, irrigation and pesticide application was significantly influenced by year, however, this did not influence the total contracting and machinery costs. Likely, the variation in the machinery cost components (costs for drilling, herbicide and nutrient application, mechanical weeding and harvest) eliminated the year effect, because the total contracting and machinery cost contains all those cost components. The year effect on irrigation can be explained by the dry summer of 2006 and the year effect on soil treatment by the drought in spring 2007 which caused a need for extra seedbed preparations on clay soil. Fungicide costs and pesticide application costs, which are linked, were significantly influenced by year. This is due to the supervised control of foliar diseases resulting in year-dependent amounts of fungicides applied (*Vereijssen*, 2004). Contrary to the effect of year, the significant effect of grower on application costs of both nutrients and pesticides also caused a significant effect of grower on the total contracting and machinery costs.

With the total variable costs reflecting the input rate per hectare of sugarbeet growing, the higher yields made the ‘type top’ growers more efficient in the production process, because their unit costs both for root and sugar yield were lower compared to the ‘type average’ growers. The same effect was observed for the nitrogen use efficiency. To produce 1 t sugar, the ‘type top’ growers used on average 11.8 kg N while the ‘type average’ growers used 12.9 kg N. The nitrogen application rate varied for all growers from 36 to 1.5 kg N per t sugar (data not shown), which is in line with results of the study by *Fuchs* and *Stockfisch* (2009) for Germany. Higher yields provide ‘type top’ growers with a more efficient resource use, which is profitable for both the grower and the environment. For sugarbeet production in the United Kingdom, *Tzilivakis* et al. (2005) also found, that a high yield could be obtained whilst minimizing the environmental impact. A study on Dutch sugarbeet production confirmed this and found ‘a persistent farmer’s management influence on efficiency’ (*De Koeijer* et al., 2002). The findings of the SUSY project confirm that in sugarbeet production the grower has a profound influence on economic and environmental sustainability.

The manure and fertilizer costs were low on average, but varied between years. This can be explained by a unique situation in The Netherlands. Due to a high intensity of animal production, combined with none or small-sized arable activities of the cattle-breeders (CBS, 2008) and a strict legislation on nutrient supply on agricultural fields (Meststoffenwet, 2006; 2009), arable farmers are paid by cattle-breeders to apply manure to their crops (*Van den Ham* et al., 2007). It is not always possible to totally meet the sugarbeet nutrient demand by manure, due to application time and uncertainty of mineral content of the manure at application time (*Wilting*, 2009b). However, with the use of the highest possible amounts of manure the grower can save on nutrition costs of sugarbeet production, or even earn with the use of manure. This directly lowers the total variable costs. On the other hand, the use of manure saves the use of mineral nitrogen, a nutrient with a high energy density (*Jensen* and *Kongshaug*, 2003). Thus, the use of manure instead of mineral fertilizers contributes to a sustainable development of sugarbeet production, both economically and environmentally.

The total variable costs for growers on sandy soils were higher in 2006 compared to the other two years on sandy soils. This cost increase is due to the irrigation costs in the dry summer. On the clay soils, where irrigation is not common, the total variable costs were more stable over the years. For the unit costs, the same pattern was observed, raising the question whether the high irrigation costs were paid back by a rise in yield or not. The regression analysis showed the irrigation costs significantly raising the total variable costs, while they did not influence the sugar yield. From this data set it is difficult to distinguish whether the irrigation costs are stabilizing the sugar yield in dry periods or are unnecessary costs, because there were no differences in irrigation between ‘type top’ and ‘type average’ growers. The sugarbeet root growth in July and August was found to be dependent on the available water in the soil (*Kenter* et al., 2006) pleading for irrigation in dry periods. Dutch research also found an increase in root yield by irrigation, but there remains a risk that irrigation costs are not fully covered by the yield increase (*Wilting*, 2009a).

The cost components which significantly raised the total variable costs in the regression analysis had no influence on sugar yield, and vice versa. Thus, savings can be made on those costs which raise the total variable costs, such as the above discussed irrigation and manure and fertilizer costs and the 'other' costs. The latter is a summation of minor cost components, such as the costs for covering the beet clamp and growing green manure crops. The significant effect of this cost component on total variable costs was most likely due to the increased length of the campaign and frost period in 2008, which triggered some growers on the sandy soils to invest in beet clamp covering materials.

The best cost strategy in sugarbeet production would be to reduce costs as much as possible, while maximizing sugar yield. At this point, the growers' management is crucial again. They can obtain a higher yield by optimizing the same level of inputs (*Märländer*, 1991) resulting in a more efficient production (*De Koeijer* et al., 2002).

In this study, the only savings which would obviously put the sugar yield at risk would be savings on costs of fungicides. To handle these costs sustainably from both an economical and environmental point of view, an integrated pest management system was developed (*Vereijssen*, 2004).

Finally, there was no relationship between the intensity of production measured by the total variable costs and the result of the costs that were made, the yield. Compared to other crops, like wheat and maize, this is a very sustainable characteristic of the sugarbeet crop. The yield of wheat and maize is strongly linked to the intensity of production (*Charles* et al., 2006; *Pingali* and *Rajaram*, 1999). For those crops, the yield level is often determined by the maximum profit, when the additional costs are not paid back by the increased financial yield (*Lobell* et al., 2009). However, this study clearly shows that maximizing sugar yield is the most profitable strategy for the growers, with optimizing costs simultaneously. The differences in sugar yield observed were not caused by economic constraints. The best preparation of sugarbeet growers for future uncertainties, like the end of the present EU sugar regime in 2015 (CR (EC) 318/2006, 2006) and presumably increasing demands of the society for environmental friendly production, is to raise the sugar yields.

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Comparaison des coûts et des rendements en sucre des entreprises agricoles aux Pays-Bas (Résumé)

En réaction à la réforme du régime sucrier de l'Union Européenne, l'industrie sucrière néerlandaise et la recherche betteravière ont lancé le projet SUSY (Speeding Up SugarYield). Le projet visait à atténuer l'impact des effets de la réforme sur le revenu des producteurs en indiquant des possibilités d'augmentation du rendement en sucre et d'identifier les économies de coûts réalisables. Dans chaque région de culture aux Pays-Bas, on a choisi 26 paires d'agriculteurs de type "top" (haut rendement) et de type "moyen" (rendement moyen) sur base de leur niveau de rendement en 2000–2004. Pendant 3 ans, tous les aspects de la prodution de la betterave ont été étudiés sur 75 champs de cultivateurs du type "top" et sur 74 champs de cultivateurs du type "moyen". Sur base des données recueillies chez l'agriculteur, les coûts variables ont été calculés et analysés en relation avec les variables de rendement et de qualité. Les facteurs année et agriculteur ont eu les effets les plus significatifs sur le rendement, la qualité et les coûts variables. L'agriculteur peut compenser l'effet de l'année sur le rendement par des variables biotiques et abiotiques. Les agriculteurs du type "top" obtiennent chaque année des rendements significativement plus élevés que les agriculteurs du type "moyen", toutefois les coûts variables ne différaient pas, en ce sens que les agriculteurs du type "top" étaient plus efficaces dans l'utilisation des ressources. Le total des coûts variables était augmenté de façon significative pour les frais des engrais organiques et minéraux, des frais spéciaux et des frais d'irrigation. Les frais de fongidides augmentaient significativement le rendement en sucre. On n'a pas trouvé de corrélation significative entre l'intensité de la production de betteraves et le rendement en sucre. En se basant sur cette étude, on peut conclure que la stratégie la plus rentable pour les producteurs est de maximiser le rendement en sucre en optimisant les coûts. Les différences observées dans le rendement en sucre ne sont pas causées par des contraintes économiques.

Comparación de los gastos y del rendimiento de azúcar en explotaciones agrícolas en los Países Bajos (Resumen)

Como reacción a la reforma de la Organización del Mercado del Azúcar en Europa la industria azucarera y el Instituto de Investigaciones sobre la Remolacha Azucarera de los Países Bajos iniciaron el proyecto SUSY (Speeding Up Sugar Yield). El objetivo del proyecto fue atenuar los efectos de la reforma sobre los ingresos de los agricultores por indicación de las posibilidades para aumentar el rendimiento de azúcar y para reducir los gastos. De cada región de los Países Bajos, en la que se cultivan remolachas azucareras, y en base de los rendimientos alcanzados entre 2000 y 2004 se seleccionaron 26 pares de agricultores 'type top' con rendimientos altos y de agricultores 'type average' con rendimientos medianos. En un período de tres años se estudió el cultivo de remolachas azucareras en 75 áreas de agricultores 'type top' y en 74 áreas de agricultores 'type average'. Los datos registrados por el agricultor fueron la base para calcular las variables de los gastos y para analizar las variables de rendimiento y calidad. Los factores año y tipo de agricultor tuvieron los mayores efectos sobre el rendimiento, la calidad y los gastos. El agricultor puede compensar el efecto del año de variables bióticas y no bióticas sobre el rendimiento. Los agricultores 'type top' tuvieron cada año rendimientos significantemente más altos que los agricultores 'type average' – los gastos para ambos tipos de agricultores pero fueron similares, solamente que los agricultores 'type top' pudieron aprovechar los recursos de manera más eficaz. Los gastos totales variables aumentaron significantemente por los gastos para abonos orgánicos y minerales, gastos para la irrigación y demás gastos. Los gastos para fungicidas aumentaron claramente el rendimiento de azúcar. No se observó una relación importante entre la intensidad de la producción de remolachas azucareras y el rendimiento de azúcar. En base de este estudio fue posible concluir que la estrategia más lucrativa para los agricultores es maximar el rendimiento de azúcar y optimar los gastos. Los distintos rendimientos de azúcar no fueron causados por restricciones económicas.

Vergelijking van kosten en suikeropbrengsten van 'toptelers' en 'middentelers' in de Nederlandse suikerbietenteelt (Samenvatting)

In reactie op de hervorming van de Europese suikermarkt startten de Nederlandse suikerindustrie en het Nederlandse suikerbietenonderzoek het project SUSY (Speeding Up Sugar Yield). Dit project had tot doel om de impact van de hervorming op het inkomen van de suikerbietentelers te verzachten door kennis aan te reiken over het verhogen van de suikeropbrengst en mogelijkheden te identificeren om kosten te besparen. Vanuit alle Nederlandse suikerbietenteeltregio's werden 26 paren geselecteerd van 'toptelers' (hoge opbrengst) en 'middentelers' (gemiddelde opbrengst), op basis van hun opbrengsten in 2000-2004. Gedurende drie jaren werden alle aspecten van de suikerbietenteelt onderzocht op 75 percelen van de toptelers- en 74 percelen van de middentelers. Op basis van de door de teler bijgehouden teeltregistratie werden de kostenvariabelen berekend, die in relatie met opbrengst en kwaliteit werden geanalyseerd. De factoren 'jaar' en 'teler' veroorzaakten de meeste significante effecten op opbrengst-, kwaliteit- en kostenvariabelen. De teler kan het jaareffect van biotische en abiotische variabelen op de opbrengst compenseren. De toptelers hadden significant hogere opbrengsten in elk jaar, vergeleken met de middentelers, echter de totale variabele kosten verschilden niet significant. Dit maakt de toptelers efficiënter in benutting van grondstoffen. De kosten van organische en kunstmeststoffen, 'overige' en beregening verhoogden significant de totale variabele kosten. De suikeropbrengst nam significant toe met hogere fungicide kosten. Er werd geen significante relatie gevonden tussen de intensiteit van de suikerbietenteelt en de suikeropbrengst. Op deze studie gebaseerd kan worden geconcludeerd dat het de meest winstgevende strategie voor suikerbietentelers is om de suikeropbrengst te maximaliseren en de kosten te optimaliseren. De gevonden verschillen in suikeropbrengst werden niet veroorzaakt door economische beperkingen.

Trefwoorden: suikerbiet, variabele teeltkosten, teler prestatie, SUSY paarvergelijking, opbrengst, concurrentiekracht

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