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PRODUCTION ECOLOGICAL CONCEPTS FOR THE ANALYSIS AND QUANTIFICATION OF INPUT-OUTPUT COMBINATIONS

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Introduction

Agriculture can be defined as the human activity in which energy from the sun is used for the production of sugars by using a set of inputs. This activity results in desirable outputs, such as grain or potatoes, and, inevitably, in undesired outputs, such as nutrient emissions. Numerous combinations of inputs and outputs are practised and possible in agricultural production systems.
Production ecology studies the way agricultural production systems function and may function in relation to physical constraints and environmental factors. Important aims of production ecology are:
i) the analysis of the relative importance of several growth factors and inputs to explain actual yield levels and resource use efficiencies and to open ways for improvement;
ii) to quantify new input-output combinations for developing sustainable production systems.
The basis of such analysis and quantifications is knowledge of basic processes at soil, field, crop and animal level. For a systematic analysis and quantification of agricultural input-output combinations various production ecological concepts have been developed.

Production level - desired output per unit area (Figure 1)

Potential, attainable and actual production levels can be distinguished according to three groups of production factors: growth defining, growth limiting and growth reducing factors. Growth defining factors include factors that, at optimum supply of all inputs, determine growth and production from a plant's point of view: CO_2-concentration, radiation, temperature and crop and cultivar characteristics. Growth limiting factors comprise the essential abiotic resources water and nutrients; they are taken up, and some are incorporated in the plant. Growth reducing factors include weeds, diseases, pests and polluting substances.

Production situation - physical conditions at which production takes place (Figure 1)

Input-output combinations are location specific. The location can be characterized by the production situation, i.e. the climate and soil conditions. The production situation is hard to manipulate and affects the potential production level or the required inputs to realize a particular production level. The other way around, agricultural activities hardly affect the production situation; only in the long run changes may occur (e.g. in organic matter content).

Target-oriented approach - adjustment of inputs to realize a particular output

On the basis of knowledge of bio-physical processes the inputs for the realization of a certain output in a particular production situation can be quantified. This so called target-oriented approach is an important concept in exploring new land use options. Input-output combinations quantified with this approach discriminate between bio-physical and technical opportunities and socio-economic constraints and objectives.

Production techniques - complete set of agronomic inputs

Production technique stands for the inputs and the way the inputs are applied to realize a particular production level in a certain production situation. Since substitution is possible between some inputs, for instance between labour, mechanization and herbicides, a production level in a particular production situation can be achieved with various production techniques.

Production orientation - aim of production activity that directs output and inputs
The production orientation directs the output and input levels. Orientations for production activities could be a high soil productivity, high resource use efficiencies, low emissions per unit product and low emissions per unit area.

Example
Table 1 gives an example of four input-output combinations (production activities) for growing a crop rotation in a particular production situation. The production activities are characterized by two production levels and two production orientations and were quantified with the target-oriented approach. They were used in an exploration for future land use options in the European Union (Rabbinge & Van Latesteijn, 1992; De Koning et al., 1995).

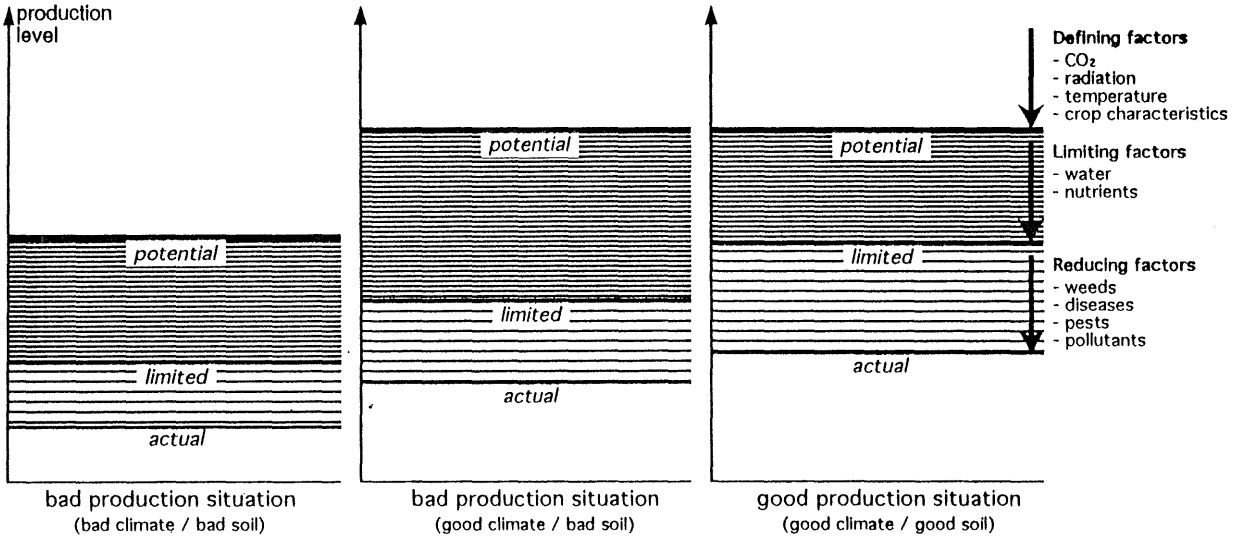

Figure 1. Production situation, production levels and associated principal growth factors.

Table 1. Example of four input-output combinations characterized by two production orientations and two production levels for growing the rotation 'potato-wheat-sugar beet-wheat' in a region in the Netherlands. Inputs are quantified with the target-oriented approach.

	Yield-oriented agric.		Environmental-oriented agric.		
	Potential	Water-limited	Potential	Water-limited	
Outputs (fresh tons $ha^{-1}yr^{-1}$)					
Wheat	9.8	8.0	7.5	6.6	
Potato	63	54	46	40	
Sugar beet	76	66	67	58	
Inputs ($ha^{-1}yr^{-1}$)					
Irrigation water (10^6m^3)	0.47	-	0.30	-	
Nitrogen application (kg)	296	273	223	214	Production
Pesticide (kg a.i.)	6.2	5.6	1.6	1.6	technique
Labour (h)	38	30	35	30	
Machines (ECU)	489	489	493	493	

References
De Koning, G.H.J. et al., 1995. Agricultural Systems 40: 125-151.
Rabbinge, R. & H.C. van Latesteijn, 1992. Agricultural Systems 40: 195-210.