19
Input Substitution in Arable Farming Systems: Research Design and Effects on Farm Income, Productivity and Environment

C. Stoyke and H. Waibel

Introduction

Since the beginning of the eighties the issue of 'agriculture and environment' has become a matter of intensive discussions among researchers and policy makers. Surplus production has led to increasing budgetary constraints. Conflicts with trading partners and the growing concern over the environmental implications of intensive conventional farming more and more gives farming a negative image (DE HAEN 1985; SRU 1985; UBA 1995). The reform of the Common Agricultural Policy (CAP) from 1992 has made some contributions towards solving the surplus problem, but its impact on the reduction of environmental hazards is clearly limited. Therefore, further adjustment of the CAP is necessary, giving more emphasis on the sustainability of natural resource use by agriculture and environmental issues as objectives of the CAP. This will raise the question, how alternative farming systems[1] should be designed in order to replace existing conventional systems. This paper deals with some economic aspects about the design of less intensive farming systems. Results of an interdisciplinary research project about less intensive farming systems are presented with respect to economic and ecological issues.

Less intensive arable farming systems (LIAFS): objectives, theoretical background and problems of evaluation

In the current discussion the call for LIAFS - which mostly lead to short-term farm income losses - is justified with the following objectives: From the society's point of view, a reduction of environmental problems is desirable. From the long-term perspective of the farmers, LIAFS are supposed to ensure the sustainability of the natural resource base which underpins agriculture (DABERKOW & REICHELDERFER 1988).

The introduction of LIAFS normally is achieved by 'extensification', i. e. the reduction of inputs such as mineral fertilisers and chemical pesticides. However, extensification is more than only the reduction of 'off-farm inputs' (BAEUMER et al. 1992). To implement LIAFS as alternative farming systems one has to consider a whole set of 'on-farm inputs' as substitutes (WAIBEL & STOYKE 1992 and STOYKE 1995).

[1] Following the definition of VEREIJKEN (1995) we have defined 'farming system' as '... *an agro-ecological unity consisting of a set of steadily rotating and interacting crops together with their accompanying (beneficial or harmful) flora and fauna'*.

According to BAEUMER (1990) the functioning and the productivity of a farming system depends on the level of internal and external regulation. Internal regulation refers to the management of the naturally regulating factors of an agro-ecosystem aiming at a low probability of damage, while external regulation refers to the corrective intervention by means of chemical inputs. Hence inputs used in a farming system can be divided into two groups according to their degree of association with internal and external regulation. The important difference is not so much the fact that external inputs are produced off-farm but rather that the ownership of the technology is with the agribusiness complex and not with the farmer. This is different with internal regulation, where management knowledge is the decisive factor. Such examples are soil fertility, positive crop rotation effects as well as the quality of physical farm work and management. These inputs are owned by the farmer as they were developed from farmer's experience and understanding of the interactions within the agro-ecosystem. It is hypothesised that a farming system with a high level of self-regulation tends to be more sustainable (BAEUMER 1990), whereas intensive use of chemical inputs weakens its self regulating forces. Because of this, a severe destabilisation of agro-ecosystems is expected (HEITEFUSS 1984; DIERCKS 1984, BAEUMER et al. 1992). However, there will be a trade-off between a high level of agronomic stability and ecological soundness on one side and a high output level on the other side (CLAUPEIN 1994). A reduction of external inputs reduces farm income on the short run but has positive long-term ecological effects as compared to a 'conventional' farming system. Hence an evaluation framework is required which allows these trade-offs to become transparent.

The Intex-Project - an example for LIAFS-Design

Since the eighties research efforts have been strengthened to improve the knowledge about LIAFS and a wide range of projects have been established. (DABERKOW & REICHELDERFER 1988; WIJNANDS & VEREIJKEN 1992; VEREIJKEN 1994; CLAUPEIN 1994). The INTEX-project at the University of Göttingen in Germany belongs to this group of research projects. Within this multidisciplinary project various working groups (agronomy, botany, economy, zoology) co-operate (WILDENHAYN 1992; GEROWITT 1995). The project was launched in 1989 as a large scale field experiment. On three experimental farms three farming systems[2] have been designed. The crop rotations are dominated by winter sown cereals and oil rape seed. The *conventional system* (I) is the reference system, representing the 'good farming practice' of agriculture in the region. System II is the *integrated system* which tries in a flexible manner to combine profitability and ecological goals such as stability, biodiversity and crop health as well as the protection of ground water quality. Compared to system I, system II allows some 25 % reduction of nitrogen and about 30 % reduction in the number of pesticide application through increasing crop diversity, mechanical weeding and a more intensive crop monitoring. The third system which is called the *reduced system* is set by restricting nitrogen input to 50 % of the use in system I and by eliminating insecticide use. No further adjustments in terms of crop rotation and monitoring were made. The changes in the systems II and III described above are reflected in the cost structure: The use of internal inputs (expressed as % of total variable costs) increases from 15 % in system I to 38 % in system II and to 17 % in system III.

[2] A fourth sytem where all chemicals have been withdrawn was not included in the analysis as this does not represent a realistic alternative. Unfortunately an organic farming option was not included in the experimental design

Results and conclusions

After five crop years some general conclusions can be drawn. However, only selected results can be presented due to space limitations. Table 1 shows the results of the economic evaluation. On average, system II has a 100 DM/ha lower net return as compared to system I, whereas system III has a 244 DM/ha lower net return. Despite of its lower income, system II shows significant improvements with respect to rates of returns to nitrogen, pesticides and total variable inputs. A high return to these factors can be interpreted as an indicator of strong self regulation. Considering that there is a difference between the market price and the social price of these inputs a high rate of return to a factor means that these are used judiciously, reflecting their true scarcity.

As mentioned above, a comprehensive evaluation of a farming system requires the consideration of a set of multiple criteria, i. e. various economic and agro-ecological indicators. In table 2 an evaluation of the examined indicators is presented. All disciplinary groups of the INTEX-project have been asked to assess in which direction and to what degree various indicators have been influenced (-- / - / 0 / + / ++) by the reduction of external inputs in comparison to system I. Summing up the scores for income, productivity and ecological criteria without assigning weights to any of the factors, system II turns out to be the best choice. Because of the only slight income loss of the integrated system, e. g. a doubling of the nitrogen price would almost break it even to system I in terms of income in addition to its positive long-term ecological effects. Furthermore, by applying the integrated system, the farmer gains more ownership of technology and reduces his dependency on prescribed external inputs.

Table 1: Gross margin and rate of return of INTEX-farming systems[1)]

	System I *'conventional'*	***System II*** *'integrated'*	***System III*** *'reduced'*
+ Revenues (DM/ha)	2426	2063	2008
- Variable costs (DM/ha)	1157	896	983
= **Gross margin** (DM/ha)	1269	1167	1025
Difference to system I (DM/ha)	-----	*-102*	*-244*
Returns to ...			
nitrogen input ($DM_{\text{gross margin less nitrogen costs}}/DM_{\text{nitrogen input}}$)	9.94	15.23	15.44
pesticide input ($DM_{\text{gross margin less pesticide costs}}/DM_{\text{pesticide input}}$)	4.66	11.81	4.32
total variable input ($DM_{\text{gross margin}}/DM_{\text{total variable input}}$)	1.10	1.30	1.05

[1)] average by rotation and three locations examined (1990 - 1994); output prices and EU acreage payments based on 1995 level

Further adjustment of system II within the INTEX-project such as more location-specific response to environmental problems will be achieved by collaborating with pilot farms following a participatory approach. It can be expected as farmers knowledge and experience is brought into the design of truly integrated systems its economic performance can be further improved.input,

Table 2: Multiple criteria evaluation of alternative farming systems[1)]

		System II 'integrated'	System III 'reduced'
■ **Income**	gross margin	-	--
■ **Returns to ...**	nitrogen input	++	++
	pesticide input	++	-
■ **Occurrence of plant protection problems**	weeds	-	**0**
	fungus diseases	+	+
	insects	+	+
■ **Soil**	soil structure / fauna	+	**0**
■ **Fauna**	number of species	++	+
	number of individuals	++	++
■ **Vegetation**	number of species	+	/
■ **Nitrogen balance**	nitrogen surplus	+	+
Comprehensive evaluation			
$\sum$points / income unweighted		***+11***	***+5***
$\sum$points / income weighted x3		***+ 9***	***+1***

++ significant improvement; + slight improvement; 0 no change
-- significant deterioration; - slight deterioration; / not evaluated

1) INTEX systems II and III compared to system I

References

Baeumer, K. (1990) Gestaltung integriert funktionierender Bodennutzungssysteme. In: Diercks, R. & Heitefuss, R. (eds.): Integrierter Landbau. München, Wien and Zürich. pp. 60-68

Baeumer, K., Claupein, W. and Wildenhayn, M. (1992) Extensivierung der Pflanzenproduktion: Ziele, Wege und mögliche Folgen. VDLUFA-Schriftenreihe, vol. 35, pp. 1-17

Claupein, W. (1994) Möglichkeiten und Grenzen der Extensivierung im Ackerbau. Göttingen

Daberkow, S.G. and Reichelderfer, K.H. (1988) Low-Input Agriculture: Trends, Goals and Prospects for Input Use. American Journal of Agricultural Economics, 12, pp. 1159-1165

DeHaen, H. (1985) Interdependence of Prices, Production Intensity and Environmental Damage from Agricultural Production. Zeitschrift für Umweltpolitik, 3/85, pp. 199-219

Diercks, R. (1983) Alternativen im Landbau. Stuttgart

Gerowitt, B. (1995) INTEX - An Interdisciplinary Project combining Farming System Development with Applied Research. European Journal of Plant Pathology, Proceedings of the XIII. Int. Plant Protection Congress, The Hague

Heitefuss, R. (1984): NKU - Pflanzenschutz im Ackerbau. Schriftenreihe des BMELF, Reihe A: Angewandte Wissenschaft, vol. 303. Münster

SRU (Rat von Sachverständigen für Umweltfragen) (1985): Umweltprobleme der Landwirtschaft. Sondergutachten. Stuttgart and Mainz

Stoyke, C. (1995) Die Ökonomik einzelbetrieblicher Anpassungsmaßnahmen an Extensivierungsauflagen in der Pflanzenproduktion - Eine empirische Analyse am Beispiel der N-Quotierung. Dissertation. Kiel

Umweltbundesamt (1995) Umweltbericht 1994. Berlin

Vereijken, P. (ed.) (1994) 1. Designing Prototypes - Progress Reports of Research Network on Integrated and Ecological Farming Systems for EU and Associated Countries. (Concerted Action AIR 3 - CT920755). Wageningen

Vereijken, P. (1995) Targeted Replacement of Inputs to Reduce Environmental Impact Whilst Maintaining Quality Production. In: Reus, J.A.W.A., K. Mitchell, C.J.G.M. Klaver, D.M. Baldock (eds.) Greening the CAP. London. pp. 58-64

Waibel, H. and Stoyke, C. (1992) Ökonomische Konsequenzen der Extensivierung. VDLUFA-Schriftenreihe 35, Kongreßband 1992, pp. 98-117

Wijnands, F.G. and Vereijken, P. (1992) Region-Wise Development of Prototypes of Integrated Arable Farming and Outdoor Horticulture. Netherlands Journal of Agricultural Science, 40, pp. 225-238

Wijnands, F.G. (1992): Evaluation and Introduction of Integrated Arable Farming in Practice. Netherlands Journal of Agricultural Science, 40, pp. 239-240

Wildenhayn, M. (1992): Konzeption eines interdisziplinären Forschungsvorhabens (INTEX) zu Auswirkungen von Extensivierungsmaßnahmen im Ackerbau. VDLUFA-Schriftenreihe 35, Kongreßband 1992, pp. 98-117