Classification of agricultural systems based on pesticide use intensity and safety

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***Abstract*— An analysis of socio-economic driving forces in crop protection is proposed to improve the implementation of sustainable strategies. The analysis includes: (1) a classification of agricultural systems based on pesticide use intensity and safety, (2) an evaluation of the profitability of farming systems and identification of socio-economic factors that influence pesticide use and (3) formulation of policy recommendations. We find that for cereals and for fruit trees alike, crop yields are much higher for agricultural systems with high doses of pesticides. The safety of applied pesticides does not affect crop protection costs significantly. For cropping systems characterised by low-intensity in pesticide use, the application of safer products has a positive effect on reduction of crop protection costs.**

Keywords— **pesticide use, driving forces in crop protection, economic analysis of agricultural systems.**

I. INTRODUCTION

Technical and legal efforts have been made, to ensure a sustainable use of pesticides in European agriculture. Within the framework of the sixth environmental programme of the European Commission (adopted in 2002), one of the five main purposes of a proposed thematic strategy is the promotion and implementation of low-input or pesticide-free crop farming such as Integrated Production (IP). Furthermore, it has been defined as a major requirement to grant an authorisation for the use of Active Substances (AS) in the European Community (article 5 of the Council Directive 91/414/EEC) that residues from application of pesticides under good agricultural practice principles do not have any harmful effect on human and animal health and the environment

As part of the model of IP, which brings together ecologic and economic concepts [1], crop protection has advanced from the idea of managing pests while maximising revenues [2] to strategies, in which pest occurrence is prevented and the most appropriate means of pest control (chemical or biological) are selected according to permanently observed levels of pest incidence [3].

Currently, the total amount of pesticides used in agricultural production in the European Union is on the decrease [4]. That trend is influenced among others by the implementation of practices such as IP and better use of resources. However, the quantities of pesticides applied may vary among regions with similar climatic condition, for example, the average dose applied in apple production in Lerida, Spain in 1997 was equal to 27 kg AS/ha with conventional farming, while in Trentino, Italy it was equivalent to 33,5 kg AS/ha under IP [5]. On the one hand, conditions such as soil properties, crop management strategies and pests biology determine differences in crop protection needs and pesticide use [6], on the other hand, the socio-economic environment will have large impacts on the strategies chosen.

Agricultural economics research may have both explanatory power and an impact on crop management strategies. Hence, an analysis of socio-economic driving forces in crop protection is proposed to improve the implementation of sustainable strategies. That analysis gathers on: (1) classification of agricultural systems based on two dimensions of pesticide use: intensity and safety (2) identification of socio-economic factors that influence pesticide use intensity and pesticide use safety under defined policy scenarios and evaluation of the profitability of crop protection strategies, and (3) formulation of policy recommendations to ensure the implementation of sustainable crop protection strategies. So far, the first part of the analysis has been completed.

II. METHODOLOGY

Agricultural systems implemented in cereal and fruit tree production in all European countries are classified by two indicators: pesticide use intensity and pesticide use safety. For both indicators, high and low categories are separated by an average value for all European countries, which is in addition weighted with the areas under production.

The pesticide use intensity indicator is calculated with the average amount of pesticides (fungicide, herbicides, insecticides and plant growth regulators) applied in crop production between 2000 and 2003 and is expressed in kg as/ha.

The pesticide use safety indicator represents the use of AS that are more target oriented, less toxic and less persistent in the environment. First a safety score for AS applied in production of cereals and fruit trees during 2003 is estimated, then a national indicator is calculated by adding the products of AS safety scores and their percentage in the total pesticide dose.

For the estimation of AS safety scores, six variables are considered: authorisation status, hazardousness to human health, side effects in beneficial organisms, toxicity to natural species, potential risk for groundwater and recommendations of use under IP. The aggregation of the six evaluations is possible through transformation of data into a safety scale, which ranks from 0.1 to 1.

Only those AS, for which evaluations of at least 80% of the chosen variables are available are taken into account in the analysis. Three presumptions are considered for the imputation of missing values: They are equal to the average of existing observations, they are equal to the median of the safety scale or they are equal to the average of observations for products belonging to the same chemical class or pesticide group.

In the computation of the safety score, the variables are weighted according to results from an expert's opinion survey.

For each agricultural system, average relative costs of crop protection strategies and the values of crop production are calculated (also weighted with the area under production) for selected crops.

III. RESULTS

A. Agricultural systems implemented in European countries

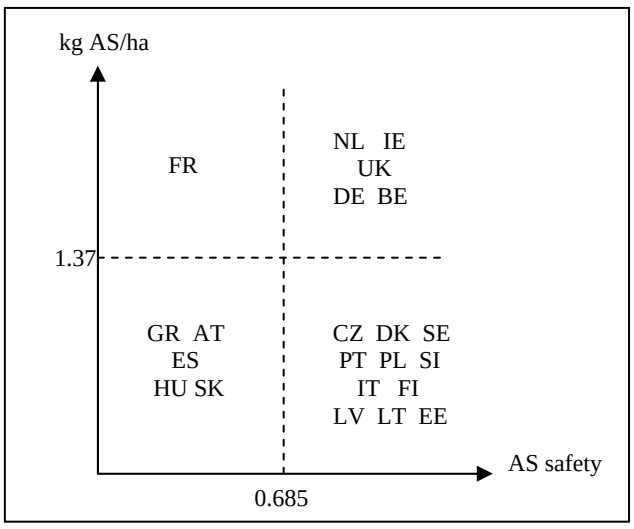

Fig. 1 Production of cereals (2003)

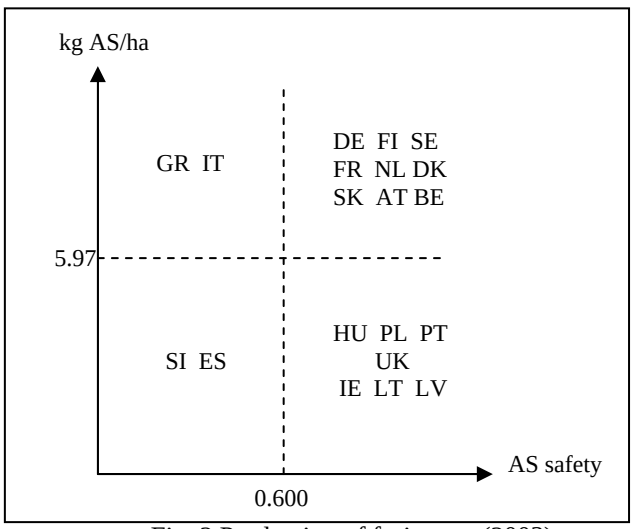

Fig. 2 Production of fruit trees (2003)

B. Crop protection costs (in % of the total production costs) and crop revenues (in Euro/ha)

Table 1 Production of cereals 2000/3

Pesticide use intensity			
	High	16.6 % 721 Euro/ha	18.7 % 856 Euro/ha
	Low	6.8 % 378 Euro/ha	5.2 % 498 Euro/ha
		Low	**High**
		Pesticide use safety	

Table 2 Production of fruit trees 2000/3

Pesticide use intensity			
	High	10.2 % 13169 Euro/ha	11 % 11359 Euro/ha
	Low	16.1 % 5887 Euro/ha	11.4 % 1602 Euro/ha
		Low	**High**
		Pesticide use safety	

Database: costs for soft wheat (group cereals) and apple-pear-peach (group fruit trees) productions [7]. Crop yield and producer price to calculate crop revenues of wheat (group cereals) and apple (group fruit trees) productions [8].

C. Importance of agricultural systems (average % of area and % crop production in 2003)

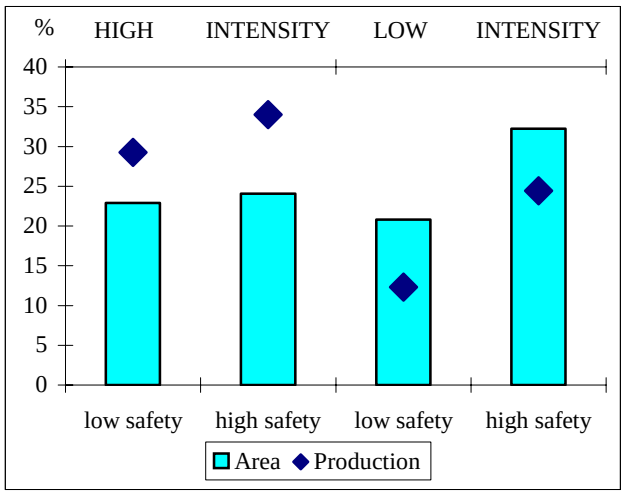

Fig. 3 Production of cereals (2003)

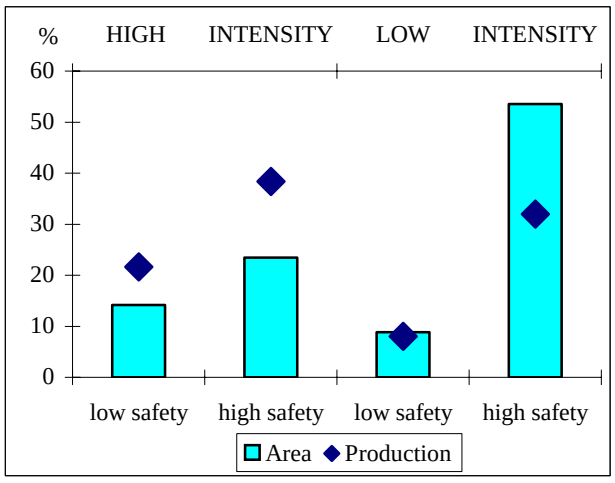

Fig. 4 Production of fruit trees (2003)

IV. DISCUSSION

- Production of cereals:

Two issues confirm the evolution in crop protection: AS applied have in average a more elevated value (0.685) than the median of the safety scale (0.55) and within the high-intensity and low-safety crop production only one country was allocated (Figure 1).

A production with high-intensity in pesticide use has elevated crop protection costs (16.6 % and 18.7 % of total cost) (Table 1) that result from a substitution of other productive factors (e.g. land, labour) by use of inputs. High crop revenues (721 Euro/ha and 856 Euro/ha) (Table 1) and high crop production (29.3 % and 34 %) (Figure 3) confirm that higher crop yields are obtained with high pesticide use intensity.

In production with low-intensity in pesticide use, the use of pesticides with higher safety increases crop revenues (378 Euro/ha and 498 Euro/ha) (Table1), while crop protection costs (6.8% and 5.2%) (Table 1) are lower if more advanced pesticides are applied.

- Production of fruit trees:

The findings from cereals can also largely be confirmed for fruit trees, particularly the higher yield level for intensive pesticide application systems (Figure 4). Pesticides used in crop protection have on average a middle value (0.600) on the safety scale (Figure 2), slightly lower than in cereal production. The most significant agricultural system is that incorporating low-intensity/high-safety pesticide use (53.5% of area) (Figure 4). This condition could be due to market forces (e.g. increasing demand for organic products) or policy objectives (e.g. promotion of low-input farming).

V. CONCLUSION

Our research shows that intensive use of pesticides pays in terms of higher yields. However, it can also be shown that the use of safer substances tends to reduce the crop protection costs when applying low doses. This should be an additional argument to promote sustainable strategies of crop protection.

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