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FOREWORD

This working paper is part of a larger ongoing activity at IIASA, investigating the impacts of new technologies and products. Pesticides were selected because of their large use and their intentional harm to living organisms. The place and role of pesticides in the national economy is analyzed by collecting data from different sources. One specific finding of this study is that statistical data is scattered and not collected in a consistent way. In spite of the uncertainties involved in the data collected, it was decided to make this report available for a restricted distribution. The information can, if necessary, also be made available on a magnetic medium.

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ABSTRACT

The production, consumption and foreign trade of pesticides are important sectors of the chemical industry in particular, and of the national economy as a whole. The pesticides sector has a positive impact on increasing crop yields and a negative effect on the environment as a pollutant hazardous to plants, humans, etc. To analyze the place and role of pesticides in the national economy, we gathered a large amount of data from sources including national and international statistical yearbooks (UN, FAO, OECD, Eurostat, National Statistical Yearbooks and Foreign Trade Statistical Yearbooks). The following pesticides data were compiled, handled and keyboarded into a PC:

- pesticides production 1966-1988, including production by types of pesticides (according to available data);
- pesticides consumption; and
- foreign trade (exports and imports of pesticides in value and volume).

The following data on territory, population and agricultural production were compiled, handled and used for suitable calculations and comparative analysis for the eight major producers and/or exporters of pesticides: Austria, Czechoslovakia, the FRG, the GDR, the Netherlands, Poland, the USA and the USSR (from 1966-1986):

- total territory;
- arable territory;
- total population;
- agricultural population;
- total cereal production;
- rye production;
- potato production;
- vegetable production;
- fruit production;
- total cereal yield;
- wheat yield;
- rye yield; and
- potato yield.

The validity of this information is determined by the data reliability taken from suitable sources. For instance, the population data in the FAO Production Yearbook were taken from the UN Demographic Yearbooks which give time series of estimates from national statistics. The data on pesticides production and consumption were compiled from National Statistics Yearbooks and National Foreign Trade Yearbooks which ensure their validity and reliability. Usually, pesticides volumes are very aggregated (in total or by large groups like herbicides, insecticides, fungicides and others), including the same components and, as a rule, are measured in identical units (thousand tons of active ingredients according to international classification), and are comparable for different countries.

With the compiled data for the period 1966-1986, the following analytical calculations were made along with a comparative analysis of eight East and West countries:

- share of main pesticide producers in the World and Europe;
- pesticides production per hectare of total and arable land;

- pesticides production per capita (of total and agricultural population);
- pesticides production per unit of agricultural production for the main agricultural products mentioned above;
- structure of pesticides production for the period 1966-1986 in the main pesticide-producing countries;
- pesticides consumption per hectare of total and arable land;
- pesticides consumption per capita of total and agricultural population; and
- pesticides consumption per unit of agricultural production for the main agricultural products mentioned above.

The following data on world foreign trade for over eighty countries over the period 1972-1986 were compiled, handled and keyboarded into a PC for analytical calculations:

- exports in value and volume;
- imports in value and volume;
- volumes of total exports by country; and
- volumes of total imports by country.

Data on world pesticides foreign trade used for calculations and comparative analysis over the period 1972-1986:

- share of pesticides exports in the total exports for each country;
- share of pesticides imports in total imports for each country; and
- dynamics of the pesticides export and import prices.

The results of this study suggest the following future research directions:

- increase in the number of countries studied in a comparative analysis;
- analysis of more detailed information on pesticides production and consumption (differentiated by types of pesticides, territories, plants, environmental impact, etc.);
- more relevant information on pesticides application efficiency based on a correlated analysis of crop yields with pesticides application by types, plants, territories, etc.; and
- pesticides hazard assessment, requiring more differentiated information on pesticides application norms for different plants, areas for plants, toxicity of specific pesticides in use, soil and water conditions, accumulation in plants, etc.

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A COMPARATIVE ANALYSIS OF PESTICIDES PRODUCTION, CONSUMPTION, AND FOREIGN TRADE

A. Koltsov

INTRODUCTION

The production of pesticides is an important sector of the chemical industry as well as of the national economy as a whole for some countries. The pesticides sector has a positive and negative side. The positive side is associated with the important role of pesticides as a means of destroying and combating pathogenic germs, insects, rodents, weeds, mosses, molds, etc., and as a result of its application, agricultural production usually increases. The negative side of pesticides production and application is associated with their penetration into soils, waters, air, and by extension through vegetables, meat, fruits, and other food products leading to various health problems, some serious.

It is of great interest and importance to follow the production, consumption, and foreign trade in different countries, because this may serve as an implicit measure of the possible positive and negative impacts of pesticides production and application. In addition, this knowledge for different countries allows us to compare the laws and rules concerning pesticides production, application and foreign trade, and to make a preliminary evaluation of the possible positive and negative consequences of pesticides application.

The analysis in this paper is based on statistical data compiled, handled, and calculated from the following main sources:

- UN Yearbooks of Industrial Statistics;
- UN Yearbooks of International Trade Statistics;
- FAO Production Yearbooks;
- Yearbooks of National Statistics;
- National Yearbooks of Foreign Trade Statistics.

Examination of these sources has revealed the following problems and difficulties for an international comparative analysis:

1. The unavailability of data on pesticides production, consumption, and foreign trade for some countries in the international and national statistics yearbooks mentioned above.
2. The incomparability of some data from different sources because of different units of measurement (in value, in volume, active ingredient, formulations, different kinds of pesticides, etc.).
3. In many cases the unavailability of time series for pesticides measures for a more detailed and comprehensive analysis of the processes.
4. The analysis of other data sources, different from the above mentioned, for separate countries has shown in most cases an absence of data on pesticides (for example, with fertilizers or with chemicals).
5. The FAO statistics on pesticides (in value) contain over thirty types of pesticides and their structure changes by years.

The validity of this information is dependent upon the reliability of the sources. The data on pesticides production and consumption is compiled from National Statistics Yearbooks which determine their validity and reliability. As usual these data are

aggregated pesticides (as a whole and by four main types) which include the same components (according to standard classification) and, as a rule, are measured in identical units (thousands of tons of active ingredients) allowing comparative analysis between different countries. The statistics on area and agricultural production are taken from UN-FAO Production Yearbooks and are based on a unique approach: the data for any particular crop refer to the calendar year in which the entire harvest took place. The population data in the UN-FAO Production Yearbooks are taken from UN Demographic Yearbooks which give time series of estimates on total population by countries. This means that most of the data mentioned are compiled on the basis of similar methodological approaches and are internationally comparable. The different groups of countries from East and West were selected for comparative analysis because of data availability and the relatively similar scales and structures of the pairs of economies being selected.

Foreign trade was analyzed for all countries using data from UN statistics on foreign trade (around ninety countries). The dynamics of pesticides exports and imports, the share of pesticides exports and imports in total exports and imports respectively, and export and import prices were analyzed for countries playing an important role in the export and import of pesticides.

PESTICIDES PRODUCTION

Let us begin with the analysis of pesticides production in the World and Europe as well as some countries which are the biggest pesticides producers out of the selected countries. The dynamics of world and European production are shown in Figure 1. It can be seen that pesticides production increased progressively from 1976 to 1984 with a small decrease by 1985 that may be explained by the decrease in pesticides production in those countries, which are the largest pesticides producers. The average annual growth rate was 1.4% for the World and 6.2% for Europe. The relatively low world growth rate of pesticides production in comparison with Europe is coupled with a significant decrease in pesticides production in the USA since 1975 as well as in the Netherlands (the biggest pesticides producers in the World and Europe, respectively).

The quantitative analysis of pesticides production for around thirty countries allowed us to divide these countries into four groups depending on average annual pesticides production during the period under consideration. The first group includes countries with average annual pesticides production of over 100 thousands tons (super large producers):

- the USA, with pesticides production from a minimum value of 400 thousand tons to a maximum value of around 700 thousand tons;
- the Netherlands (from 250 to 500 thousand tons);
- the FRG (from 150 to 300 thousand tons);
- the USSR (from 100 to 150 thousand tons);
- France (around 300 in 1982-1983).

The second group includes those countries with an average annual pesticides production of 50 to 100 thousand tons (large producers):

- Spain (from 20 to 140 thousand tons);
- Poland (from 30 to 100 thousand tons);
- Hungary (from 30 to 70 thousand tons).

The third group consists of countries which produce 20 to 50 thousand tons of pesticides (middle producers):

- Japan (from 20 to 30 thousand tons);
- Portugal (from 15 to 40 thousand tons);
- Rumania (from 25 to 50 thousand tons);
- Belgium-Luxembourg (from 15 to 30 thousand tons);
- the GDR (from 20 to 60 thousand tons).

The fourth group includes countries with average annual pesticides production of less than 20 thousand tons: Austria, Czechoslovakia, Denmark, Finland, Greece, Bulgaria, Sweden, Italy, Norway, and Canada.

Comparative Analysis of Pesticides Production

The dynamics of pesticides production for the first group of super large producers from 1966-1988 is presented in the Figure 2. As can be seen, pesticides production increased in all of these countries until 1975 with a decrease in the USA and the Netherlands that may be explained by some kind of saturation in internal consumption and in foreign trade (decrease of demand inside and outside the countries). Pesticides production grew progressively until 1985 in the FRG and the USSR, with a decrease by 1988 that may be explained by the same reasons as for the USA and the Netherlands but with some delay.

Similar tendencies in pesticides production can be seen for the second group of large producers (Figure 3), for the third group of middle producers (Figures 4 and 5), and for some countries which are small pesticides producers (Figures 6 and 7). There are some exceptions associated with deflections from these tendencies (for the second and third groups of countries). Pesticides production decreased progressively in Poland from 100 thousand tons in 1966 to around 40 thousand tons by 1987 (with some oscillations during the period under consideration) that may be explained by the general situation in the Polish economy. Pesticides production in Spain increased sharply to 1975, then decreased during the following five years and then started to grow sharply again. The stable tendencies for growth are inherent to other large and middle pesticides producers (Hungary, GDR, Rumania, Japan, Belgium-Luxembourg and Portugal). Specific features are associated with Rumania and Portugal, where pesticides production decreased significantly after 1973 and 1984, respectively, and Japan, where pesticides production decreased sharply during 1968-1970 followed by a period of growth.

For most small pesticides producers, the tendency for progressive growth at different rates is inherent (Figures 6 and 7). It is necessary to note only that pesticides production began to decrease in Czechoslovakia and Denmark around 1980 which resembles the tendencies of the largest pesticides producers (USA and Netherlands) and probably may be explained by the same reasons.

Analysis of pesticides production structures has indicated a large similarity in the main pesticides producers. In the FRG (Figure 8) herbicides form the main part of the pesticides production (over 30%), followed by insecticides and fungicides (around 20-25%) and others (less than 20%). The share of herbicides, insecticides, and fungicides production in the total pesticides production changed very slowly over the last twelve years, with a

relative decrease in herbicides production and a relative increase in other pesticides production (Figure 9) in the FRG.

In the USA we can see a similar structure in pesticides production (Figure 10) with herbicides accounting for over 50% during the period under consideration and insecticides around 30-40%. The production of fungicides is relatively low and does not exceed 10%. The share of herbicides and fungicides production in total pesticides production in the USA changed insignificantly, but the share of insecticides production decreased from around 40% in 1975 to around 25% by 1984 (Figure 11) which corresponds to the tendency of total pesticides production in the USA since 1975.

The structure of pesticides production in the USSR (Figure 12) is similar to that of the FRG, namely the majority is herbicides (30-50% during the period under consideration) and insecticides (around 30%). The share of fungicides and other pesticides production was not more than 10-20% (Figure 13). It is necessary to underline the stable character of the structure of pesticides production in the USSR from 1980-1988 (Figure 13).

Dynamics of Pesticides Production

We now consider the dynamics of the share of the largest pesticides producers in the total pesticides production for all countries considered and all European countries. The dynamics of pesticides production for all countries (including the USA, Canada and Japan), and for European countries are shown in Figure 14. It can be seen that pesticides production increased progressively until 1982 and then decreased significantly to 1985, which corresponds to the tendencies of pesticides production in the largest world and Europe pesticides producers, namely the USA and the Netherlands.

The dynamics of pesticides production for the main pesticides producers in total production (of all countries under consideration) are shown in Figures 15 and 16. The USA takes first place in pesticides production but their share decreased progressively from 33% in 1976 to around 27% in 1985. At the same time the shares of the Netherlands and the USSR in total pesticides production increased slowly from 1976-1985 and the share of the FRG decreased insignificantly during this period. The same tendencies of pesticides production are inherent for the shares of the main producers in world pesticides production (Figures 19 and 20), but the values of these shares are lower in comparison to shares in the production of all countries being considered.

In the European countries, the largest pesticides producers are the USSR and the Netherlands (Figures 17 and 18). The share of the USSR production increased significantly in 1977 (from 22 to 37%) and decreased progressively since 1977 to a level of around 32% that is approximately equal to the level of the Netherlands share in 1985, which had increased progressively since 1976. The share of FRG pesticides production in the European countries changed very slowly and oscillated insignificantly from 16-20% (Figure 18).

More objective information on the level of pesticides production development may be acquired on the basis of a comparative analysis for the main pesticides producers using measures like per capita production (consumption), production (consumption) per hectare of land, and per unit of agricultural production (for main agricultural crops).

The following eight countries are selected for comparative analysis: Austria, Czechoslovakia, the FRG, the GDR, the Netherlands, Poland, the USA and the USSR. The reasons for selecting these countries are as follows: availability of data for a suitable time period, the place and role of these countries in the world and European pesticides production, comparability of the national economic scales and structures for separate pairs of countries, and the intention to compare groups from the East and West.

In the first stage we compare pesticides production per capita of the total population. The dynamics of these measures for the countries mentioned are presented in Figures 21-23. Analysis of these graphics allowed us to draw the following conclusions:

- the main tendency of this measure is progressive growth (excluding Poland and the USA);
- the maximum per capita pesticides production was in the Netherlands (33 kg by 1984) with double growth from 1975-1985 (Figure 23);
- the minimum level of per capita pesticides production was in the USSR and Czechoslovakia (around 1 kg) with insignificant change during the period considered;
- pesticides production per capita of the total population increased progressively in Austria, the FRG and the GDR with values ranging from 2.5-5 kg by 1985;
- per capita pesticides production decreased significantly in the USA (from 3.4 kg in 1975 to around 1.6 kg by 1985) and in Poland (from 2 to 1 kg).

More objective information on the intensity of pesticides application is given by pesticides production per capita of agricultural population. The dynamics of these measures for the countries considered are presented in Figures 24-26. There are two main tendencies: progressive growth (the Netherlands, Austria and the GDR) and stabilization on different levels (Czechoslovakia, the FRG, the USA, the USSR, and Poland). The greatest value is inherent to the Netherlands (growth from around 300 kg in 1975 to around 700 kg by 1985) which is explained by a high level of pesticides production and a low level of agricultural population in the country (Figure 25). The next two countries are the USA and the FRG where the per capita of agricultural population pesticides production was very stable during the period considered (around 100 kg, Figure 25). The significantly lower level of this value is inherent (very stable during the period considered) to Czechoslovakia (in the range of 8-10 kg), the USSR, and Poland (around 5 kg).

These figures are not the real values of pesticides application in agriculture because most of the countries are great exporters and/or importers of pesticides and a more realistic pattern of pesticides application may be seen on the basis of a pesticides consumption comparative analysis (see below). However, these measures give some ideas concerning pesticides production, and if we regard pesticides as a factor in the intensity of agricultural development, we can affirm that pesticides production should be increased in those countries with significantly lower levels of pesticides production per capita of agricultural population (Poland, the USSR and Czechoslovakia) in comparison with countries having much higher levels (the Netherlands, the FRG, the USA).

Another important measure characterizing the level of pesticide industry development is pesticides production per hectare (ha) of total and arable land. The first measure is very aggregated and characterizes the average level of possible pesticides application per unit of total territory; the second measure is more indicative and determines the average level of possible pesticides application per ha of arable land, i.e. the real average level of pesticides application in agriculture.

The dynamics of pesticides production per ha of total land are presented in Figures 27-30. The main tendency is progressive growth (except where this measure decreased during all periods in Poland, since 1975 in the USA, and since 1980 in Czechoslovakia). The maximum growth (from 75 kg in 1975 to 140 kg by 1984) as well as the absolute maximum value was in the Netherlands. The following countries have significantly lower levels of pesticides production per ha of total land: the FRG (13 kg by 1984), the GDR (around 5 kg) and Poland and Austria (around 2 kg). The smallest values of these measures are inherent to Czechoslovakia (around 1 kg), the USA (around 0.6 kg) and the USSR (around 0.2 kg by 1984). These differences in pesticides production per ha of total land are explained on the one hand by large differences in the countries' territories and the relatively close values of total pesticides production. In spite of the differences mentioned it is necessary to mark a relatively low level of pesticides production per ha of total land in some countries (the USSR, the USA, Poland, Czechoslovakia) in comparison to other countries (the Netherlands, the FRG, the GDR).

Similar features are inherent to pesticides production per hectare of arable land (Figures 31-34). The main tendency is progressive growth (except in Poland, where this value decreased during the whole period, and the USA, where it has decreased since 1975). The largest growth rate (from 300 kg in 1975 to around 540 kg in 1985) and maximum absolute value of this measure were inherent to the Netherlands (Figure 34). Austria showed growth from 4 kg in 1966 to around 12 kg in 1984, and the GDR from 5 kg in 1966 to around 11 kg in 1984. The smallest values of this measure are inherent to the USSR (progressive growth from 0.5 kg in 1966 to around 1.5 kg by 1984), the USA (growth from 2.5 kg in 1966 to around 4 kg by 1984 with a decrease to around 3 kg by 1984), Poland (decrease from around 5 kg in 1966 to around 2.5 kg by 1984), and Czechoslovakia (slow growth from over 2 kg in 1966 to over 3 kg by 1984). If we regard the production of pesticides per ha of arable land as one of the factors in agricultural production intensity (in spite of the negative effect on the environment as a pollutant), it is expedient to recommend an increase in this value for some countries with low levels (the USSR, Poland and Czechoslovakia).

Comparative Analysis of Pesticides Production Impact on Agricultural Production

In this section, we regard the relations between pesticides production per unit of agricultural production and the values of the most important agricultural production for the last 10-20 years.

Cereals

Pesticides production per unit of cereal production has different tendencies in different countries: slow growth in Austria and the USSR (Figures 35a and 37a), slow, decreasing or stabilization in Czechoslovakia, the FRG, the GDR, Poland (Figures 35a and 36a), relatively rapid growth in the Netherlands with a sharp decrease from 1985 to 1986 (Figure 38a) and a relatively rapid decrease from 2.9 kg/ton of cereals in 1975 to around 1.7 kg/ton by 1984 (Figure 37a). It is rather interesting to note that the main tendency of cereal production is progressive growth (Figures 35b and 36b) except for the Netherlands (Figure 38b) where cereal production decreased from 1.6 million tons in 1966 to around 1.1 million tons by 1985, and the USSR where cereal production has decreased since 1978 (220 million tons) to around 170 million tons in 1984, along with an increase in pesticides production per unit of cereal production from 1980-1984. The opposite tendencies in

pesticides production per unit of agricultural production are inherent to the USA (Figures 37a and 37b). Cereal production increased in the USA from 180 million tons in 1966 to 350 million tons by 1985 (except for a sharp fall in cereal production in the USA from 1982-1983), along with the above-mentioned rapid decrease in pesticides production per unit of cereal production.

The large differences in values of pesticides production per unit of cereal production are inherent to all countries with the maximum level being obtained in the Netherlands (300 kg/ton on average from 1975-1986) with significantly lower values in other countries (12-13 kg/ton in the FRG and 3-5 kg/ton in Austria, Poland and the GDR, and less than 3 kg/ton in Czechoslovakia, the USA and the USSR).

The above analysis indicates that there is no direct relationship between pesticides and cereal production and that the main tendencies are rather opposite, i.e. the increase in pesticides production per unit of cereal production is not accompanied by an increase in cereal production. This may be explained on the one hand by the fact that pesticides production does not characterize the real values of pesticides application for different cultures (a more relevant pattern may be based on the comparative analysis of pesticides consumption). On the other hand, the real cereal production may more drastically depend on other important factors like weather, agricultural technology, application of fertilizers, etc.

As can be seen from Figures 35c, 36c and 37c, cereal yields have grown for all countries with different rates, different sizes of oscillations (evidently weather is the main factor, because the peaks coincide, e.g. for closed countries like Austria and Czechoslovakia, the FRG and the GDR) and different levels of yields. At the same time the pesticides production per hectare of arable land decreased significantly in the Netherlands (from 1984 to 1986, Figure 34), in the USA (from 1975 to 1984, Figure 33) and in Poland (progressively from 1966 to 1982, Figure 32). In the Soviet Union this yield increased slowly from 1966 to 1984 (Figure 33).

Wheat

Similar tendencies are inherent to pesticides production per unit of wheat production (Figures 39-42). This value increased slowly or stabilized in most countries (except the USA where it decreased from around 13 kg/ton in 1973 to around 9 kg/ton by 1984, Figure 41a). Together with the growth of pesticides production per unit of wheat production, this value increased progressively in all countries (Figures 39b-42b) except the USSR (Figure 41b) where wheat production oscillated from 1966-1978 with a large decrease from around 120 million tons in 1978 to around 80 million tons by 1984.

The values of pesticides production per unit of wheat production are very different for the countries under consideration. The maximum value is inherent to the Netherlands (450 kg/ton on average from 1975-1985) followed by the FRG (35 kg/ton) and the USA, the GDR, and Austria (10-15 kg/ton). The minimum values are to be found in Poland (5-10 kg/ton) followed by the USSR and Czechoslovakia (2-5 kg/ton). Based on this analysis it is rather difficult to judge the real pesticides application impact on agricultural production, but it is possible to ascertain that in most cases, the growth of wheat production has gone hand in hand with the growth of pesticides production per unit of this crop production and higher values of these measures are as a rule associated with the higher values of wheat production.

The dynamics inherent to wheat yields (Figures 39c, 40c, 41c), show the main tendency as a progressive increase with different growth rates and different sizes of oscillations.

Rye

The next important crop in most countries is rye. The dynamics of pesticides production per ton of rye production are presented in the Figures 43-46. The main tendencies are progressive growth and stabilization except for Poland (Figure 46a) where this value decreased from around 11 kg/ton in 1975 to around 5 kg/ton by 1985. In spite of these tendencies to increase, the main tendencies of rye production are stabilization and a progressive decrease that may be explained by a general decrease in rye production in all countries (Figures 43b-46b) which may be regarded as a progressive change in cereal production structure. It is rather difficult to talk about the impact of pesticides production on rye production, because of the significant influence of other factors (a reduction in the area allotted for rye production, weather, application of fertilizers, etc.) in comparison with pesticides production. More relevant knowledge of the impact of pesticides on agricultural production may be gained on the basis of pesticides consumption along with the yields (not only total production) of the main agricultural products; it may be a problem to investigate further in this area.

Rye yields have increased progressively in all countries under consideration, with relatively large peaks of oscillations, especially in some East European countries (e.g. Czechoslovakia, Figure 43c; Poland and the USSR, Figure 46b) and the USA (Figure 46c). Relatively fewer oscillations of rye yields are inherent to the FRG, the GDR and the Netherlands (Figure 44c) indicating a more stable character of rye production in these countries.

Potatoes

Potatoes are the next important agricultural product and are regarded as an important substitute for cereals. The dynamics of pesticides production per ton of potato production for all countries are presented in Figures 47-49. The main tendencies of this measure to change are slowly increasing or stabilizing (except the USA where this measure decreased twice from around 50 kg/ton in 1975 to around 25 kg/ton by 1985, Figure 48a). The maximum value of this measure is inherent to the Netherlands (around 80 kg/ton in 1983, Figure 48a) followed by the USA and the FRG (around 40 and 30 kg/ton, respectively, on average during the period under consideration, Figure 48a) and Austria (around 12 kg/ton, Figure 47a). The minimum values of this measure are inherent to Poland (around 1 kg/ton, Figure 49a) followed by the USSR (3-4 kg/ton from 1973-1975, Figure 49a), Czechoslovakia and the GDR (4-5 kg/ton on average, Figures 47a and 49a).

As can be seen in Figures 47b-49b, the main tendency is a decrease in potato production in most countries except for the Netherlands where potato production increased from around 4 million tons in 1966 to around 7 million tons by 1985 (Figure 48b). These tendencies are opposite to those of pesticides production per ton of potato production in most of the countries, which implies that certain factors have a more significant impact on potato production (e.g. land, weather, fertilizers, etc.) in comparison with pesticides production.

The observed patterns of change for potato yields shows a slow increase with oscillations, except for the USSR, where potato yields decreased slowly from 1966-1988 (Figures 47c, 48c, 49c).

Vegetables

Vegetables play a very important role in population nutrition. The main tendencies of pesticides production per ton of vegetables differ in each country as follows (Figures 50-53):

- increasing (Austria, the Netherlands and Czechoslovakia, Figures 50a and 51a);
- slowly decreasing (the FRG, the GDR and Poland, Figures 51a and 52a);
- sharply decreasing from 29 kg/ton in 1975 to around 18 kg/ton by 1984 in the USA (Figure 53a);
- stabilization in the range of 9-11 kg/ton during the period 1975-1984 in the USSR (Figure 53a).

The main tendency of vegetable production in all countries under consideration is increasing with different growth rates (except Austria where vegetable production increased in the period 1982-1985, Figure 50b). This means that the tendencies of pesticides production per unit of the vegetable production do not coincide with the tendencies of vegetable production. For instance, in the USSR with the lowest value for this measure, the growth rates of vegetable production were the largest (along with a maximum absolute level in their production) in comparison with other countries (Figures 53a and 53b). The USA had the largest value for this measure (with a sharp decline during the period) but production of vegetables was lower in comparison with the USSR and increased with lower growth rates (Figures 53a and 53b). This proves that other factors have a more significant impact on vegetable production in comparison with pesticides application impact.

Fruits

Finally we discuss the relationship between pesticides production per unit of fruit production and fruit production for country groups from East and West. Fruits are very important and the level of production (and consumption) has an impact on the health and life expectancy of the population.

The tendencies of pesticides production per unit of fruit production for 1975-1985 are presented in Figures 54-57. As can be seen these tendencies differ as follows:

- slow decrease with some oscillations (Czechoslovakia, the GDR, Poland, the USA, Figures 54a-56a);
- increase with significant oscillations (Austria, the FRG and the Netherlands, Figures 54a, 55a, 57a);
- small oscillations in the relatively low range 17-21 kg/ton (the USSR, Figure 56a).

The tendencies of fruit production for these countries are as follows:

- slow decrease with oscillations during the period in Austria, the USA and the Netherlands (Figures 54b, 56b, 57b);
- slow increase in Czechoslovakia, Poland, the FRG, the GDR and the USSR (Figures 54b-56b);

These comparisons indicate that in some cases the tendencies of pesticides production per unit of fruit production coincide (the USA, the FRG) but in some cases the tendencies are rather different (the Netherlands, Austria, Czechoslovakia) which is evidence of an insignificant relationship between pesticides and fruit production.

All these facts about pesticides production and consumption, along with the changes in agricultural yields, do not indicate a connection between pesticides application and the dynamics of some agricultural yields. This means that an increase in pesticides production and consumption does not lead in all cases directly to an increase in yields.

Based on the structure of pesticides application, more adequate information may be gathered for different plants, soils, weather conditions, soil conditions, etc. It is necessary to make careful decisions concerning production, import, consumption and use of pesticides, taking into account their negative impacts on the environment, including biosphere, humans, etc.

PESTICIDES CONSUMPTION

A more adequate evaluation of pesticides application may be done on the basis of a comparative analysis of per hectare pesticides production and consumption impact on yields of the most important agricultural products (cereals, wheat, rye and potatoes), because the main reason for using pesticides is to increase agricultural productivity. The values of pesticides production give only an approximate pattern of the development in this sector of the economy. Because of data unavailability, only five countries from the East and West (the FRG, the GDR, Poland, the USA and the USSR) are considered in the comparative analysis.

We begin with pesticides consumption per capita of the total population. The increase in this value is a tendency inherent to three countries (Figures 58 and 59) namely: the rapid growth in the GDR and the relatively slow decrease with some oscillations in the FRG and the USSR. The opposite tendency is seen in Poland (Figure 59), where pesticides consumption decreased from 2.2 kg in 1975 to 1.2 kg by 1985 and in the USA where pesticides consumption decreased significantly from 2.8 kg in 1975 to 0.9 kg by 1985. The largest value for pesticides consumption by 1985 was in the GDR (around 1.6 kg) followed by the USSR (around 1.5 kg) and Poland (around 1.3 kg). The lowest level was in the USA (around 0.9 kg) followed by the FRG (around 0.5 kg). Bearing in mind that the USA and the FRG have a very intensive and productive agriculture in comparison with other countries it is possible to suppose that consumption of pesticides is not a very important factor in agricultural development. It would seem expedient to recommend to the GDR, the USSR and Poland to decrease pesticides consumption taking into account their negative impact on the environment and food products.

A more effective factor for pesticides consumption as a factor of agricultural intensification may be carried out on the basis of pesticides consumption per capita of agricultural population (Figures 60 and 61). The tendencies of these values change and are approximately the same as consumption per capita of the total population, but their levels are very different. The highest level in pesticides consumption per capita of agricultural population was in the USA (around 30 kg by 1985) followed by the FRG (around 17 kg). Approximately the same levels were found in the USSR, Poland and the GDR (around 10 kg by 1985).

In the USA this value decreased sharply from 70 kg in 1975 to 30 kg by 1985 (Figure 61). In the FRG and the GDR pesticides consumption increased from 1975 to 1983 with a decrease by 1985. In the USSR it increased slowly from around 5 kg in 1975 to around 10 kg by 1985 and in Poland it was stable at the level of 5 kg. These differences are explained mainly by the relatively low share of agricultural population and the relatively high level of pesticides production and consumption in the USA and the FRG in comparison with the USSR, the GDR and Poland.

The other measures of pesticides application intensity are pesticides consumption per hectare of total and arable land. The dynamics of pesticides consumption per hectare of total land are shown in Figures 62 and 63. The tendencies for this measure are as follows: rapid growth in the GDR (from around 1 kg in 1970 to around 2.5 kg by 1984), slow growth in the USSR and the FRG and a rapid decrease in the USA (from around 0.7 kg in 1975 to around 0.2 kg by 1985) and an oscillating value in Poland (around 2 kg by 1982).

The maximum pesticides consumption per ha of total land was in the GDR (around 2.5 kg by 1985) followed by Poland (around 2 kg) and the FRG (around 1.2 kg), and the lowest value was in the USSR and the USA (around 0.2 kg by 1985). These values may be explained by the immensely large territories in the USA and the USSR with approximately similar levels of pesticides consumption.

A more accurate measure of pesticides application intensity in agriculture is the consumption per hectare of arable land (Figures 64 and 65). The tendencies of change of these measures are in general identical to the previous measures (consumption of pesticides per hectare of total land). The values of these measures are higher in the GDR and the FRG (with approximately the same relatively high growth rates (Figure 64) and relatively lower growth rates in the USSR (Figure 65).

The maximum level of pesticides consumption per ha of arable land was in the GDR (around 5.2 kg by 1984) followed by the FRG and Poland (around 4.2 kg by 1985 and by 1982, respectively). The lowest value of this measure was in the USA (around 1 kg by 1985) followed by the USSR (around 2 kg, Figure 65). Bearing in mind the high productivity of USA agriculture, it is possible to say that application (consumption) of pesticides does not have a strong impact (because of low pesticides consumption of arable land per ha) on agricultural productivity and the decrease in this measure may be regarded as a progressive tendency which may be recommended to countries with high levels of pesticides consumption per ha of arable land (the GDR, the FRG).

Now we regard the dynamics of pesticides consumption per unit for the most important agricultural products (cereals, wheat, rye, potatoes, vegetables and fruit).

The dynamics of pesticides consumption per unit of cereal production is presented in Figures 66 and 67. There are two main tendencies of change: progressive growth (the USSR and the FRG) and progressive decrease (Poland, the GDR and the USA, which have a more rapid decrease). A comparison of these tendencies with the tendencies of cereal production (see Figures 36b and 37b) shows that they are opposite for Poland, the GDR and the USA, and are similar for the USSR (with significant oscillations in cereal production) and the FRG. This implies an absence of a direct link between pesticides consumption and cereal production and a more significant impact of other factors.

Approximately the same is true for the relationship between pesticides consumption (Figures 68-71) and wheat and rye production (Figures 40b and 41b). The tendencies of change of pesticides consumption per unit of wheat production and wheat production are opposite to that of the USA, Poland, the GDR and the USSR and approximately the same as in the FRG (stabilization of the first one and small growth of the second one).

Pesticides consumption per unit of rye production (Figures 70 and 71) and rye production have opposite tendencies of change in the FRG and the GDR (see Figure 44b) as well as in the USSR and Poland (with large oscillations in the USSR and relatively stable change in Poland).

The highest level of pesticides consumption per unit of cereal production was in the USSR (2.6 kg/ton by 1985) followed by the GDR and Poland (around 2.4 and 2 kg/ton, respectively) and the lowest level was in the USA (around 1.2 kg/ton by 1985) and the FRG (around 0.6 kg/ton). Approximately the same proportions are inherent to the levels of pesticides consumption per unit of wheat (Figure 68) and rye (Figure 70) production. This means that pesticides consumption does not have a strong impact on cereal, wheat and rye production and it is necessary to study the relationship between crops yields and real pesticides consumption for different cultures in connection with other factors. The above does not take into account the differences to cultures, soils, climate, etc.

The main tendency of pesticides consumption per unit of potato production is growth (except Poland with some oscillations at the level just over 1 kg/ton, Figures 72 and 73). The main tendency of potatoes production (Figures 47b-49b) is growth. This means that in spite of pesticides consumption growth the tendency of potato production is to decrease indicating an absence of direct and positive links between these two measures.

The opposite situation holds for pesticides consumption per unit of vegetables (Figures 74 and 75) and fruit consumption (Figures 76 and 77). The main tendency of these measures is growth (except the USSR). The main tendencies of vegetable and fruit production (Figures 50b-53b and 54b-57b) for most countries is opposite. This indicates again a negative link between these two measures and a stronger impact on these tendencies of other factors.

WORLD PESTICIDES FOREIGN TRADE

According to the UN statistics [1] there are over 90 countries that are exporters and importers of pesticides. The comparative analysis of the data available on pesticides exports and imports allowed us to divide all countries into groups according to the average annual values of pesticides exports and imports. In total there are 16 countries that are exporters and importers of pesticides, 7 countries are only exporters and all the rest are pesticides importers only.

The first group of super large pesticides exporters (50-100 thousand tons and over of average annual exports from 1966 to 1986) are the following: France, the FRG, the Netherlands, Switzerland, the UK and the USA. The second group of large exporters (20-50 thousand tons) consists of the USSR and Belgium-Luxembourg. The third group of middle exporters (10-20 thousand tons) are Greece and Israel. The fourth group of small importers (5-10 thousand tons) comprises Colombia, Costa Rica, Guatemala and Yugoslavia. Other exporters (Barbados, Cote d'Ivoire, Cyprus, El Salvador, Kenya,

Nicaragua, Pakistan, Panama, Senegal) form the fifth group of very small exporters (less than 5 thousand tons).

Regarding imports, three countries (Canada, the USSR and France) are the super large pesticides importers (50-100 thousand tons of average annual imports from 1966 to 1986). Two countries (Brazil and Cuba) are the large pesticides importers (20-50 thousand tons). Many countries (Denmark, Egypt, India, Indonesia, Ireland, Pakistan, Poland, Sudan, and Thailand) form the group of middle pesticides importers (10-20 thousand tons). All the rest form two groups of small and very small pesticides importers (5-10 thousand tons and less than 5 thousand tons, respectively).

Dynamics of Pesticides Exports

Now we turn to the comparative analysis of the dynamics of pesticides exports, the shares of pesticides exports in total exports and export prices for major pesticides exporters. The main tendency of pesticides exports is progressive growth as well as for the shares of pesticides exports in total exports. The largest pesticides exporters are the USA and the FRG (with pesticides exports around 220 and 180 thousand tons, respectively, by 1985, Figure 78). The share of the pesticides exports in total exports increased significantly in the USA (from 0.32% in 1975 to around 0.6% by 1985) and decreased slowly in the FRG (from 0.52% in 1975 to around 0.42% by 1985, Figure 79). It is necessary to underline the low share of pesticides exports in total exports and some decrease in pesticides exports from 1984 to 1986.

The tendencies of export prices are very stable for all countries: progressive growth (Figures 80 and 81) for the largest exporters with growth from around US$ 2,000 in 1975 to around US$ 5,600 by 1986 for the USA, the FRG, the UK and France. The exports and share of exports in total export tendencies are very similar for the next group of pesticides exporters (UK and France, Figures 82 and 83). The exports of the UK and France increased in 1975 to around 130 thousand tons by 1985 (with a small decrease in the UK from 1985 to 1986, Figure 82). The shares of the pesticides exports in total exports increased in France from around 0.3% in 1975 to around 0.45% by 1986 and in the FRG from 0.45% in 1975 to around 0.6% by 1986 and are as well very small (with insignificant decrease in 1985-1986).

The pesticides exports and its shares in total exports increased as well in other large pesticides exporters (the Netherlands and Switzerland, Figures 84 and 85 and the USSR and Belgium-Luxembourg, Figures 88 and 89). In the Netherlands and Switzerland the exports of pesticides increased to around 50 and 70 thousand tons by 1986 (with a small decrease in 1984-1986). The share of pesticides exports (Figure 85) decreased in Switzerland from 1.6% in 1975 to around 1% by 1985) and changed very slowly in the Netherlands (around 0.3%, Figure 85).

The pesticides exports increased (as well as the share of pesticides exports in total exports) rapidly in Belgium-Luxembourg from around 20 in 1975 to around 80 thousand tons by 1980 (followed by a decrease to 60 thousand tons by 1985), and the share increased from 0.2% in 1974 to around 0.6% by 1980 with a decrease by 1982 (Figure 89). In the USSR exports increased slowly in 1975 from around 20 to around 30 thousand tons by 1984 and the share was stable during the period (around 0.15%).

The export prices increased as well in these countries from around US$ 2,000 in 1974-1975 to a maximum of US$ 7,500 per ton by 1985 in Switzerland and in the range of US$ 3-5,000 by 1984 in the Netherlands, the USSR and Belgium-Luxembourg (Figures 86 and 87).

Pesticides exports increased in Israel in 1975 from 10 to around 18 thousand tons by 1982 and increased in 1975 from 3.5 to 21 thousand tons by 1980 followed by a sharp decrease in 1982 (Figure 90). The share of pesticides exports decreased in Israel from around 1.4% in 1975 to around 0.7% by 1982 and increased from 0.3% in 1975 to 0.8% by 1980 followed by a decrease to 0.2% by 1982 (Figure 91). The exports prices for these countries changed in a range from 1.1% in 1975 to around 2.4% by 1982 (Figure 92).

Dynamics of Pesticides Imports

Now we compare the dynamics of pesticides imports, the share of pesticides imports in total imports and import prices for the largest importers. Pesticides imports increased in the USSR, France and Canada (Figure 93) with a small decrease in Canada from 1980 to 1985. The maximum level of pesticides imports was in the USSR (around 120 thousand tons by 1984) followed by France (around 110 thousand tons) and Canada (around 70 thousand tons by 1986).

The same tendencies are inherent to the share of pesticides imports in total imports (Figure 94) with a change in the range 0.25-0.6%. The import prices in these countries (as well as in Brazil) increased progressively (except Iran) in the range from US$ 1,900 to US$ 5,500 (Figures 95 and 96).

Pesticides imports for Brazil and Iran (Figure 97) increased during 1975-1978 with very slow growth in Brazil (from 34 to 35 thousand tons) and rapid growth in Iran (from 18 to 33 thousand tons) with a tendency for slow growth in Brazil and the opposite tendency in Iran (slow decrease followed by an increase, Figure 98). The import prices for Brazil and Iran changed in the same range as in other countries (from US$ 2-3,700 per ton) with an increase in Brazil and a decrease in Iran (Figure 96).

Different tendencies are inherent to pesticides imports for other large and middle pesticides importers (Egypt, Cuba, Denmark, Poland and Ireland, Figures 99 and 103) as well as for the share of pesticides imports in total imports (Figures 100 and 104). Imports decreased in Egypt, Indonesia (very sharply, close to zero) and increased slowly in Cuba (with a decrease during the period), in Poland (with sharp growth from 11 thousand tons in 1979 to 21 thousand tons by 1984 followed by a decrease to around 15 thousand tons by 1986, Figure 103).

The share of pesticides imports in total imports decreased in Indonesia (very sharply), in Cuba and in Egypt (with a maximum level around 1.4% in 1979 and a decrease to around 0.8% by 1985, Figure 100), increased sharply in Poland (a maximum of 0.7% in 1981 with oscillations between around 0.4% in 1982 and around 0.7% by 1984, Figure 104), increased sharply in Denmark (from 0.25% in 1979 to around 0.7% by 1984 with a decrease to around 0.5% by 1986, Figure 104); it changed very slowly without exceeding 0.3% during the period in Ireland (Figure 104). Import prices for these countries increased progressively during the period considered from a range of US$ 2,000 to US$ 7-8,000 per ton in Egypt and Denmark, respectively (Figures 101-102).

Finally we analyze the dynamics of the same measures for other middle pesticides importers (Pakistan, Sudan and Thailand, Figures 105-107). Imports increased in all of these countries with large oscillations in Pakistan during the period (from 3 to 19 thousand tons during 1974-1977, decreasing from 19 to around 5 thousand tons during 1977-1981 and increasing again to 19 thousand tons by 1985, Figure 105). In Sudan the pesticides imports increased from 13 to 22 thousand tons during 1974-1981 with small oscillations, and increased as well in Thailand from 13 to around 19 thousand tons by 1985 with some oscillations during the period considered (Figure 105).

The share of pesticides imports in total imports increased slowly in Sudan (with a relatively large share in the range of 2.4-3.6%), increased very slowly in Pakistan (with large oscillations in the range 0.4-2%) and changed very slowly in Thailand in the range 0.6-0.8% (Figure 106).

Pesticides import prices in these countries (Figure 107) decreased sharply in Pakistan to around US$ 2,000 per ton during 1974-1977 with a slow increase to US$ 5,000 by 1985. In Thailand the import prices increased slowly from US$ 1,500 to US$ 3,000 during 1974-1985, and in Sudan it increased from US$ 1,000 to US$ 5,000 during 1974-1980 with a sharp decrease to around US$ 1,500 by 1981 (Figure 107).

DYNAMICS OF ENERGY INPUTS ON THE PRODUCTION OF PESTICIDES

Our analysis in this section is based on the above information and values of energy (heat and electricity used in the manufacturing process) [2]. The average energy inputs for the basic production of various pesticides is equal to approximately 49 kcal for the production of 1 kg active ingredient. Based on this value we calculated the shares of energy inputs for pesticides production in eight countries for total energy consumption (Figures 108-111) and for four countries for energy inputs in chemical electric energy consumption (Figures 112 and 113).

The share of energy inputs for pesticides production in total energy consumption has a tendency to growth (except the USA, where this share decreased from 0.22% in 1975 to around 0.12% by 1986 achieving the same level as in the USSR). In other countries these shares increased slowly (in Austria, Figure 108; the FRG and GDR, Figure 109; and the Netherlands, Figure 110) and was very stable in Czechoslovakia (Figure 108), Poland (Figure 110), and the USSR (Figure 111). The maximum level of this share was in the Netherlands (around 4% by 1983 with a decrease to 2.5% by 1985, Figure 110). In other countries this share was much less and did not exceed 0.5-0.7%.

The dynamics of energy inputs for pesticides in chemical electric consumption is presented in Figures 112 and 113. These shares are much higher in comparison with the share in total energy consumption and increased progressively in the Netherlands (from around 30% in 1970 to around 42% by 1985), increased very slowly in the FRG (with oscillations around 34% during the period considered), decreased sharply in Poland (from 38% in 1970 to around 16% by 1980 with an increase to 24% by 1983 and then decreasing to 16% by 1985, Figure 113). This share was stable in Czechoslovakia during the period considered and changed slowly in the range of 12-16% (Figure 112).

Bearing in mind that pesticides may be regarded as a factor of agricultural production we can study the correlation between these two measures on the basis of

production function techniques along with traditional factors like capital, labor forces, land, fertilizers, weather, etc., which are used in the forecasting of agricultural production.

During the tentative experiments we used different combinations of factors including pesticides production, arable lands and the agricultural population for different countries. The first calculations indicated the main applicability of analyzing the correlation between pesticides production and consumption and agricultural production. As usual the coefficient of determination was not less than 0.8. More accurate calculations require more detailed information on pesticides consumption including the differentiation by land, types of pesticides, plants and other factors of agricultural production.

The analyzed information on pesticides production and consumption may be regarded as a first step in the complicated scheme for pesticides hazard assessment [3]:

- total use;
- amount per hectare;
- frequency of application;
- type of the active ingredient;
- route of entry into the environment; and
- respective toxicity data for a hazard assessment.

This scheme shows that pesticides hazard assessment is rather complicated. Most of the steps mentioned above require detailed information on pesticides, environmental conditions, toxicity data for different pesticides and their formulations, etc.

CONCLUSIONS

1. Production of pesticides in the World and Europe increased during the last 15 years with some slowdown toward the end of the period.

2. The countries are divided into groups according to the amounts they produce. The USA, the FRG, the Netherlands and the USSR produce the most pesticides (over 100 thousand tons annually).

3. The growth of pesticides production is inherent in most countries (with some decreasing during the period studied, such as in the USA, Spain and Portugal).

4. The structure of pesticides production is approximately the same in the most productive countries. Herbicides make up most of the production followed by insecticides and fungicides.

5. The USA produced the most pesticides of all countries being studied (from 22% to 33%) during the last ten years. The Netherlands (from 15% to 24%) and the USSR (from 10% to 18%) are next. The same tendencies are inherent to these countries' shares in world production (with a decrease for the USA and slow growth for other countries) and to European countries in total European production, with decreases in the USSR (from 40% to 30% by 1985) and slow growth in the Netherlands and the FRG.

6. The per capita pesticides production grew in all countries being compared, except in the USA and Poland, with maximum level in the Netherlands (33 kg by 1984) and in

other countries only in the range of 1-5 kg. The per capita pesticides production in agriculture grew in all countries with maximum level in the Netherlands (from 300 kg in 1975 to 700 kg by 1984) followed by the USA and the FRG (approximately 100 kg during the whole period).

7. The pesticides production per hectare of total and arable land grew in all countries except Poland (decreasing from 3 kg to 2 kg by 1984) and USA (where it has not changed significantly during the period). The maximum value was in the Netherlands (140 kg by 1984) followed by the FRG (13 kg by 1984). The minimum value was in the USSR (0.1 kg by 1984), followed by the USA (0.6 kg by 1984) and all other countries (in limits 1-2 kg). The same tendencies are inherent to pesticides production per hectare of arable land: maximum level in the Netherlands and minimum level in the USSR.

8. It is rather difficult to evaluate the impact of pesticides production on agricultural production because this value per unit of agricultural production does not determine the real (but only "marginal") level of pesticides application. In many cases, the dynamics of agricultural production follow the dynamics of pesticides production (except in the USA where decreasing pesticides production was accompanied by increasing agricultural production, and in the Netherlands where the opposite occurred). This was the case for cereals, wheat, and rye production.

9. In most cases the dynamics of pesticides production per unit of potatoes, vegetables and fruit production were similar to the dynamics of the corresponding agricultural production (with some exceptions). This indicates a generally positive relationship between pesticides and agricultural production for these cases.

10. More relevant information on the levels of pesticides application and agricultural production may be obtained on the basis of a comparative study on pesticides consumption. The per capita pesticides consumption increased in the USSR, the FRG and the GDR, but decreased in the USA and Poland. The highest levels of pesticides consumption were in the USSR and the GDR (about 1.6 kg by 1985) and the lowest levels were in the USA and the FRG (about 1 and 0.6 kg in 1985, respectively).

11. Per capita pesticides consumption in agriculture increased in the GDR and the FRG (decreasing after 1983), decreased in the USA, and changed very slowly in Poland and the USSR. The maximum level was in the USA (about 30 kg by 1985) followed by the GDR and the FRG (approximately 17 and 10 kg, respectively, by 1985).

12. Pesticides consumption per hectare of total land increased slowly in the USSR, the FRG, and the GDR and decreased in the USA and Poland. The maximum level was in the GDR (2.5 kg by 1985), followed by Poland (2 kg by 1982), and the minimum level was in the USSR and the USA (about 0.2 kg by 1985).

13. Similar tendencies are inherent to pesticides consumption per hectare of arable land with a maximum level for the GDR (5.2 kg by 1984), followed by the FRG and Poland (4.2 and 4 kg by 1984 and 1982, respectively). The minimum level was in the USA and the USSR (about 1 and 2 kg in 1985, respectively).

14. The main tendencies of pesticides consumption per unit of agricultural production are decreasing or stabilizing (except for rye and potato production, where pesticides

production per unit of agricultural production increased slowly, showing the relatively rapid growth in comparison with pesticides production).

15. The analysis of pesticides production and consumption impact per hectare of arable land impact on yields of the main agricultural products (cereals, wheat, rye and potatoes) has shown that in most countries these yields have been increasing along with growing pesticides production and consumption. But it is important to emphasize that the growth of yields has continued in spite of significant decreases in pesticides production and consumption (in different years) in the FRG, the Netherlands and the USA. This raises the question about expediency to increase production, import and consumption of pesticides in countries with relatively slow yield growth along with continuous pesticides production, imports and consumption increases.

16. According to UN statistics, approximately 90 countries participate in the foreign trade of pesticides. Comparative analysis shows that 16 countries are exporters and importers of pesticides, 7 countries are exporters, and the rest are regarded as importers.

17. Six countries (France, the FRG, the Netherlands, Switzerland, the UK and the USA) may be regarded as super large exporters of pesticides (50-100 thousand tons and more exported annually), two countries (Belgium-Luxembourg and the USSR) as large exporters (20-50 thousand tons), and the remaining countries as middle (10-20 thousand tons), small (5-10 thousand tons) or very small (less than 5 thousand tons) exporters of pesticides.

18. Three countries (Canada, France and the USSR) are the super large pesticides importers (50-100 thousand tons and more imported annually), two countries (Brazil and Cuba) are large pesticides importers (20-50 thousand tons), and the remaining countries are middle, small or very small importers.

19. The largest exporters have tended to increase production progressively, with a slight slowdown in the mid-1980s. In addition, the share of pesticides exports in total country exports has increased, but the value of this share is not high (not more than 1% for the largest exporters).

20. Export and import prices of pesticides have tended to increase progressively, with relatively small differences between countries coupled with differences in formulations in each country.

21. Demand for pesticides from the largest pesticides importers (as well as a share of the pesticides imports in total imports) has increased progressively, but has decreased slowly for some smaller importers (Egypt, Indonesia, and Pakistan).

22. Attempts have been made to evaluate the impact of pesticides production and consumption on agricultural production using the classical production function with the value of pesticides production or consumption as an additional factor.

23. The calculations of shares of energy inputs in total energy consumption for pesticides production gave low levels, with the maximum in the Netherlands (4%) and less than 0.5-0.7 in other countries under consideration. This share increased in Austria, the FRG, the GDR, the Netherlands, and the USSR, and decreased sharply in the USA and the Netherlands after 1983.

24. The share of energy inputs for pesticides production in chemical electric energy consumption increased in the Netherlands (maximum about 34%), oscillated in the FRG (around 34%), decreased sharply in the USA (from 38% to 16%), and changed slowly in Czechoslovakia (from 12-16%).

25. The first calculations showed the possibility of using the production function technique for correlating pesticides measures and agricultural production. This approach may be used for agricultural production forecasting, taking into consideration pesticides production and consumption.

26. This study may be regarded as a first step in the direction of pesticides hazard assessment (total use and amount per hectare). This assessment requires much more detailed information concerning pesticides consumption, environmental impacts, toxicity, and many other factors.

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Fig.1 World and Europe pesticide production

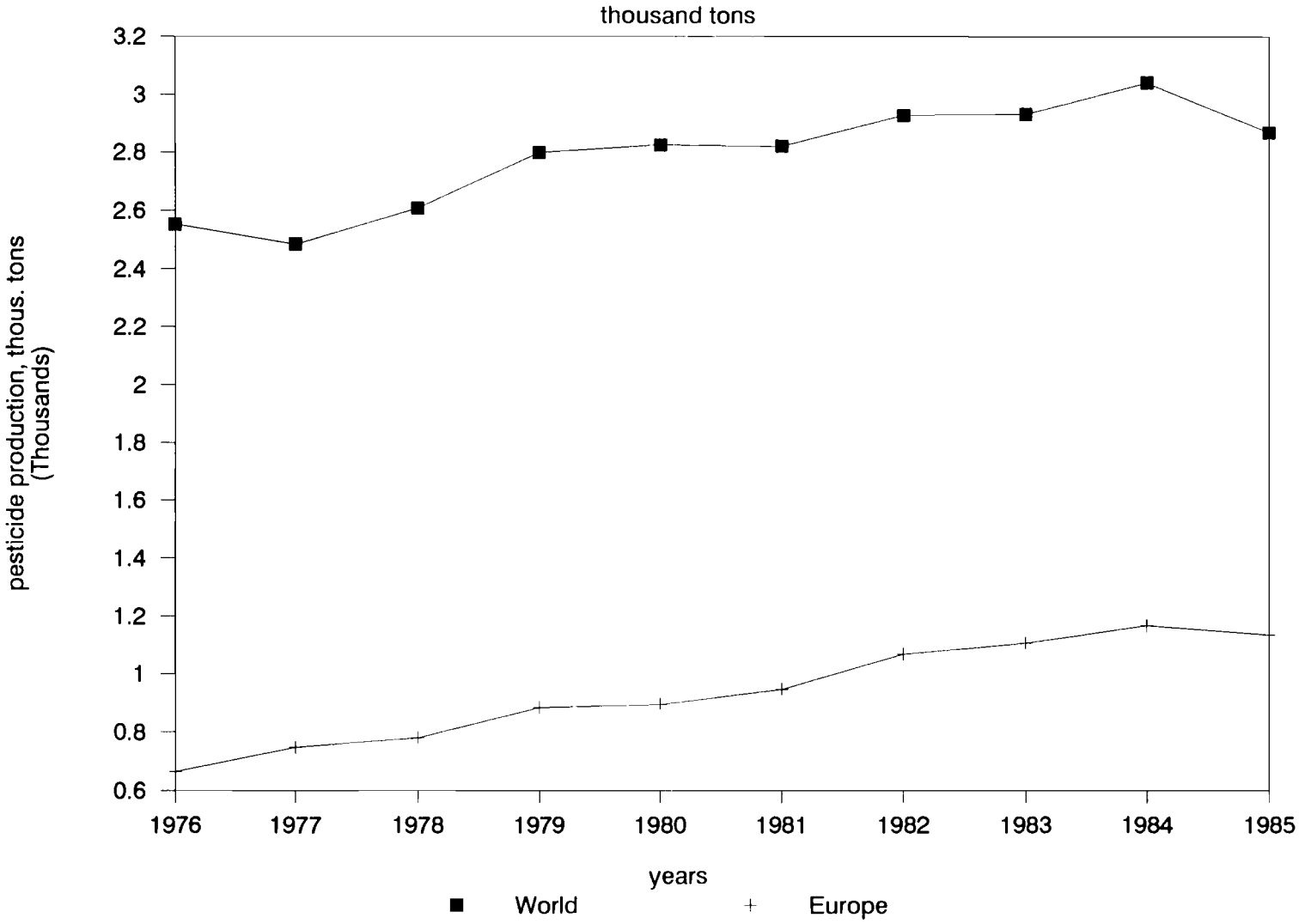

Fig.2 Pesticide production

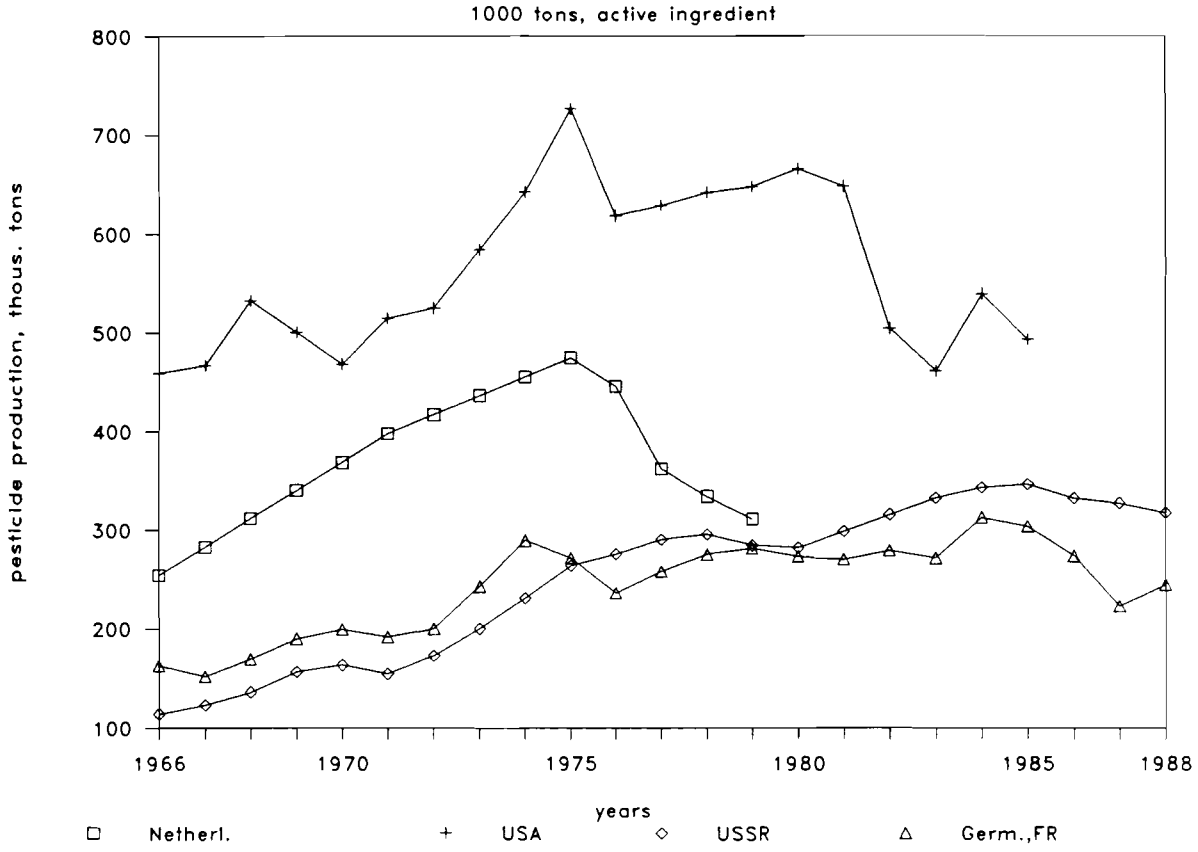

Fig.3 Pesticide production

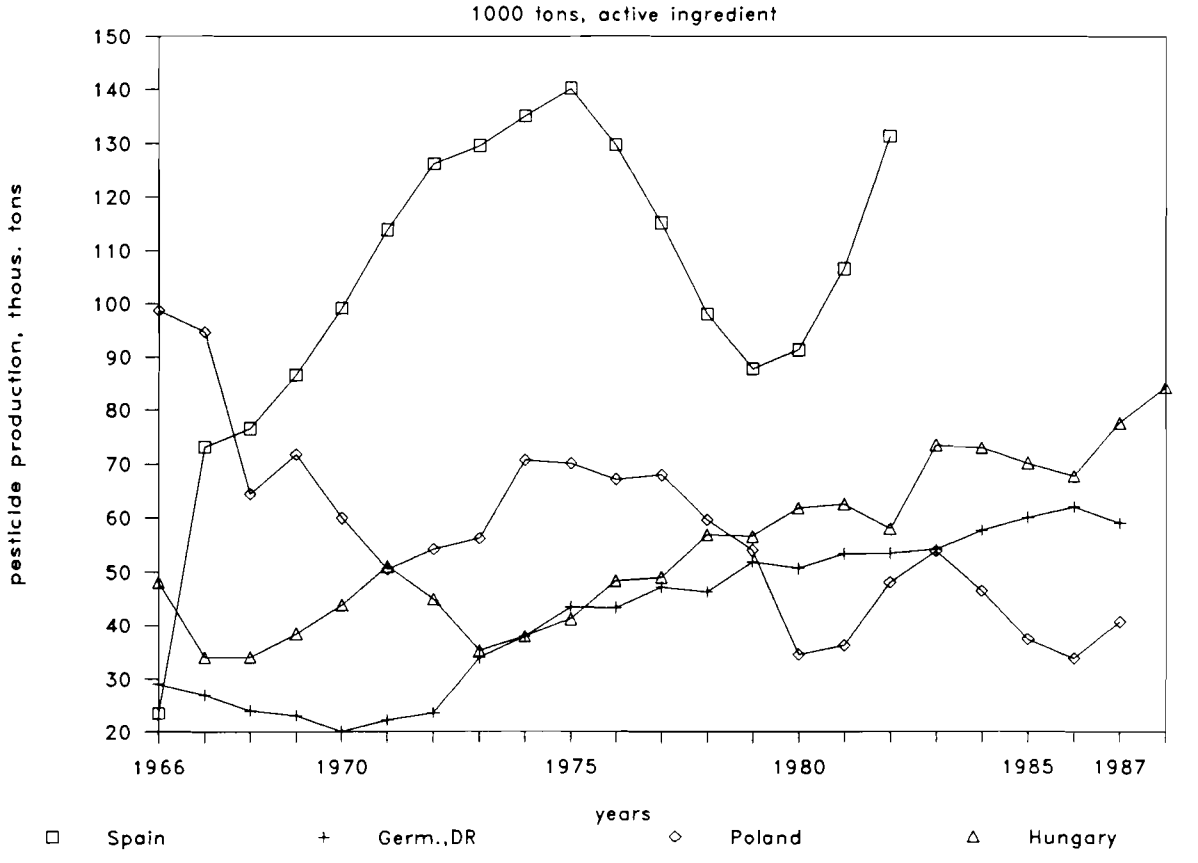

Fig.4 Pesticide production

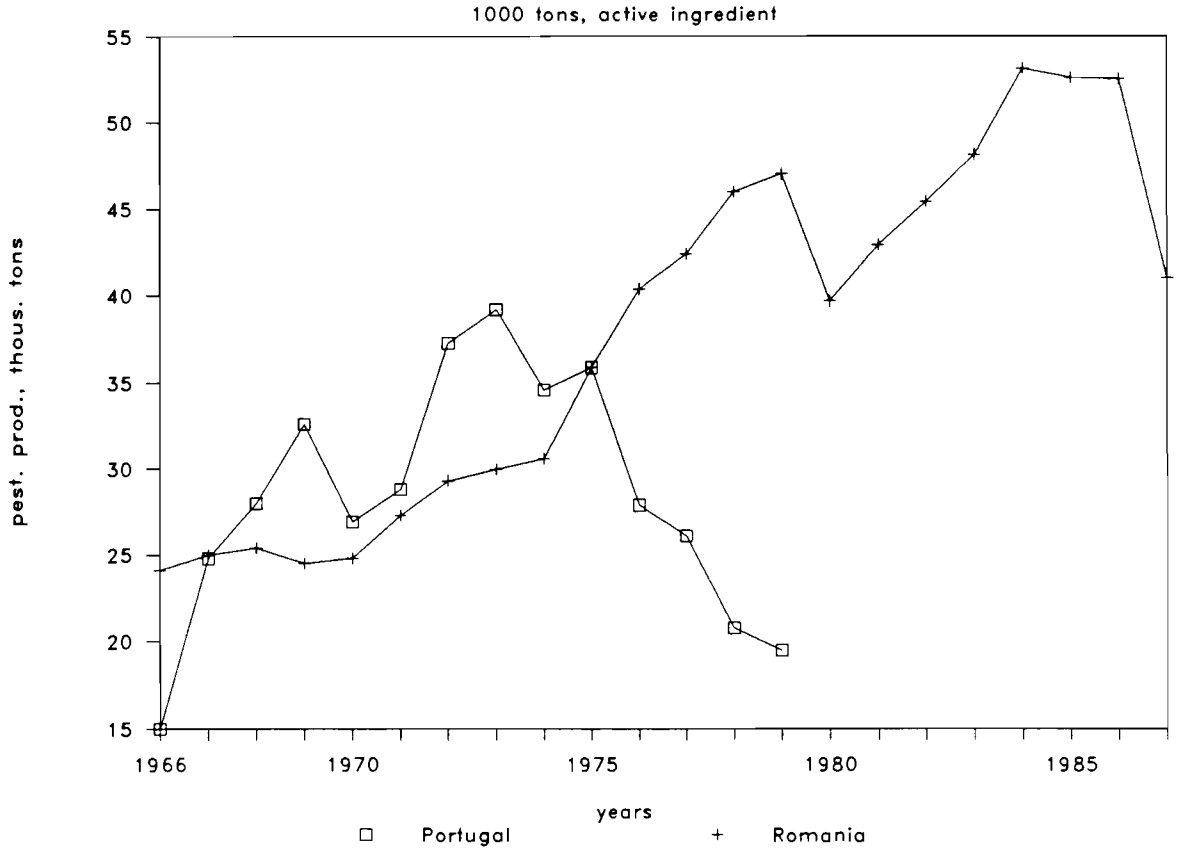

Fig.5 Pesticide production

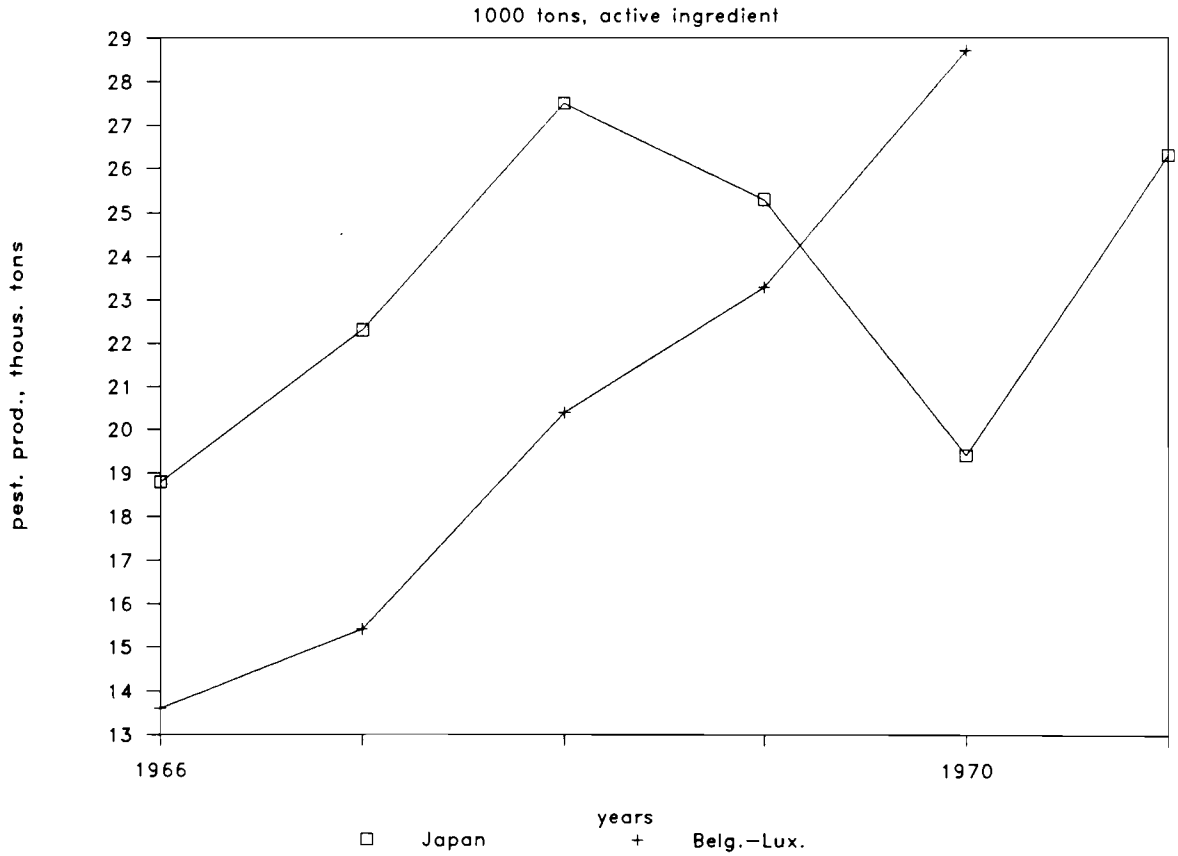

Fig.6 Pesticide production

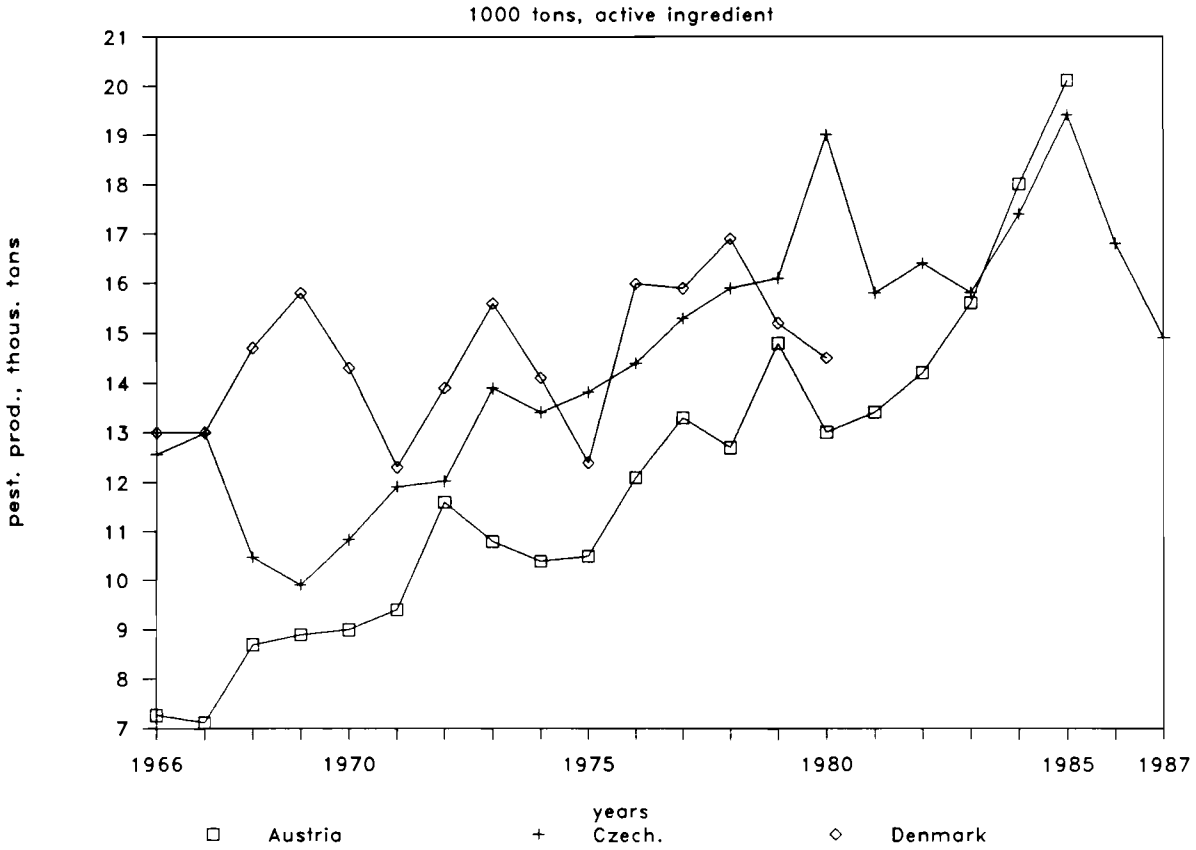

Fig.7 Pesticide production

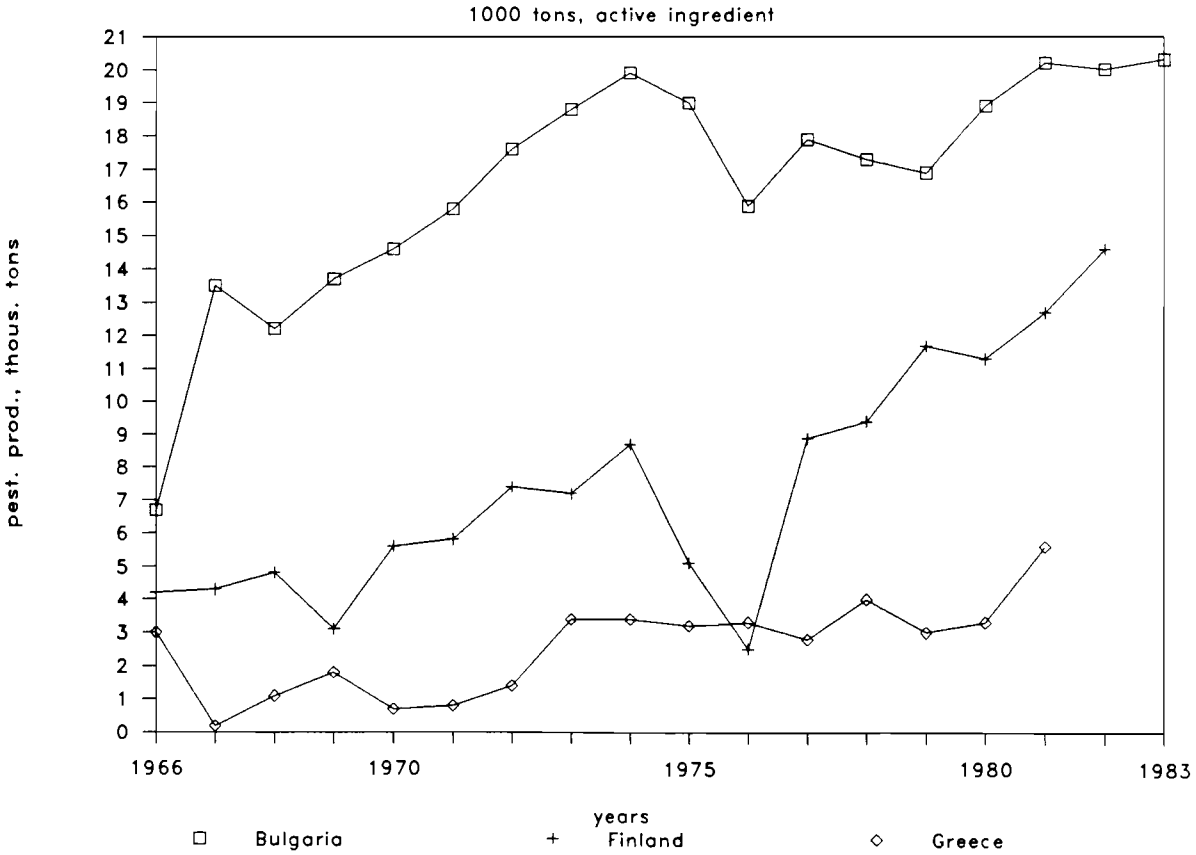

Fig.8 Structure, pesticide production

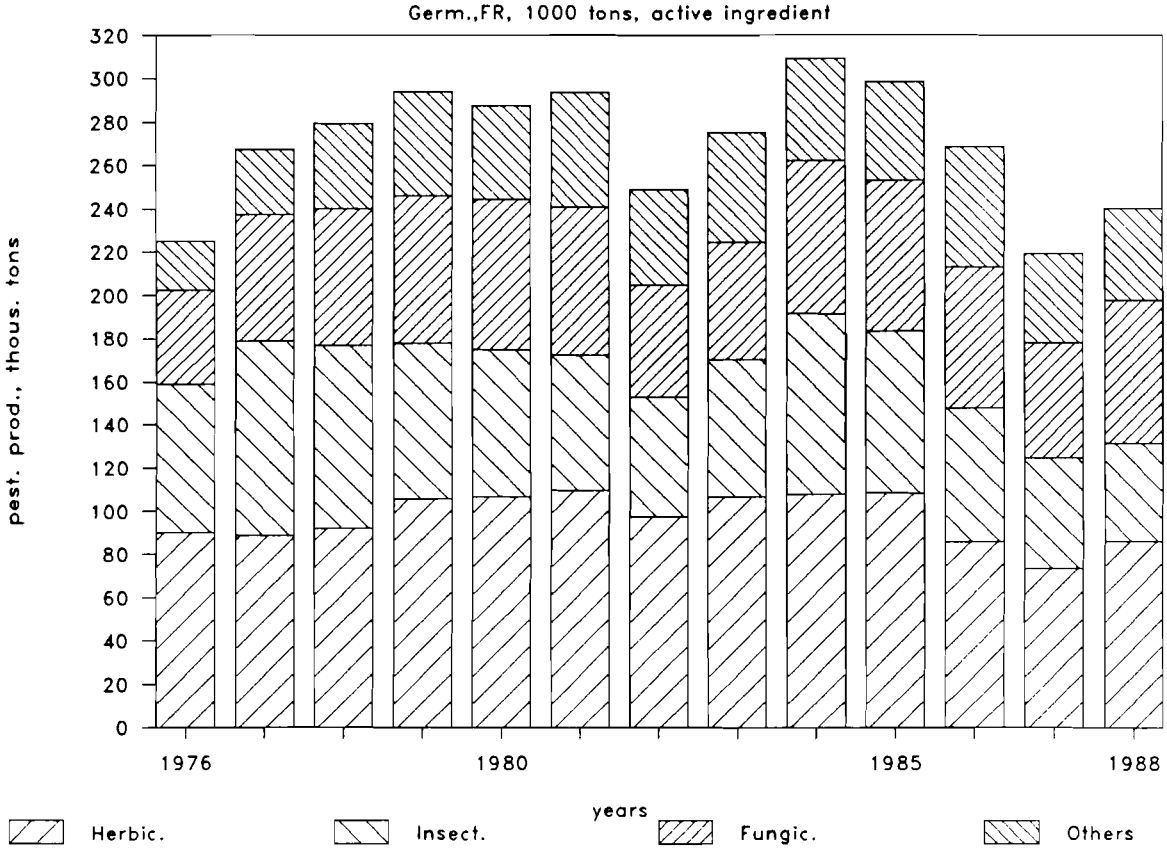

Fig.9 Structure, pesticide production

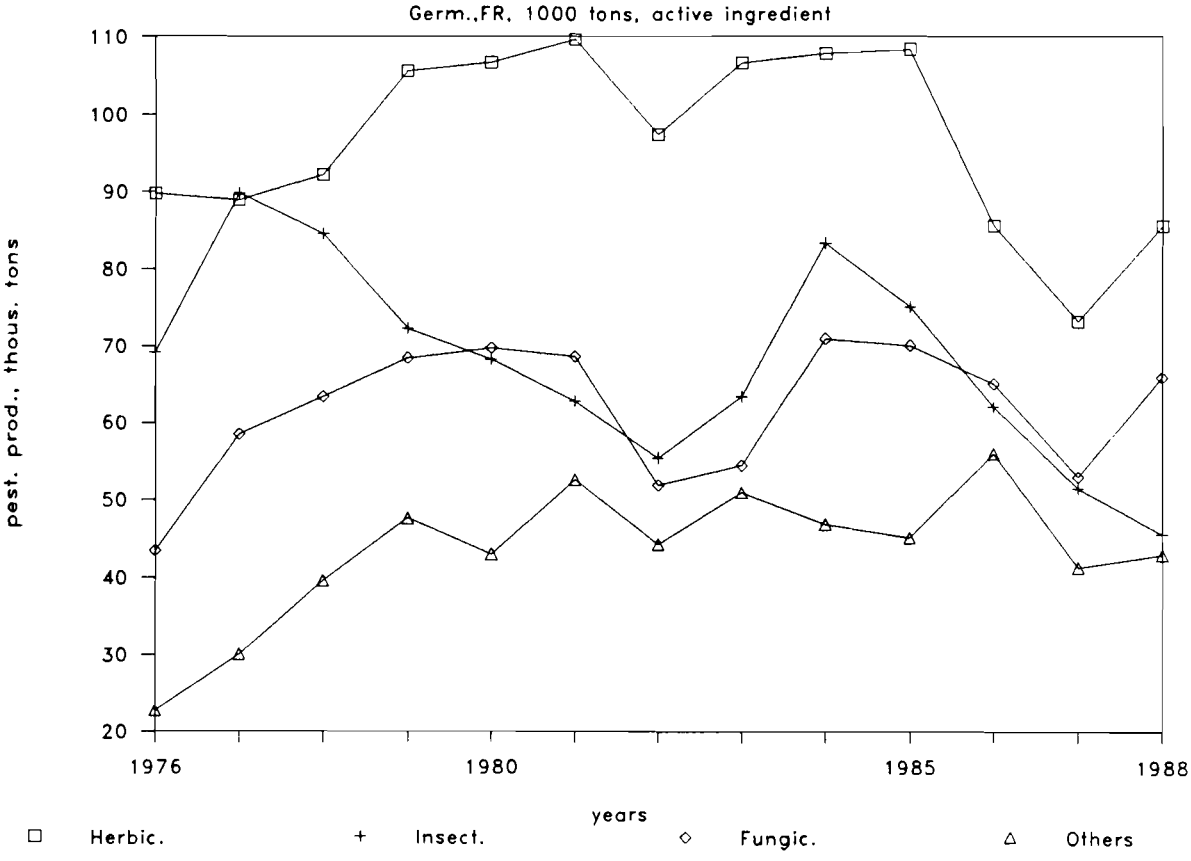

Fig.10 Structure, pesticide production

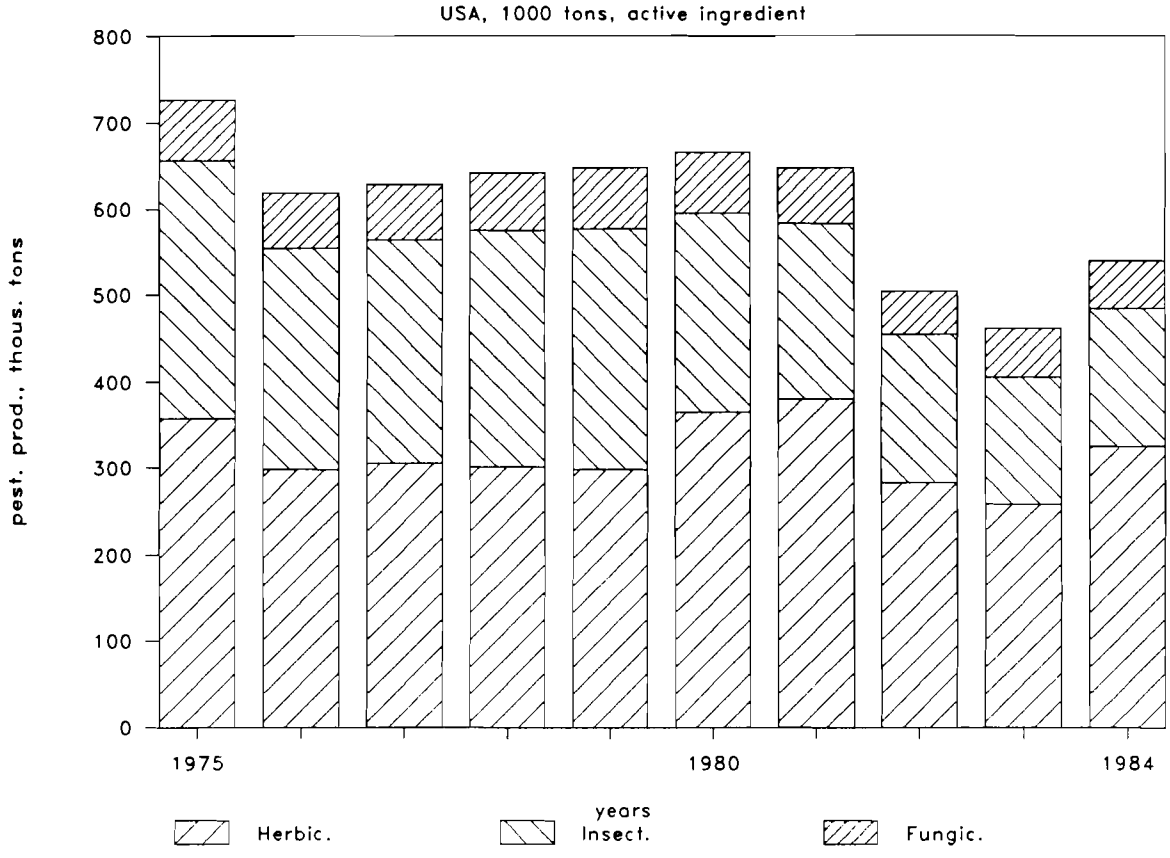

Fig.11 Structure, pesticide production

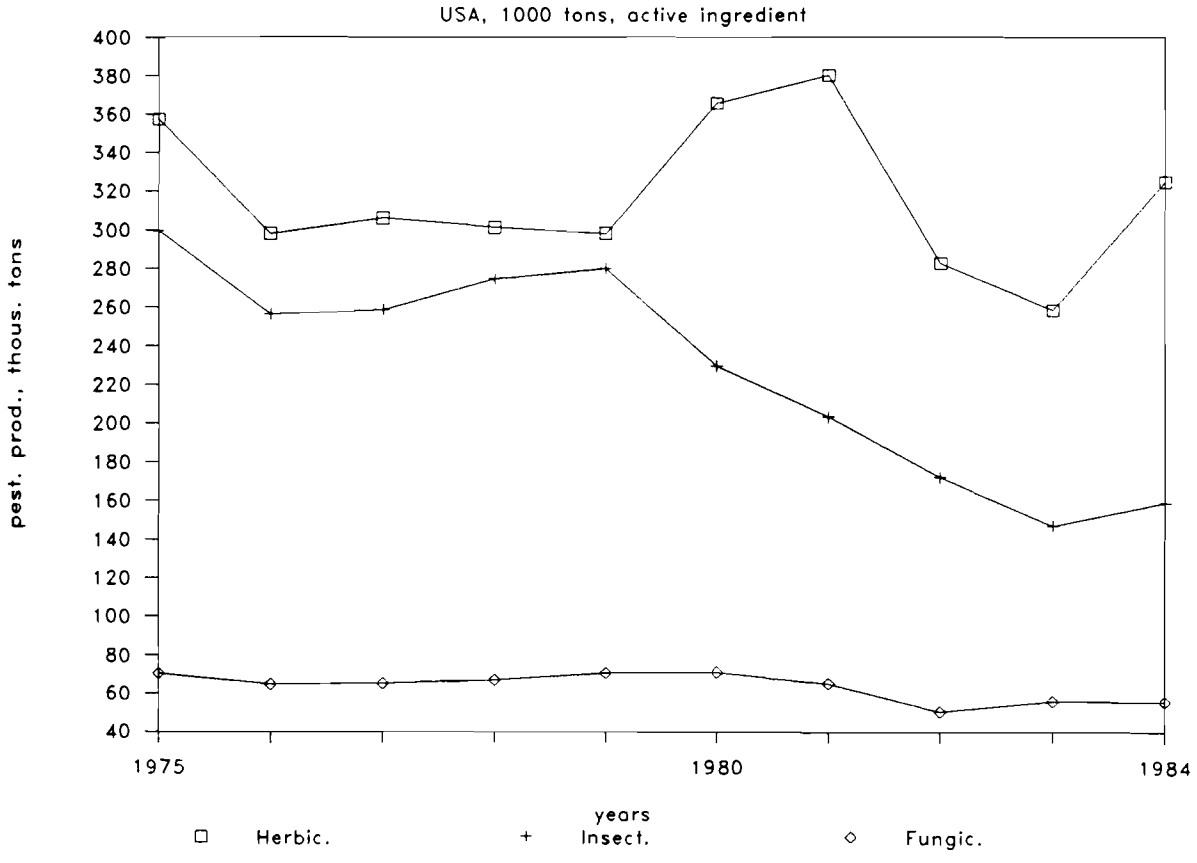

Fig.12 Structure, pesticide production

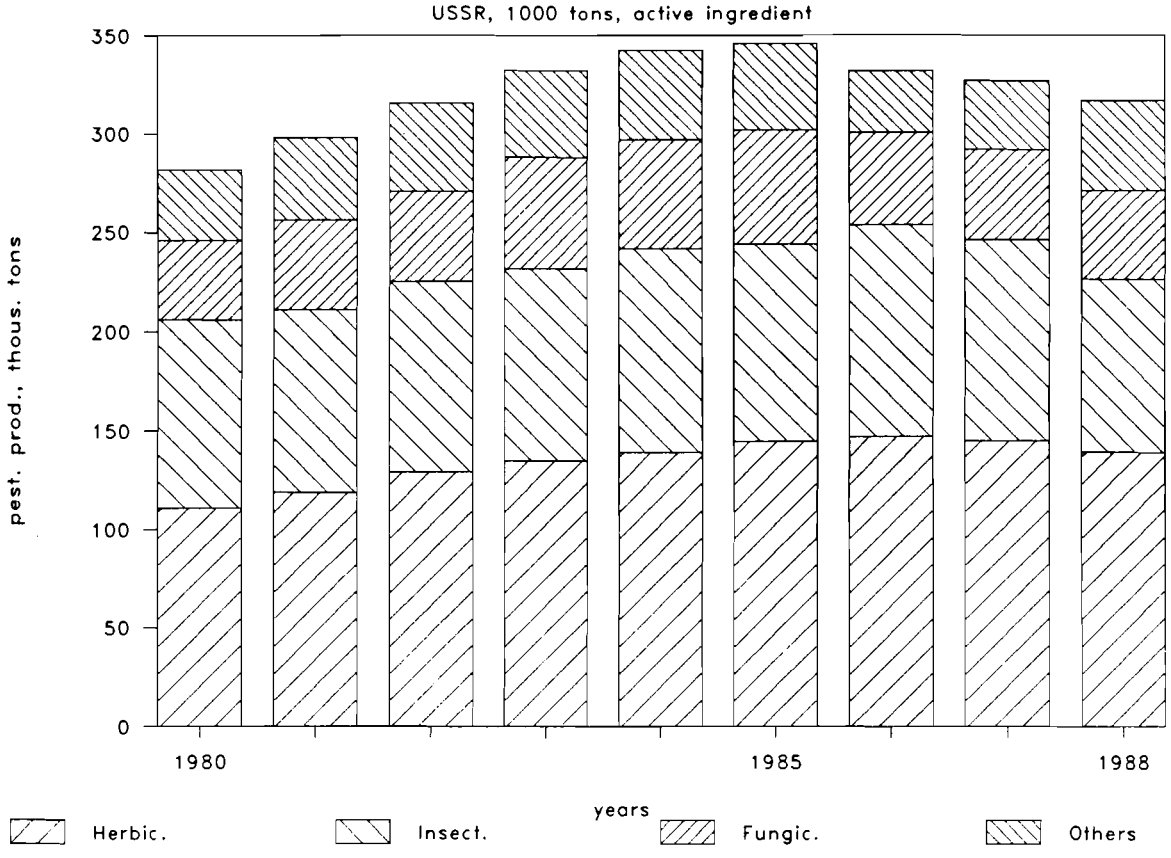

Fig.13 Structure, pesticide production

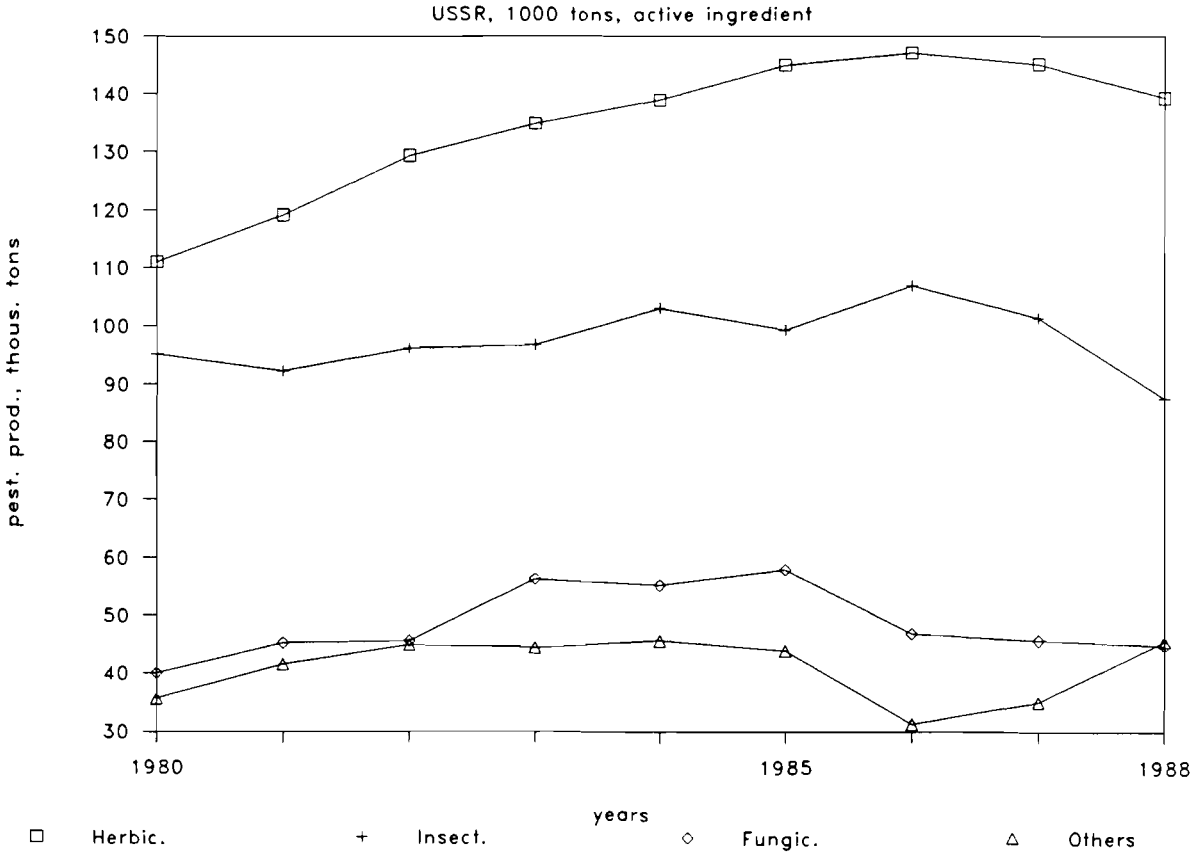

Fig.14 Total production, pesticides

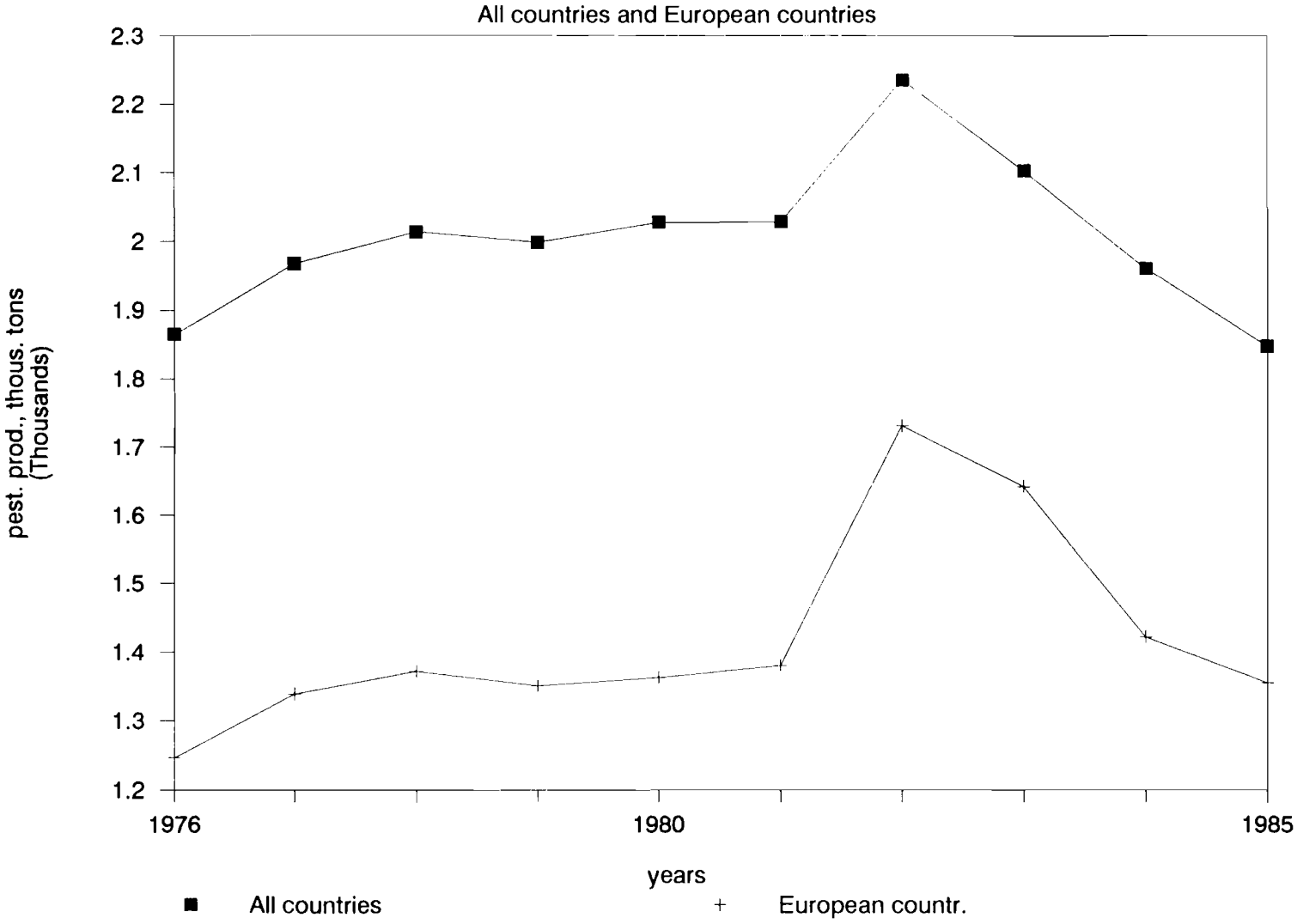

Fig.15 Share, pesticides production

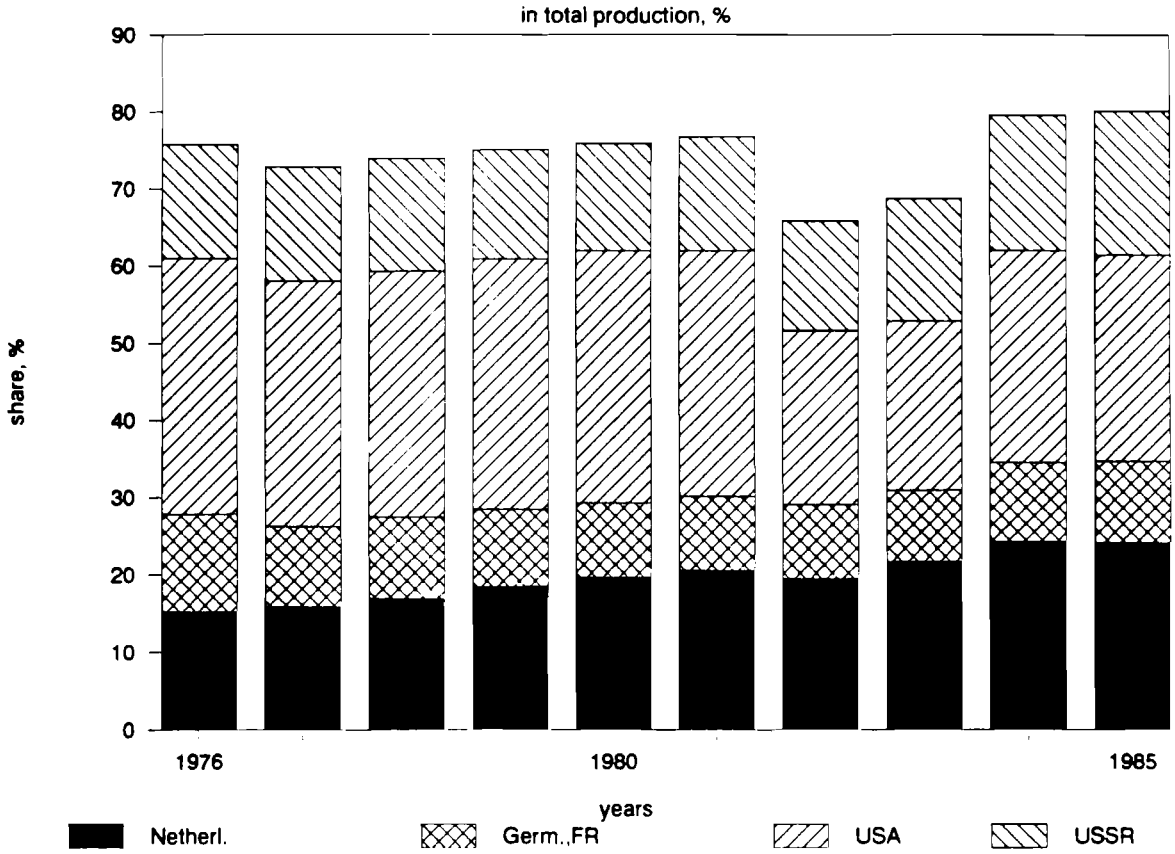

Fig.16 Share, pesticides production

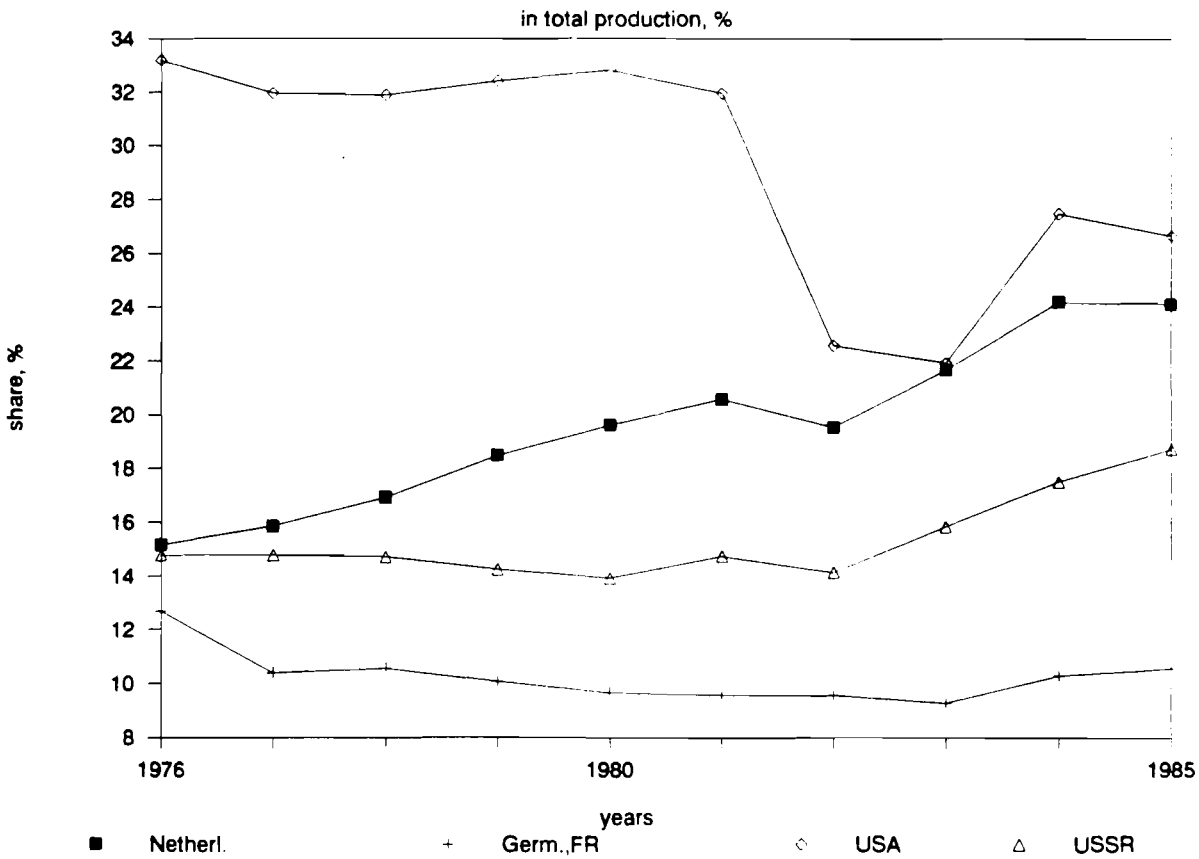

Fig.17 Share, pesticides production

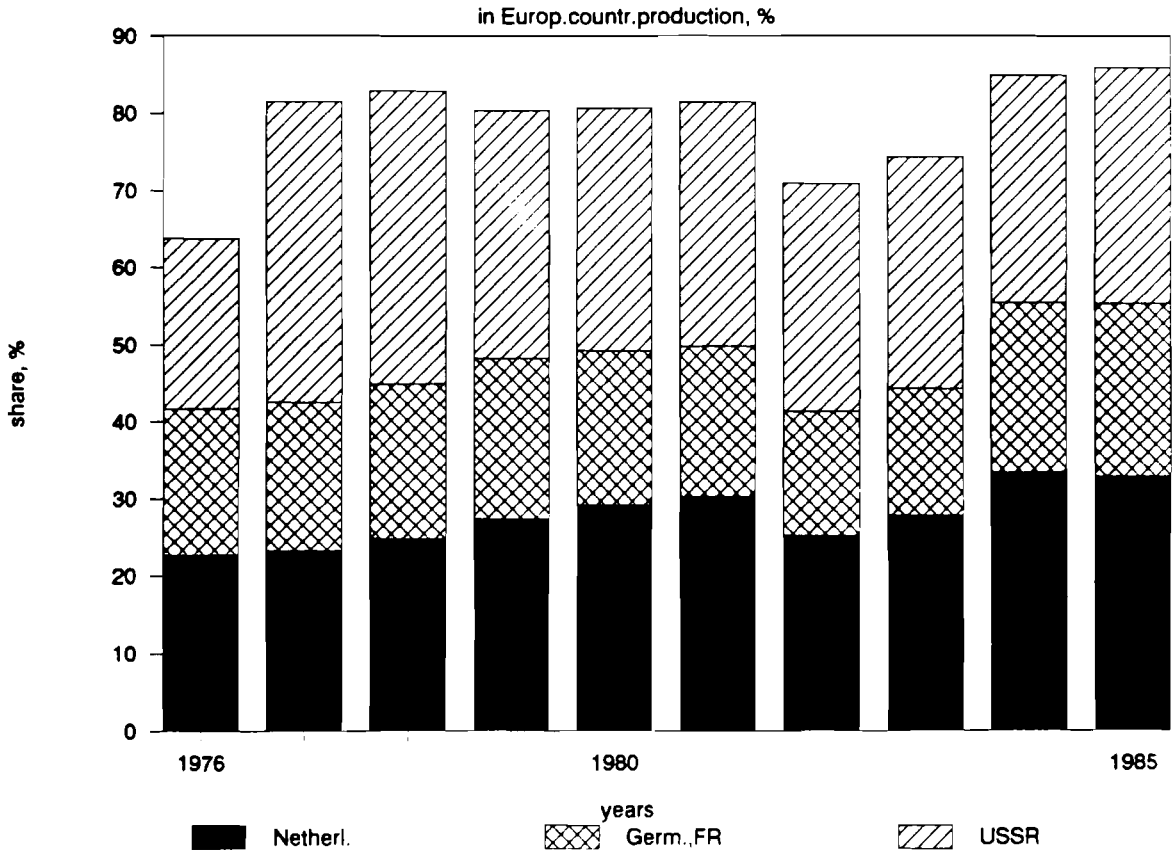

Fig.18 Share, pesticides production

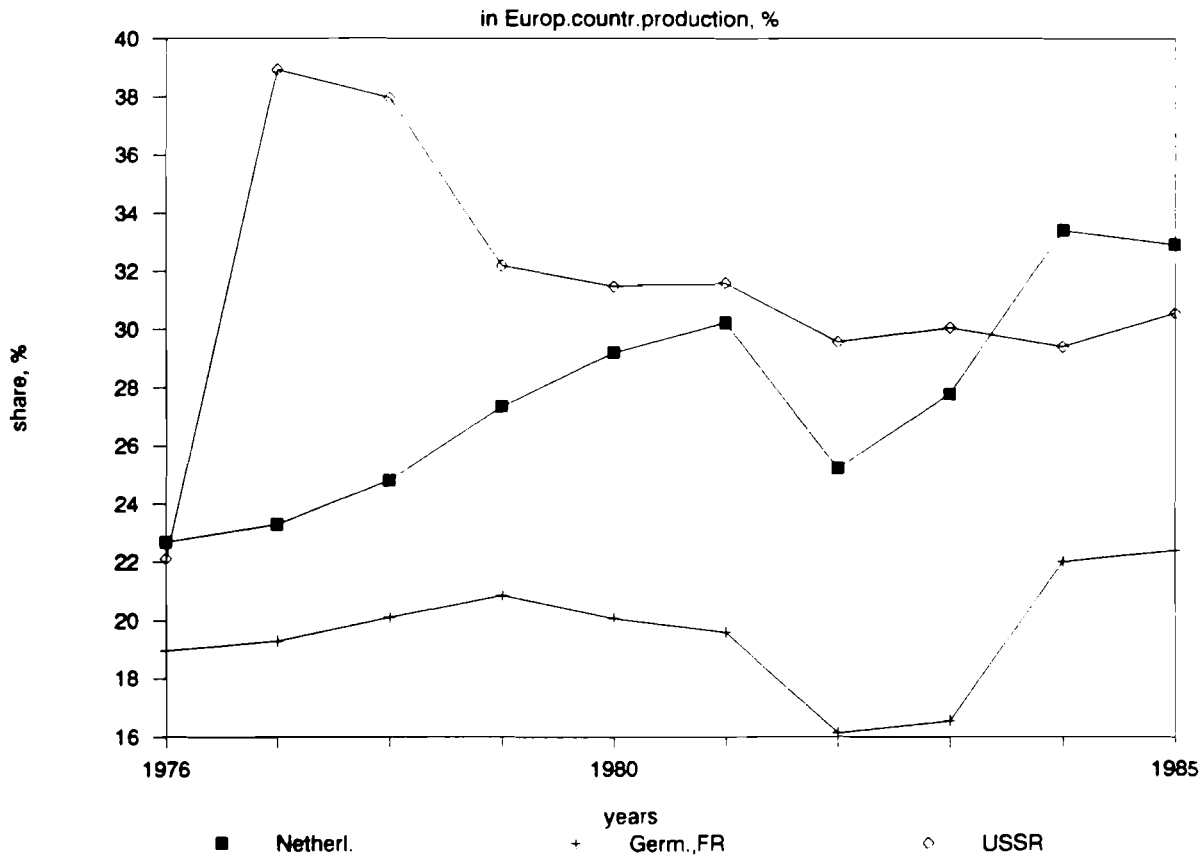

Fig.19 Share, pesticides production

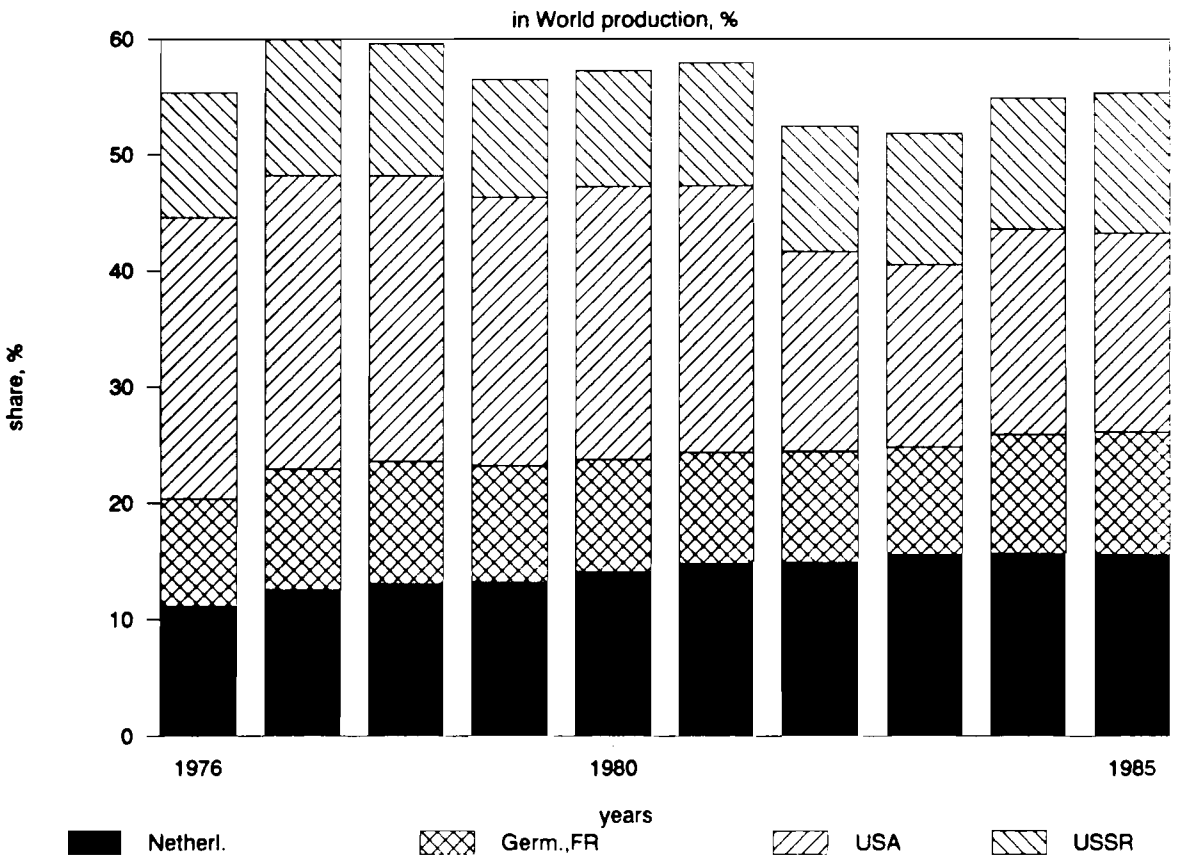

Fig.20 Share, pesticides production

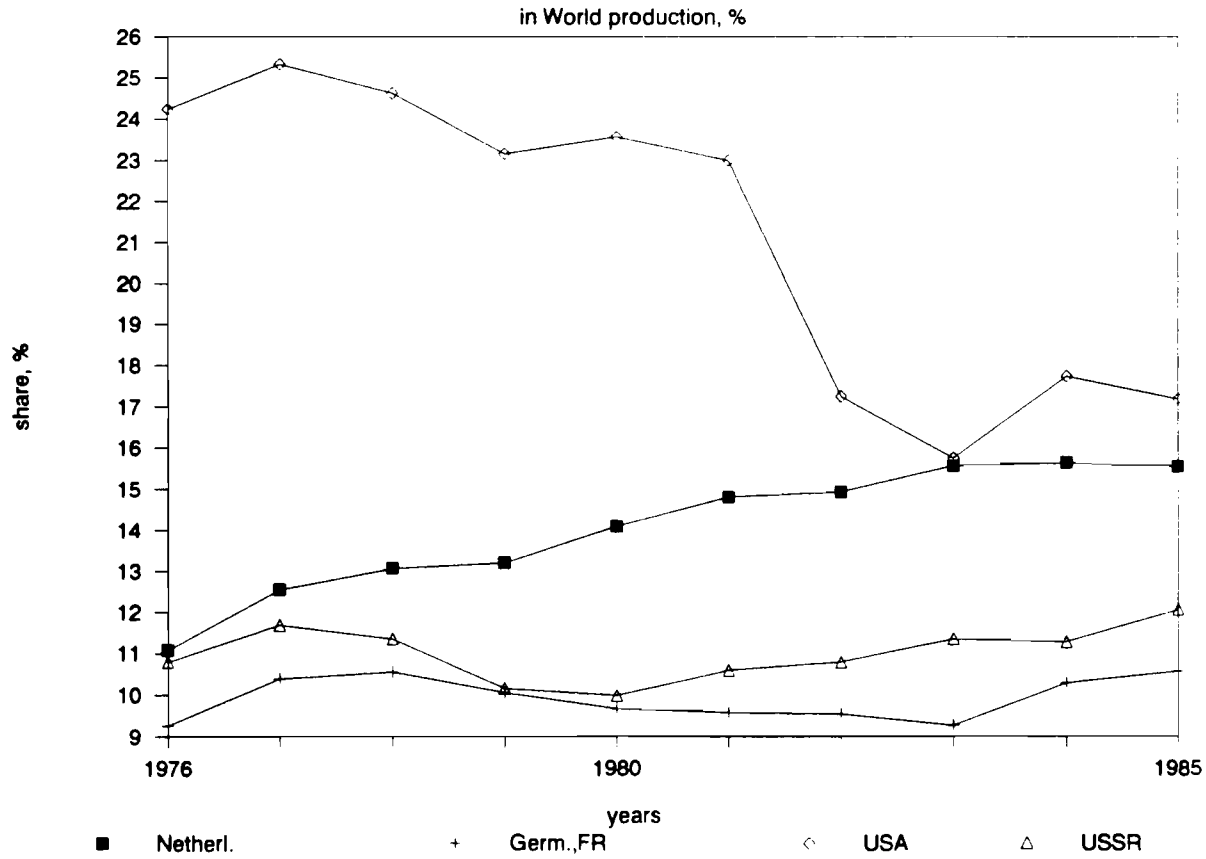

Fig.21 Per capita pestic. prod.,kg

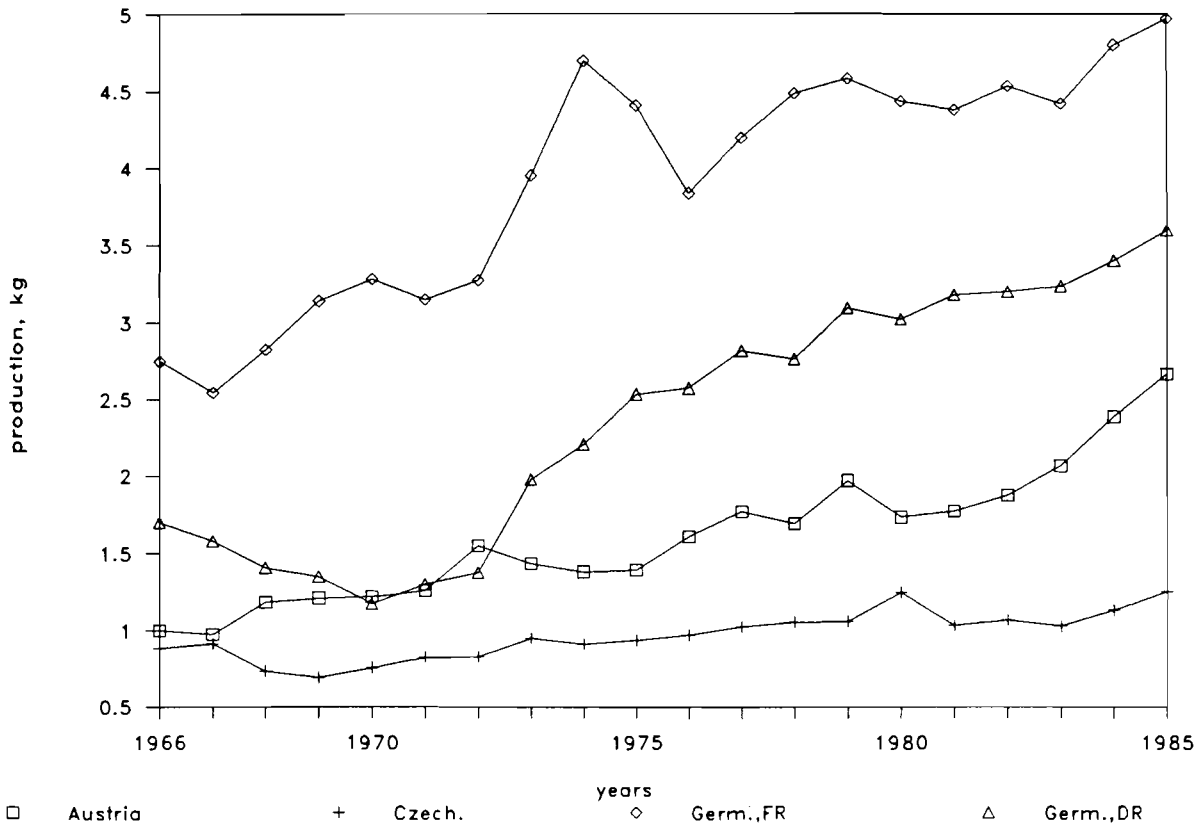

Fig.22 Per capita pestic. prod.,kg

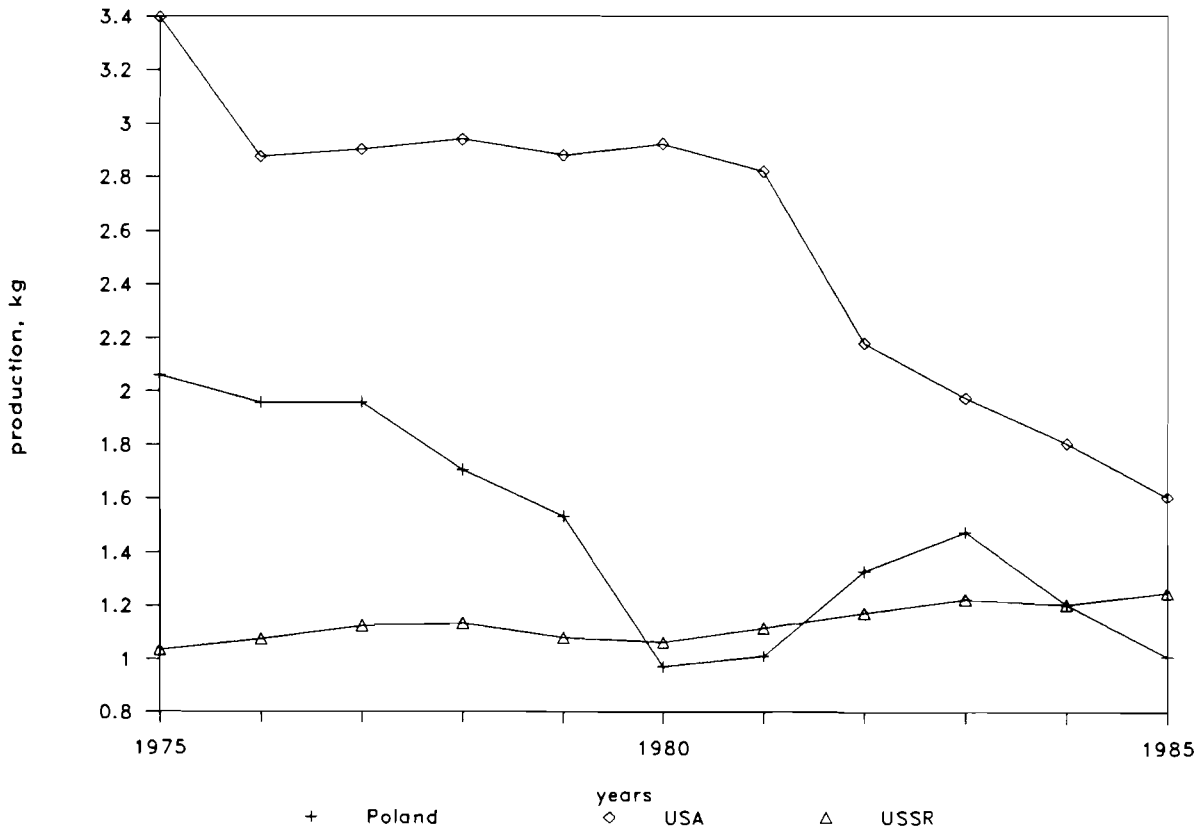

Fig.23 Per capita pestic. prod.,kg

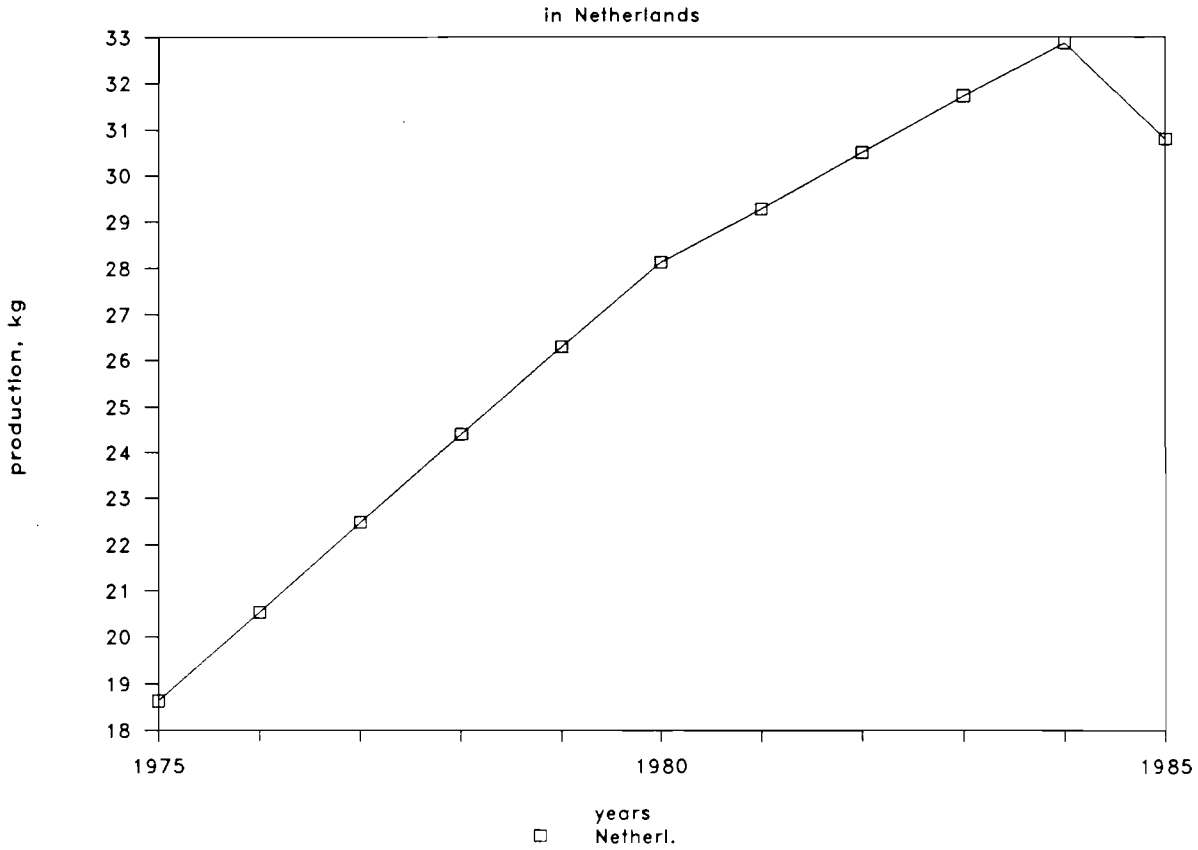

Fig.24 Per capita pestic. prod.,kg

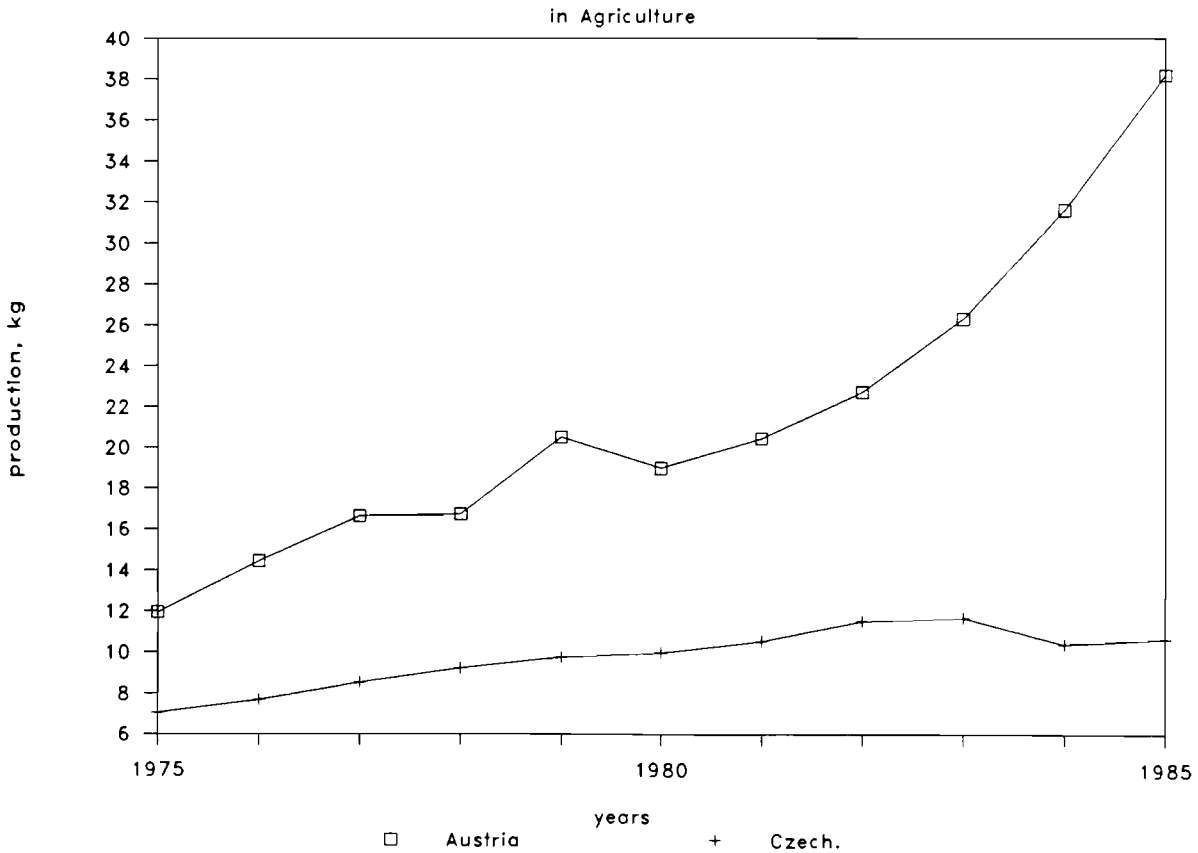

Fig.25 Per capita pestic. prod.,kg

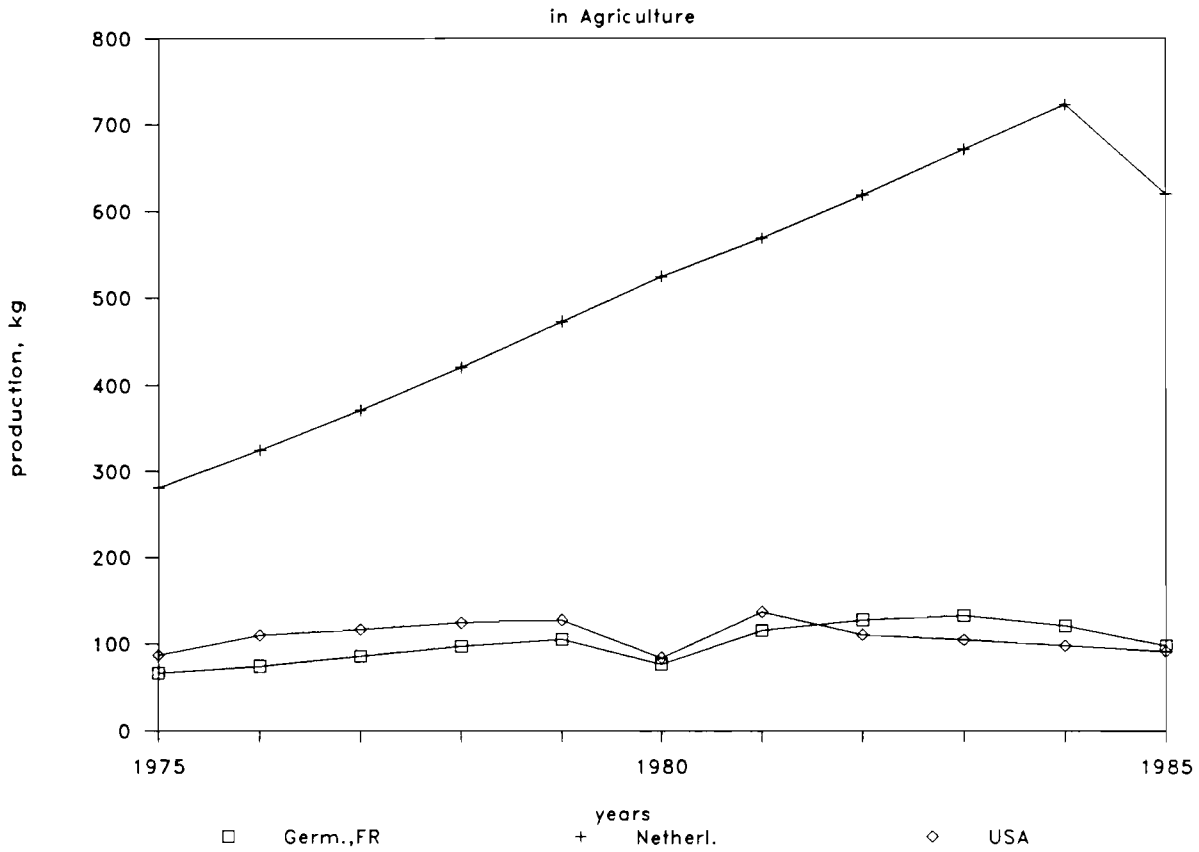

Fig.26 Per capita pestic. prod.,kg

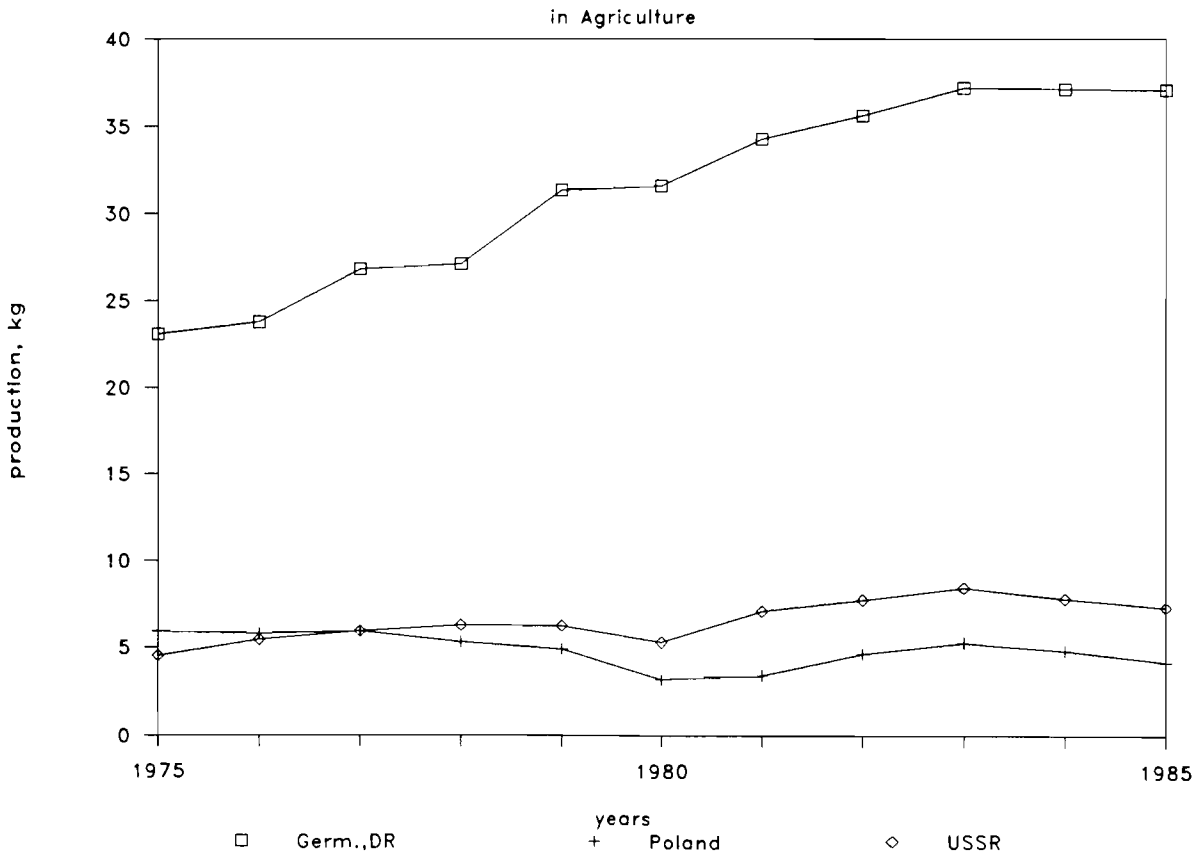

Fig.27 Pesticide production

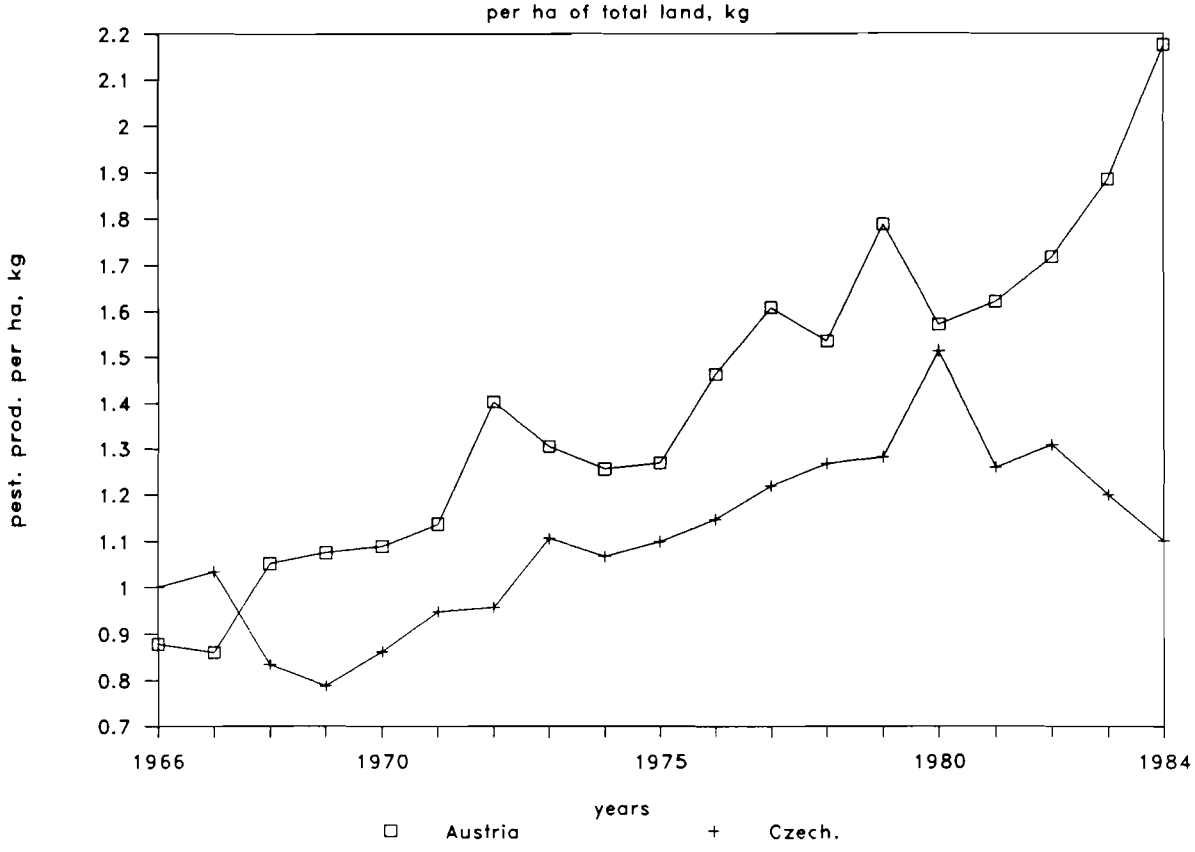

Fig.28 Pesticide production

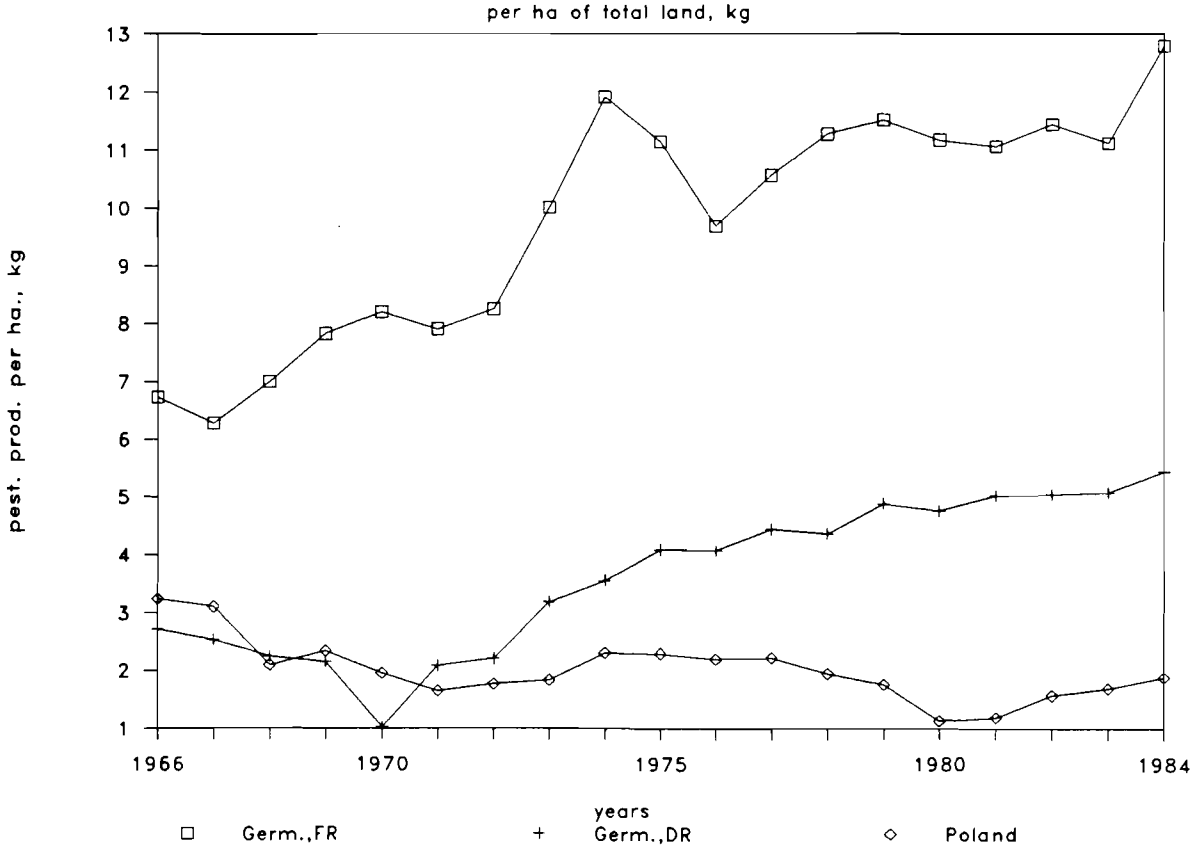

Fig.29 Pesticide production

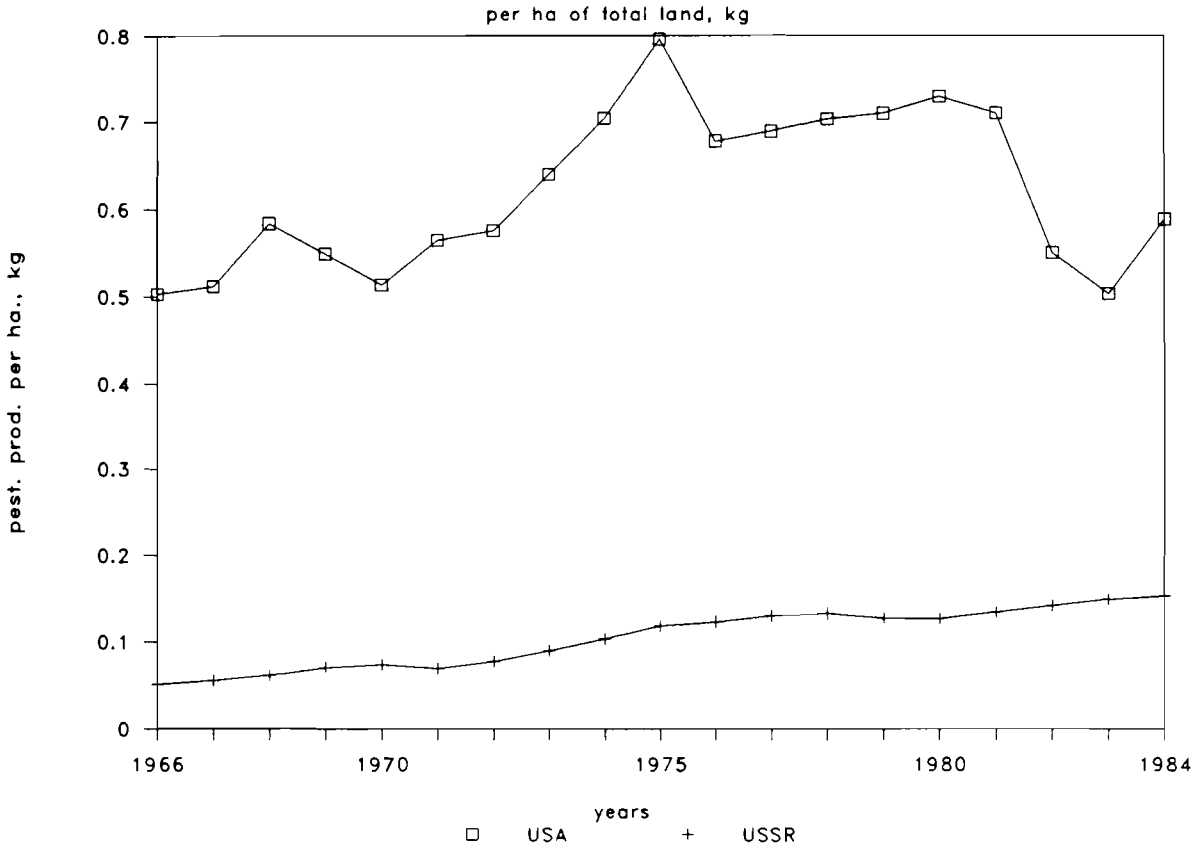

Fig.30 Pesticide production

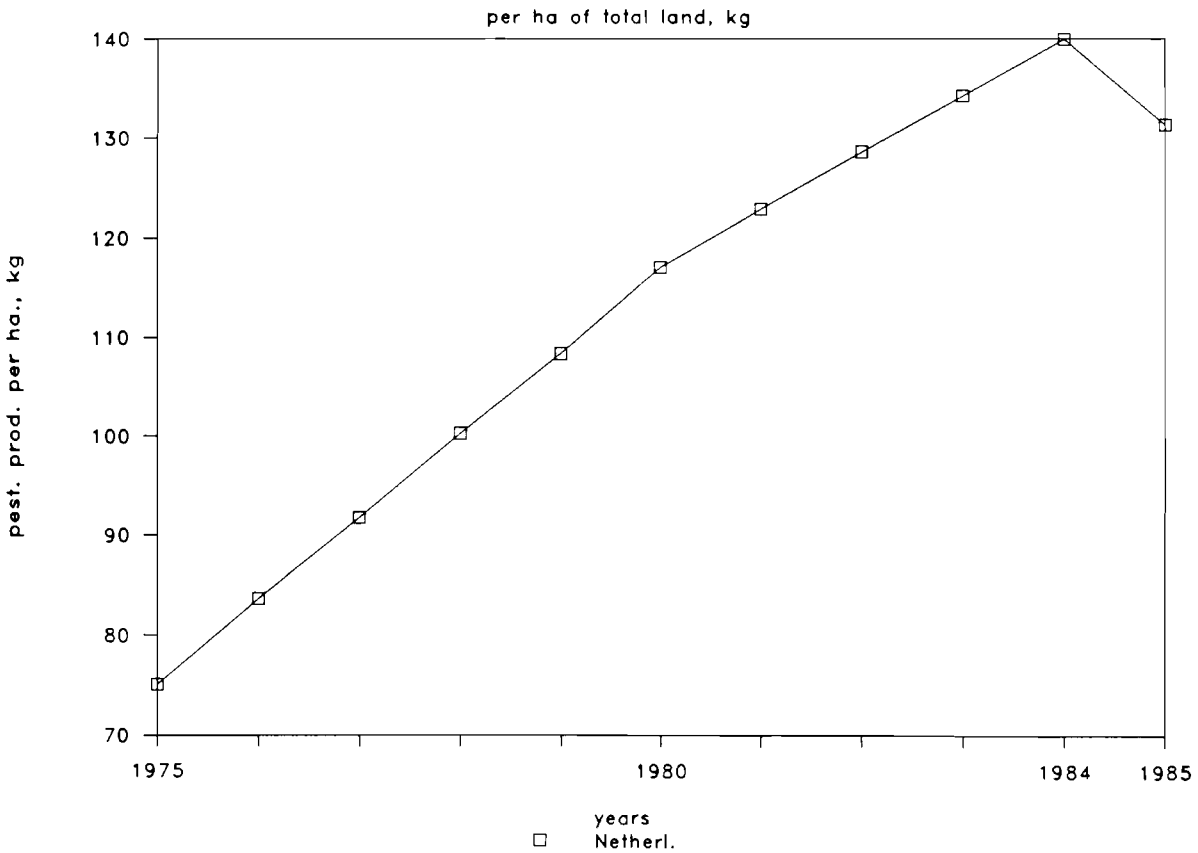

Fig.31 Pesticides production

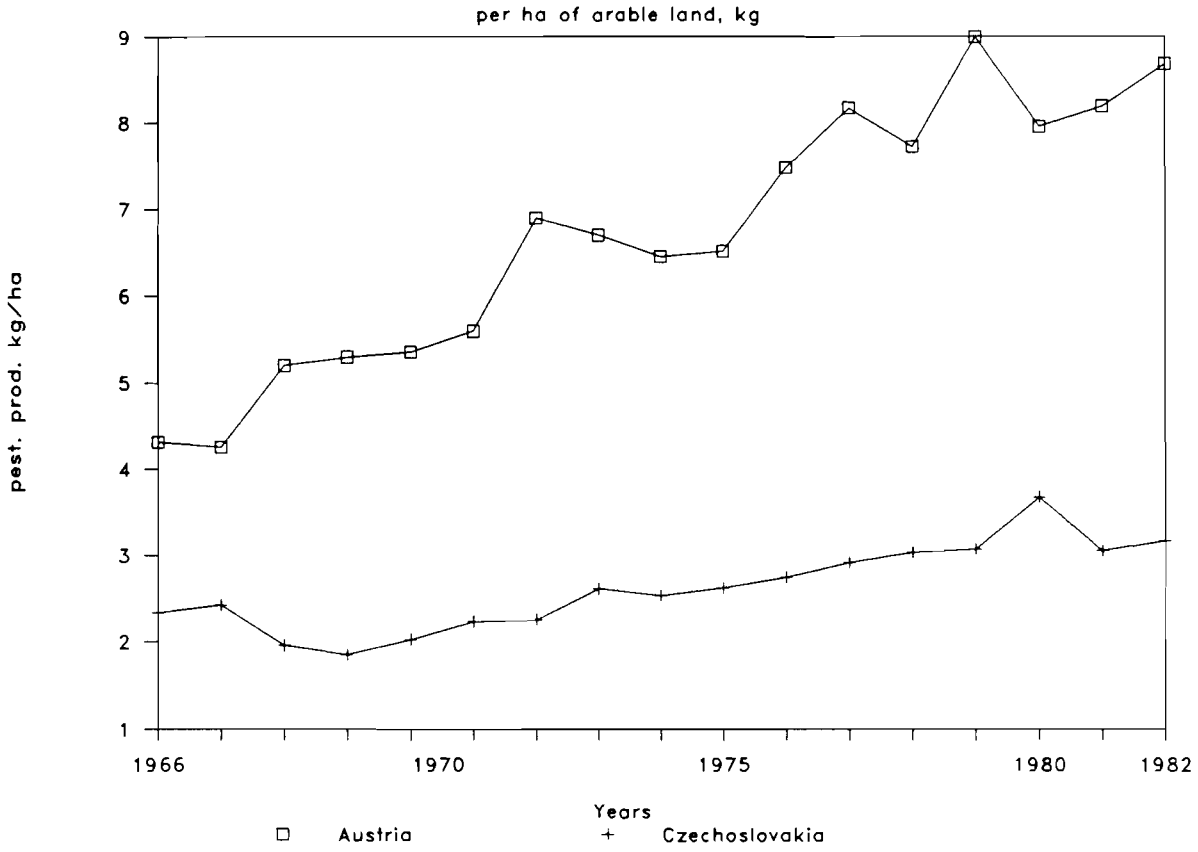

Fig.32 Pesticides production

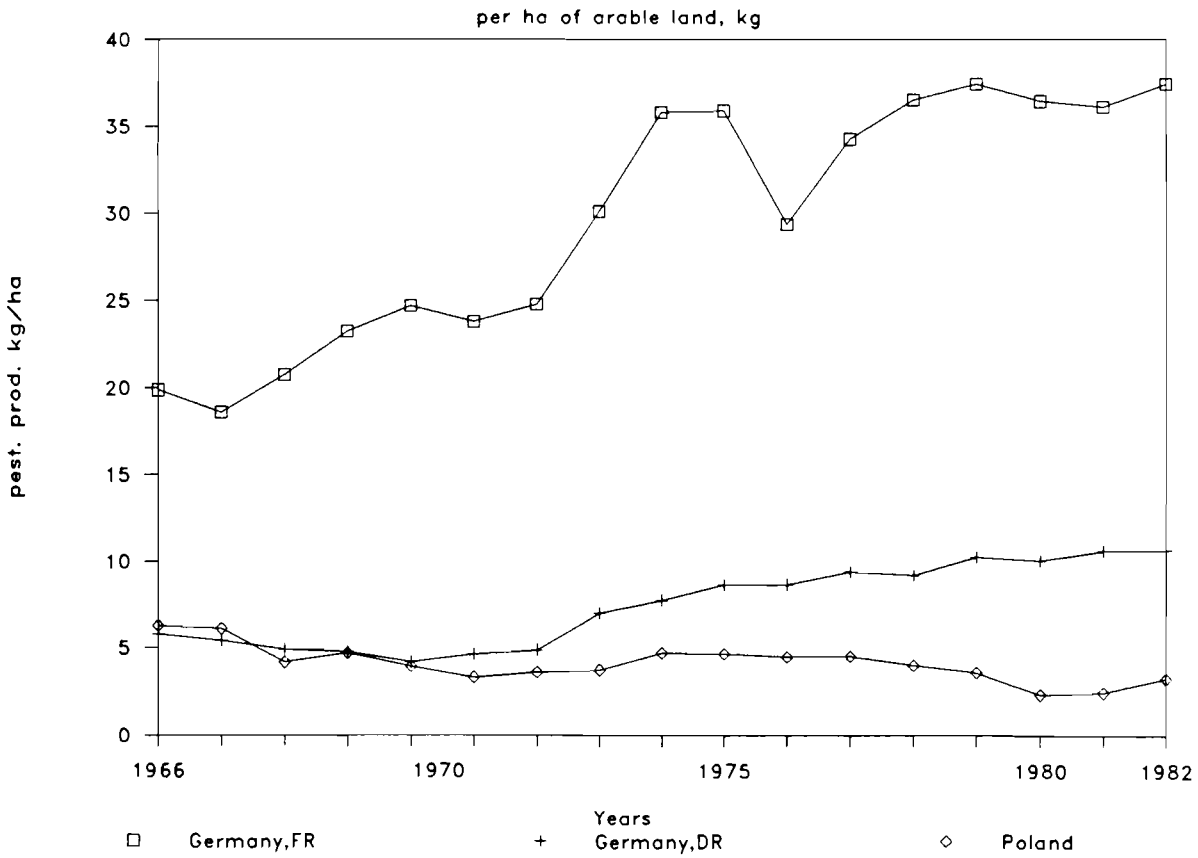

Fig.33 Pesticides production

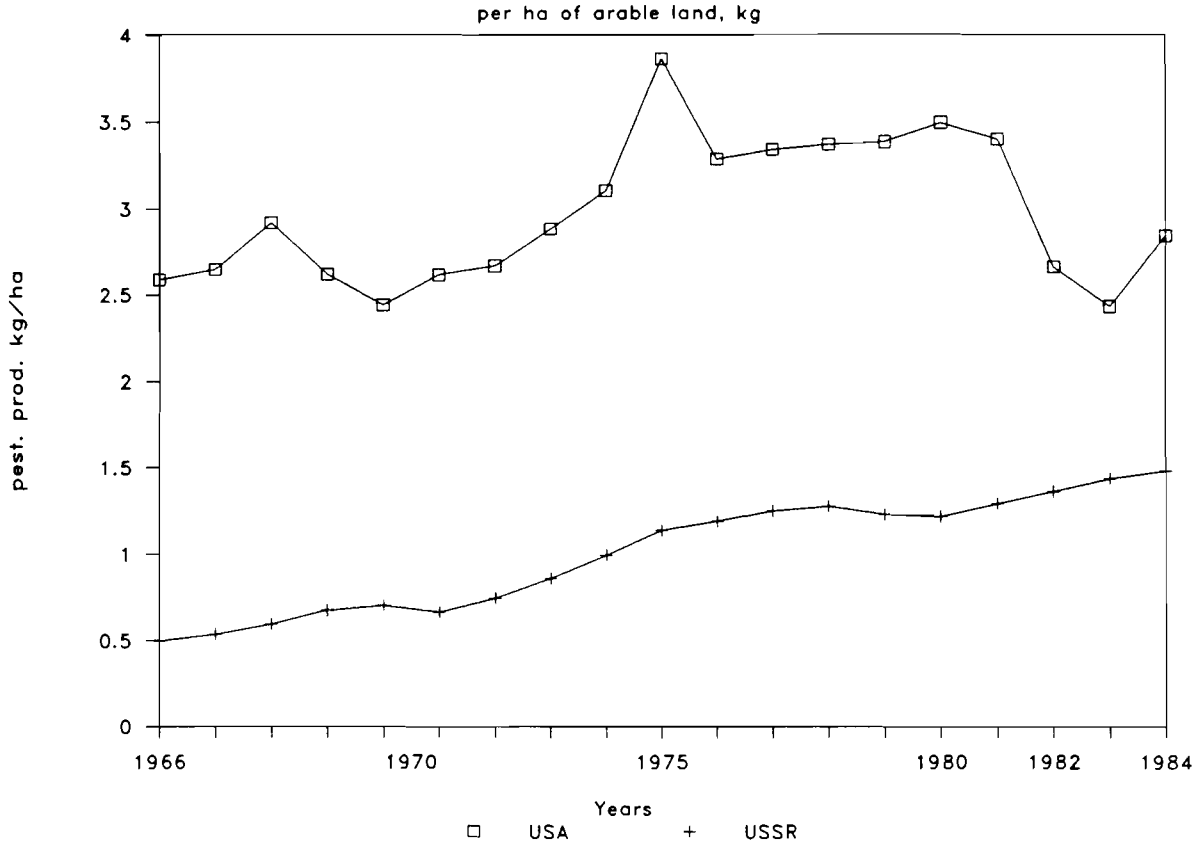

Fig.34 Pesticides production

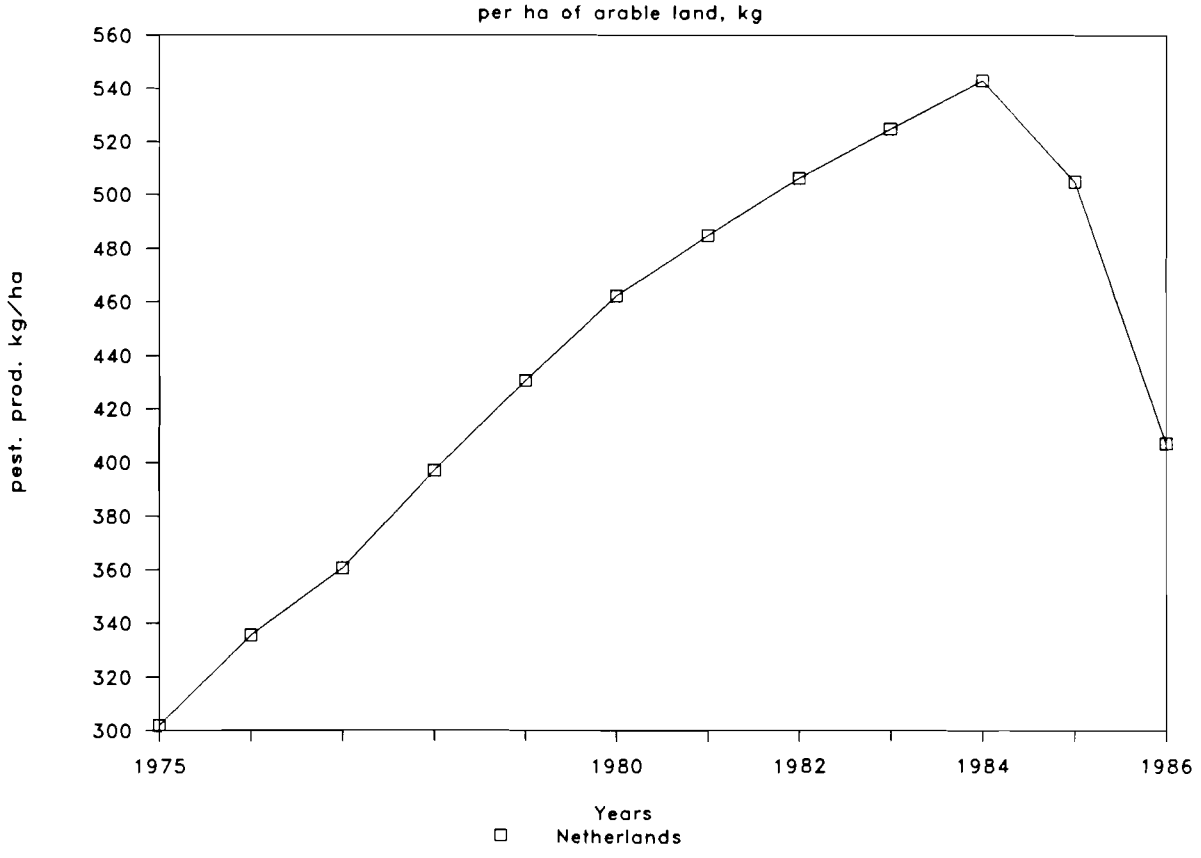

Fig.35a Pesticide production

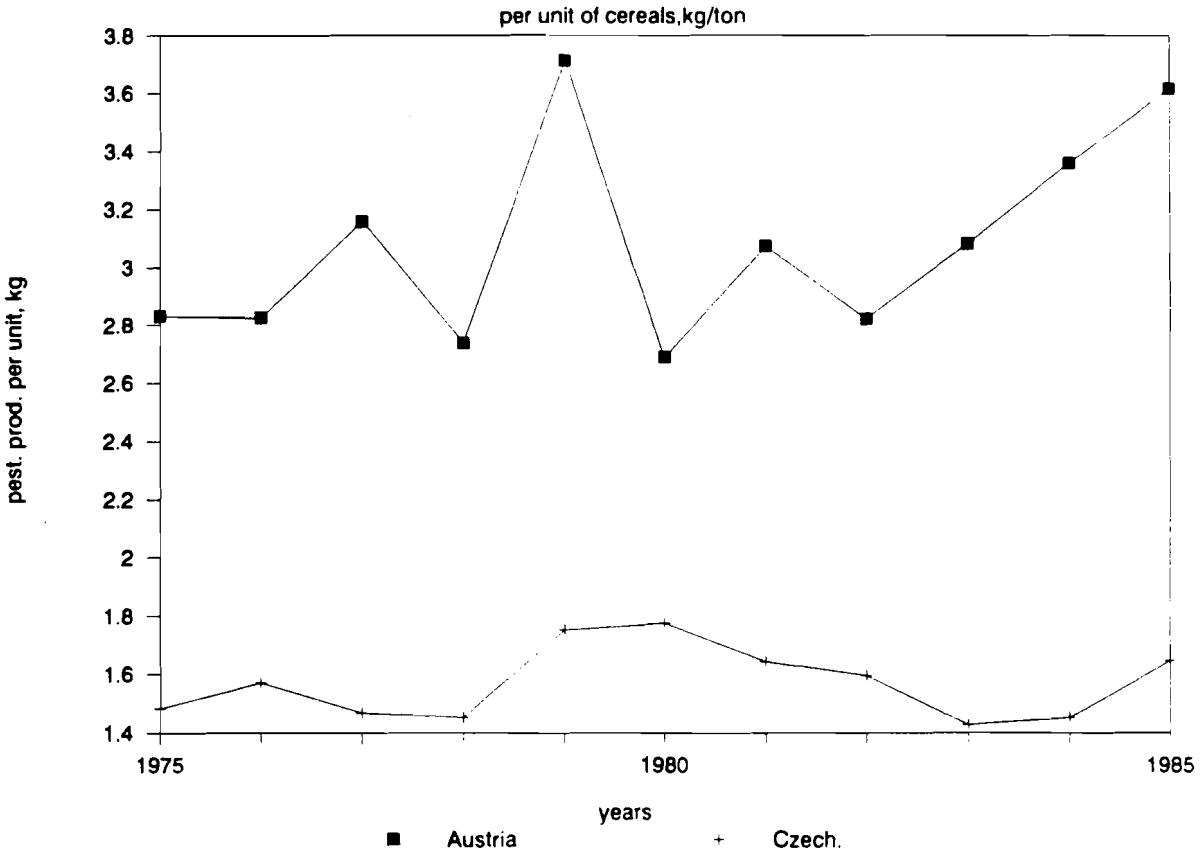

Fig.35b Cereal production, mln.tons

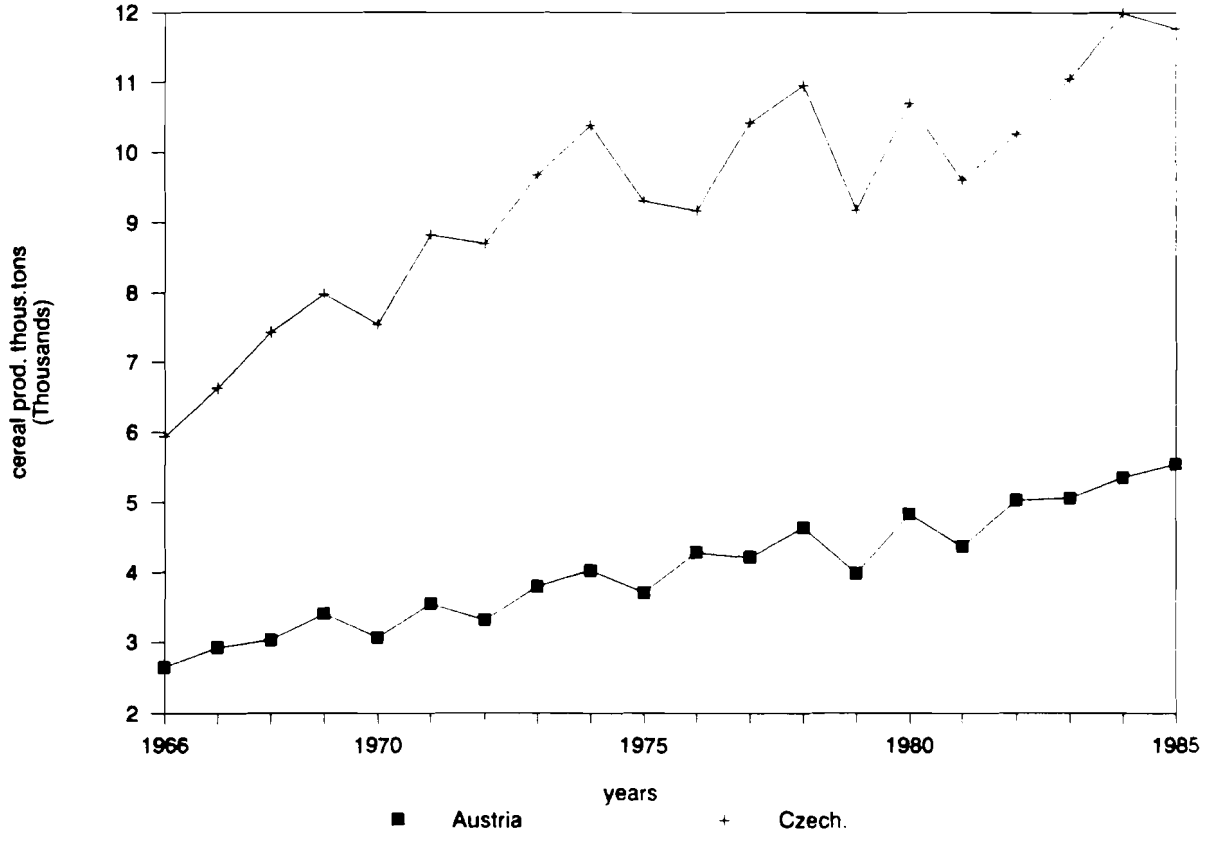

Fig.35c Cereals Yield, kg/ha

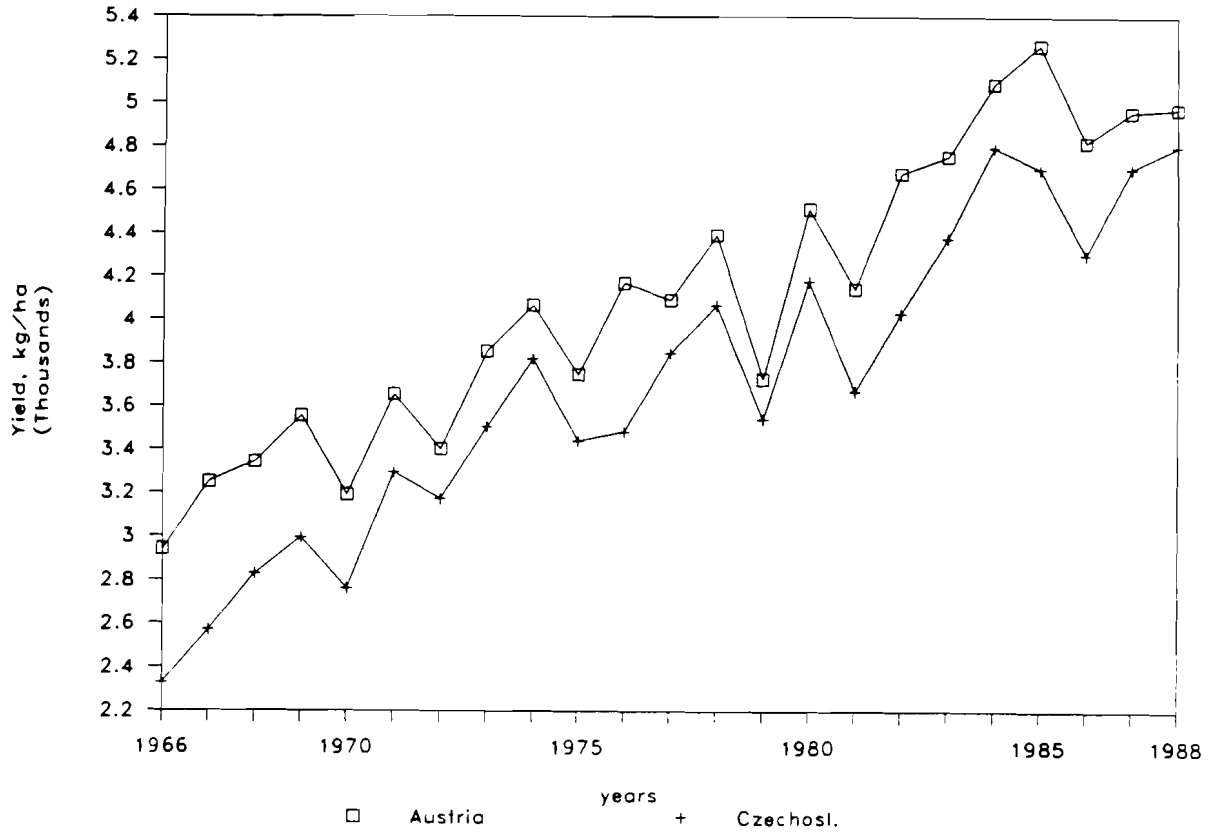

Fig.36a Pesticide production

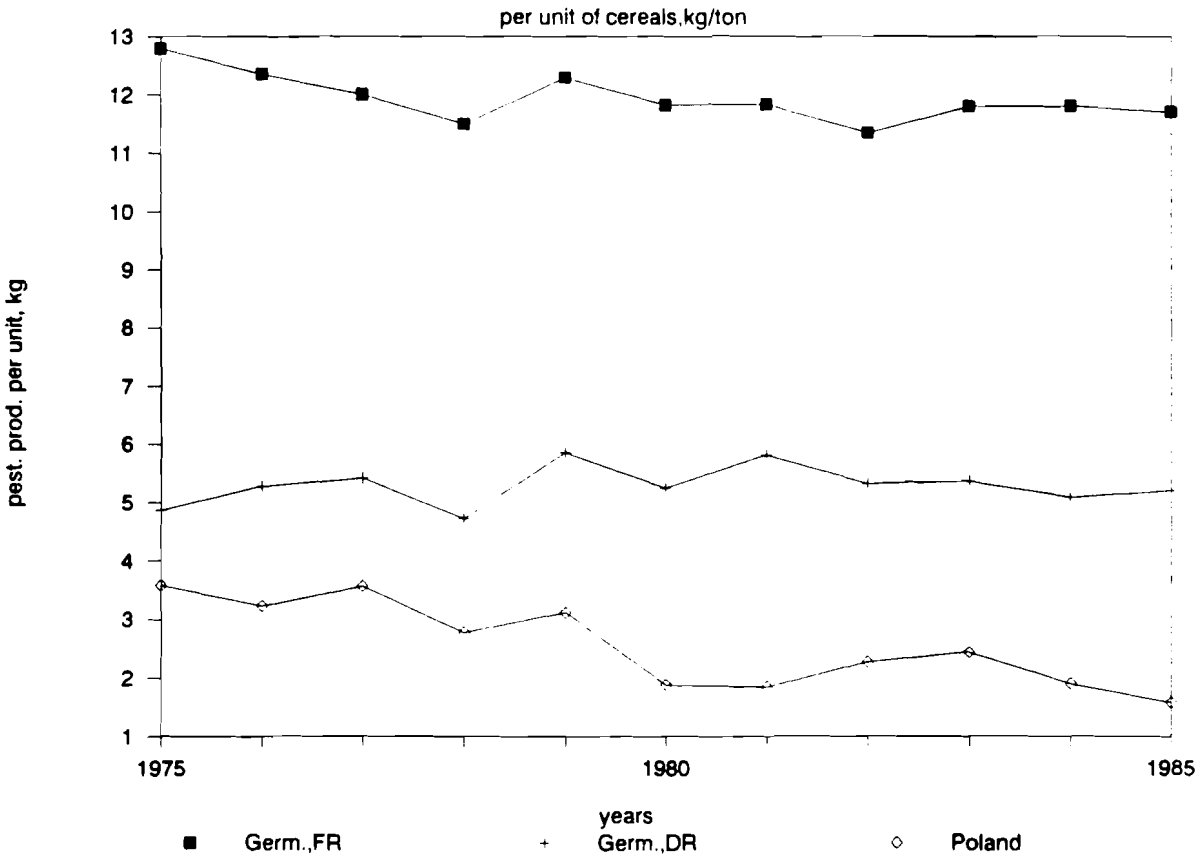

Fig.36b Cereal production, mln.tons

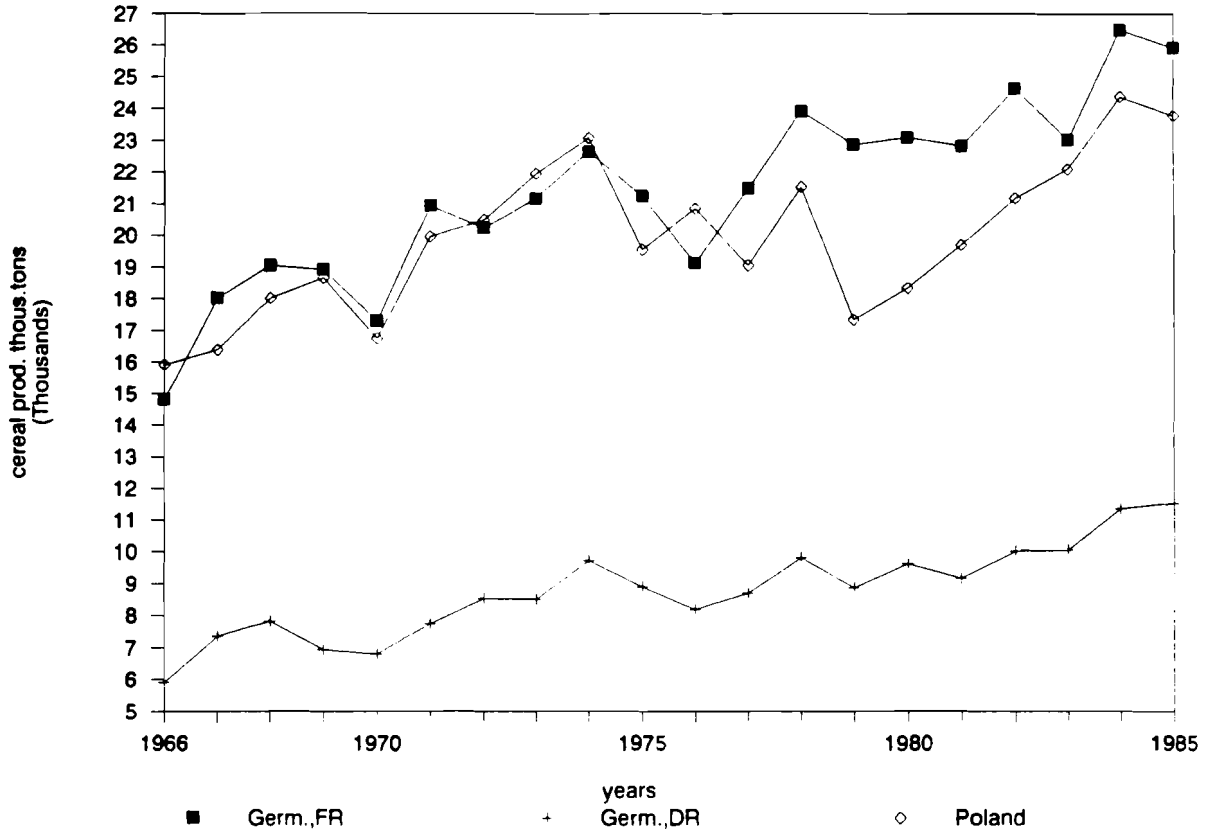

Fig.36c Cereals Yield, kg/ha

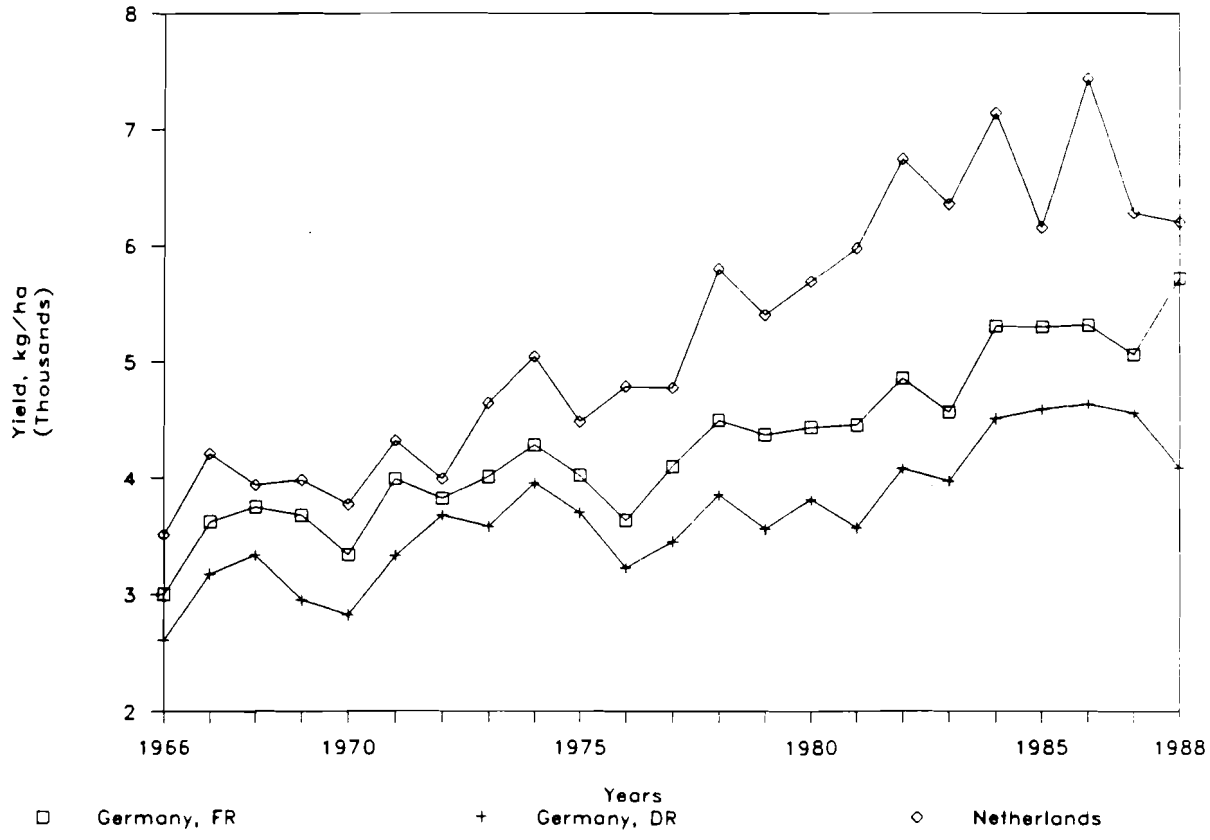

Fig.37a Pesticide production

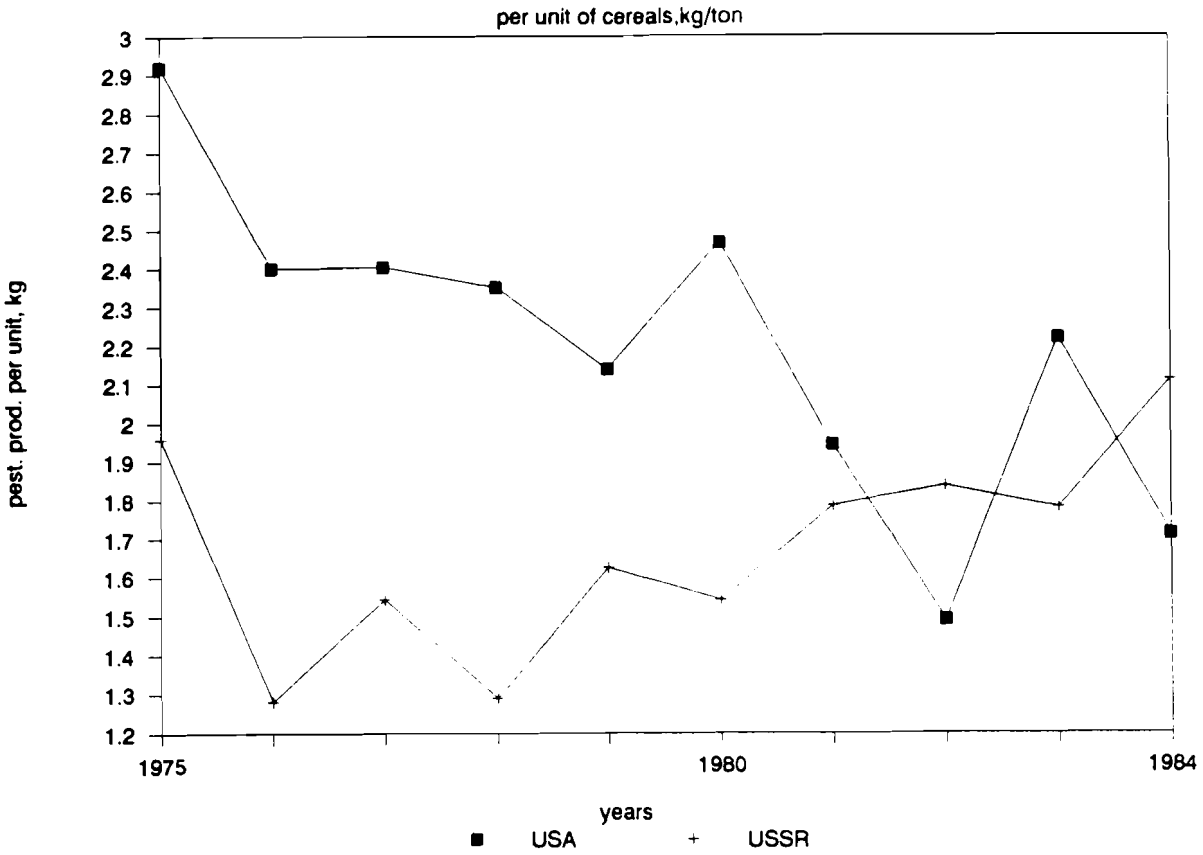

Fig.37b Cereal production, mln.tons

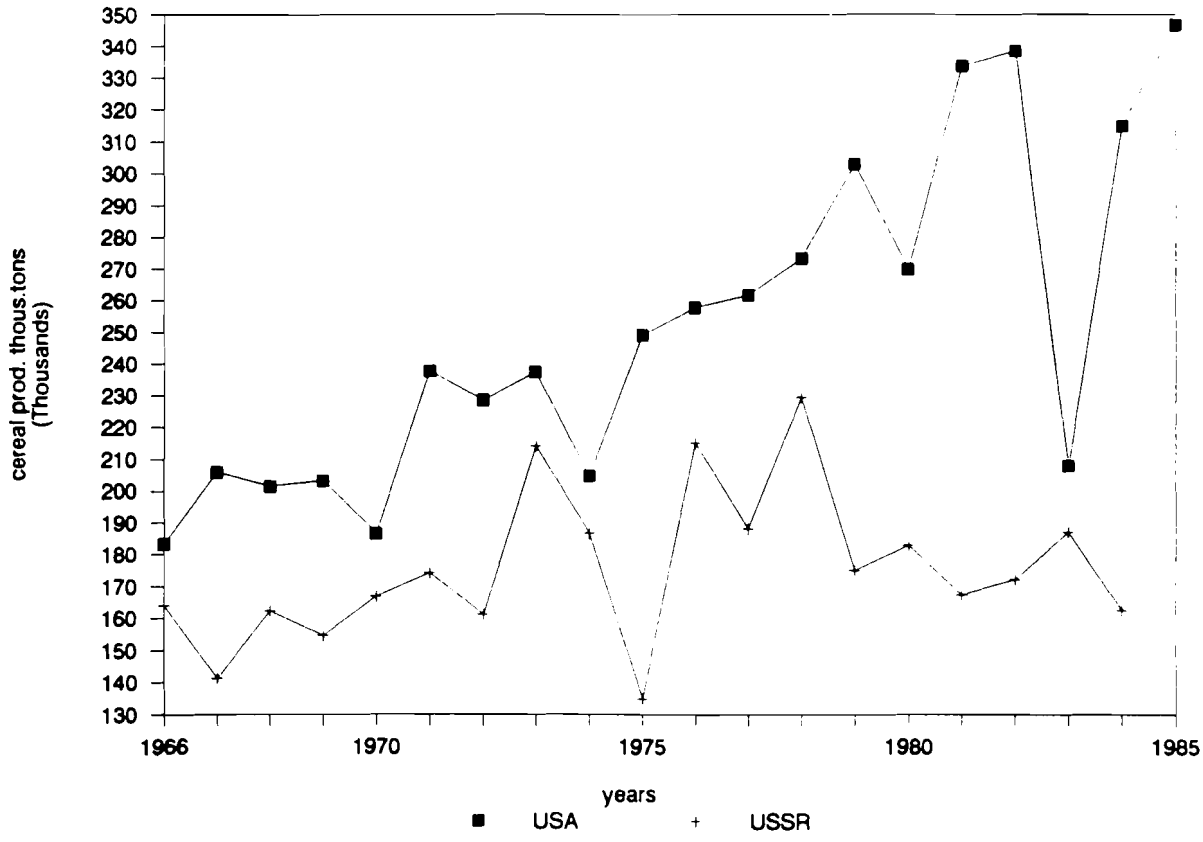

Fig.37c Cereals Yield, kg/ha

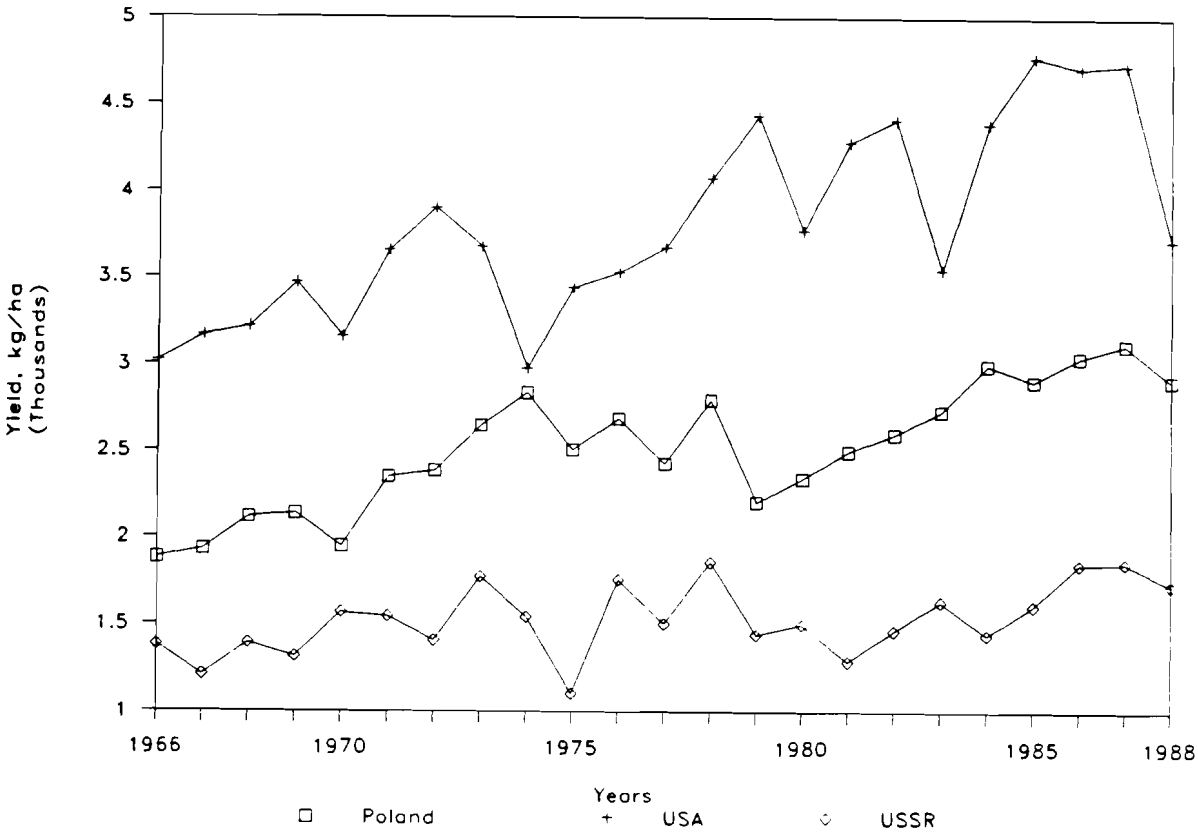

Fig.38a Pesticide production

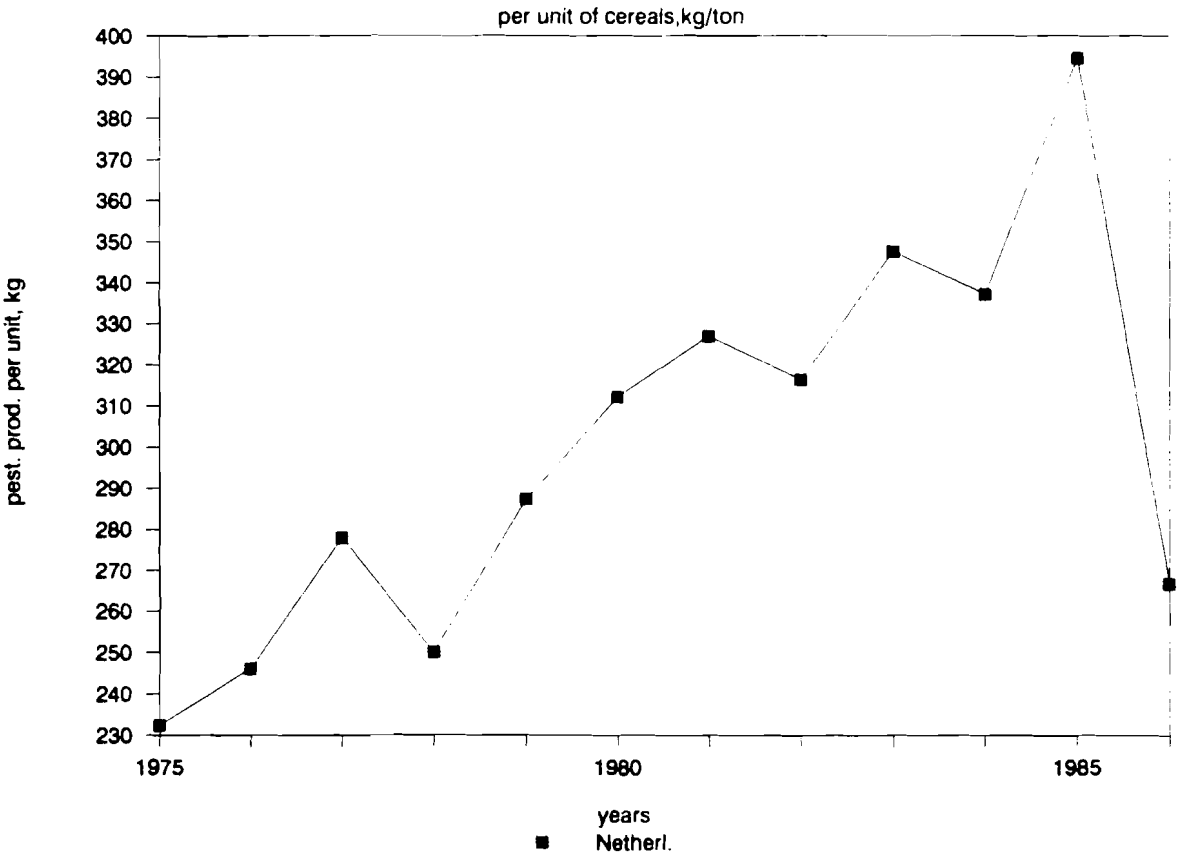

Fig.38b Cereal production, mln.tons

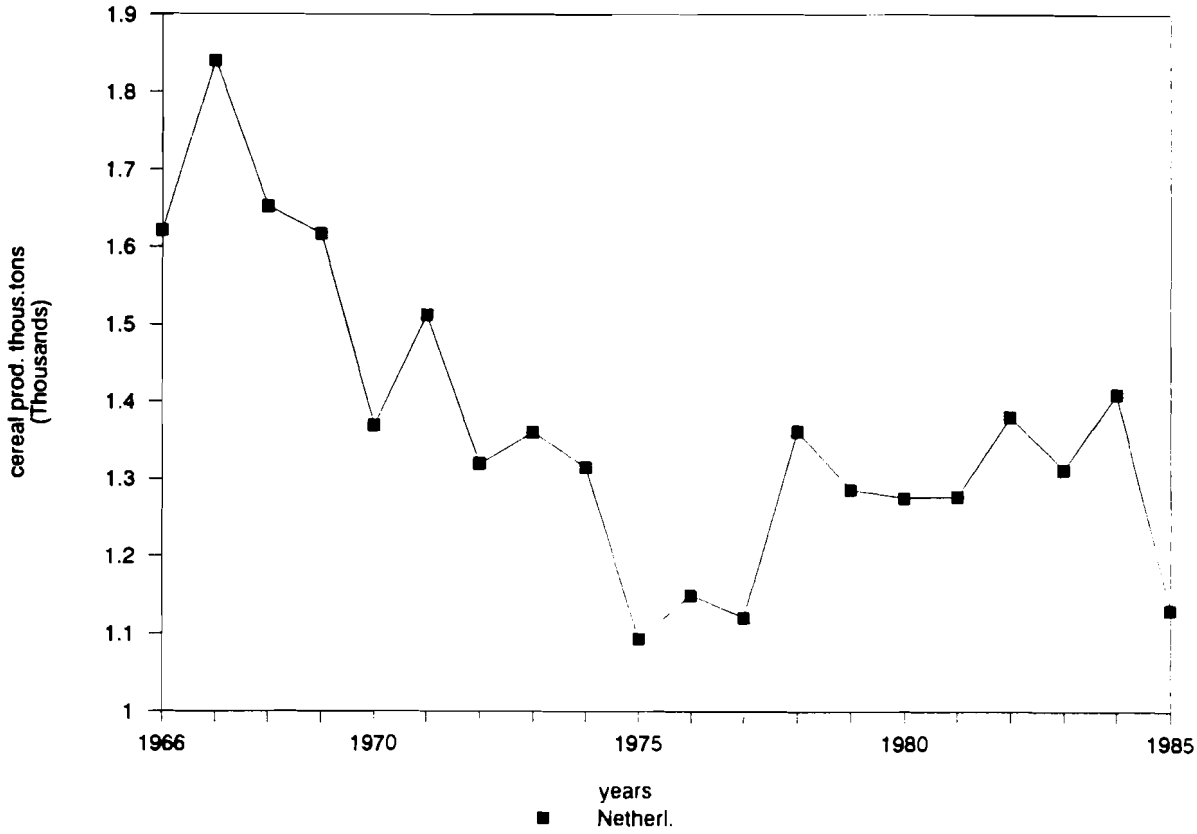

Fig.39a Pesticide production

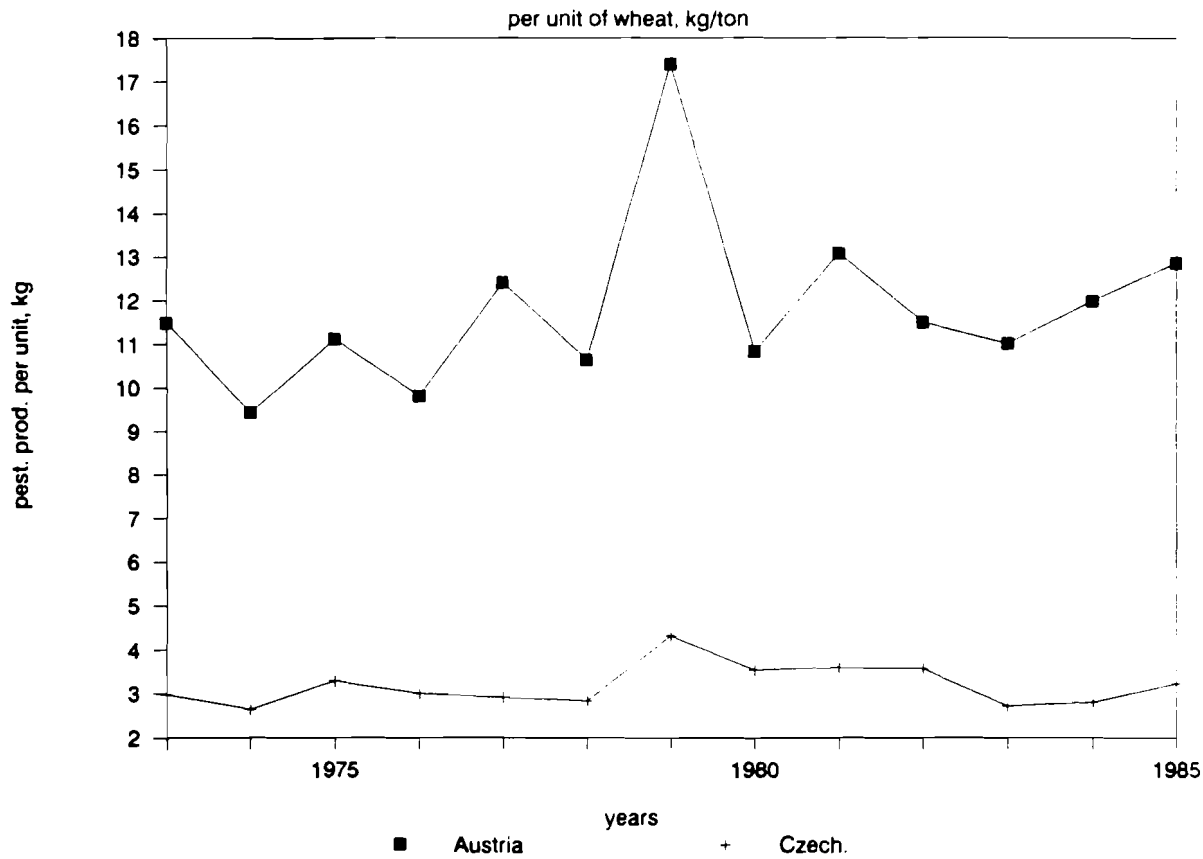

Fig.39b Wheat production, mln.tons

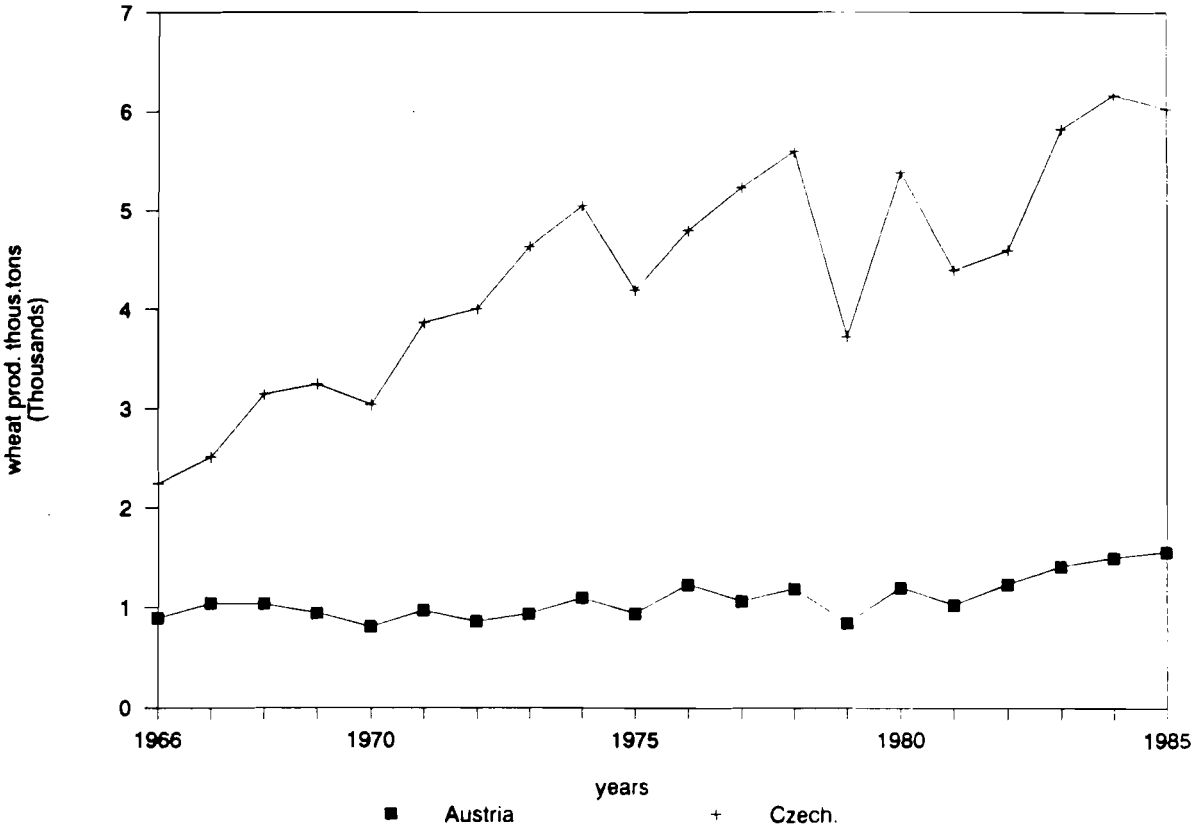

Fig.39c Wheat Yield, kg/ha

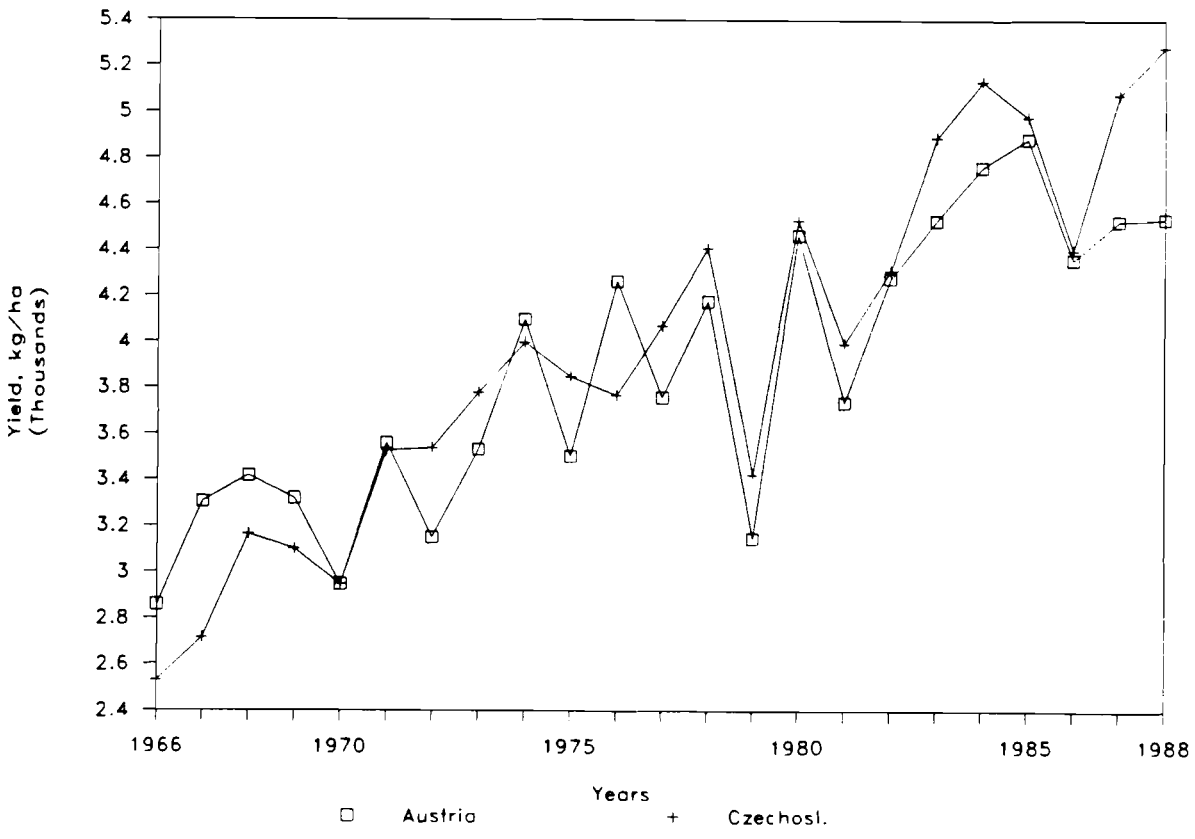

Fig.40a Pesticide production

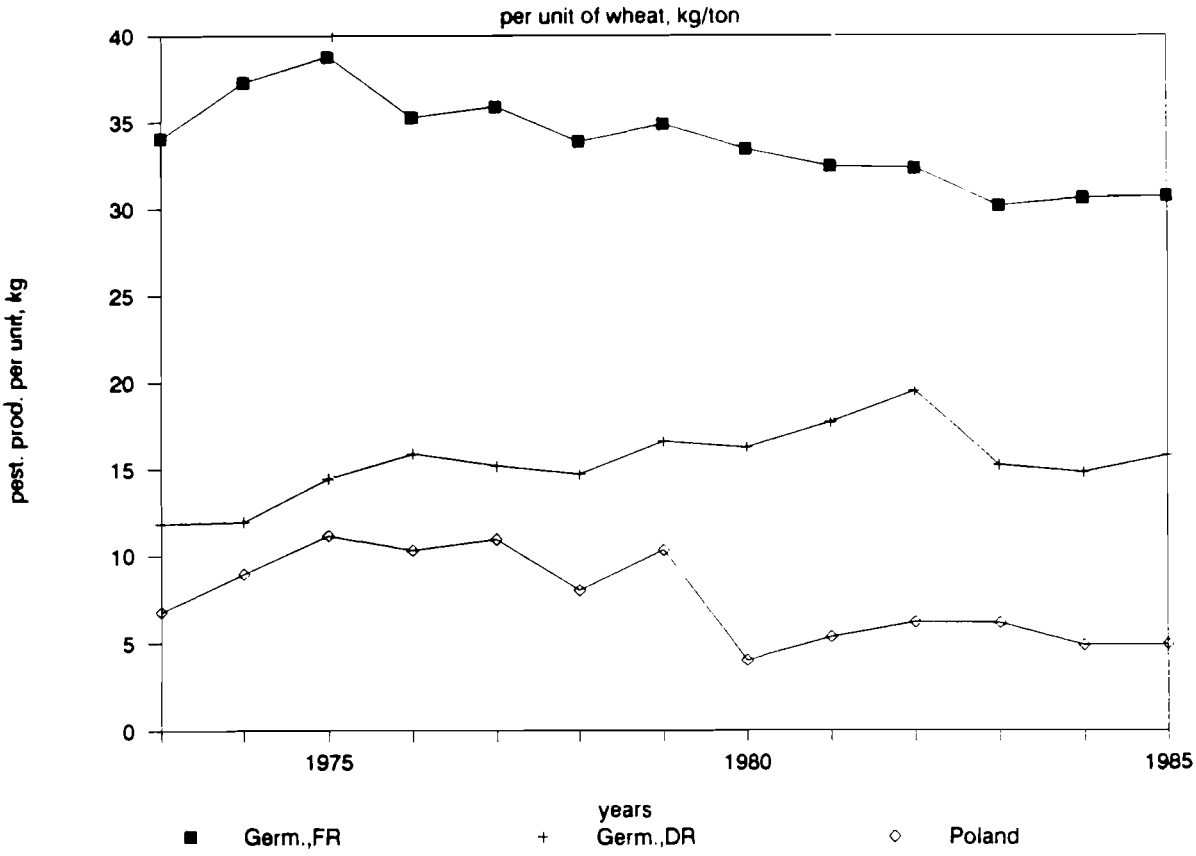

Fig.40b Wheat production, mln.tons

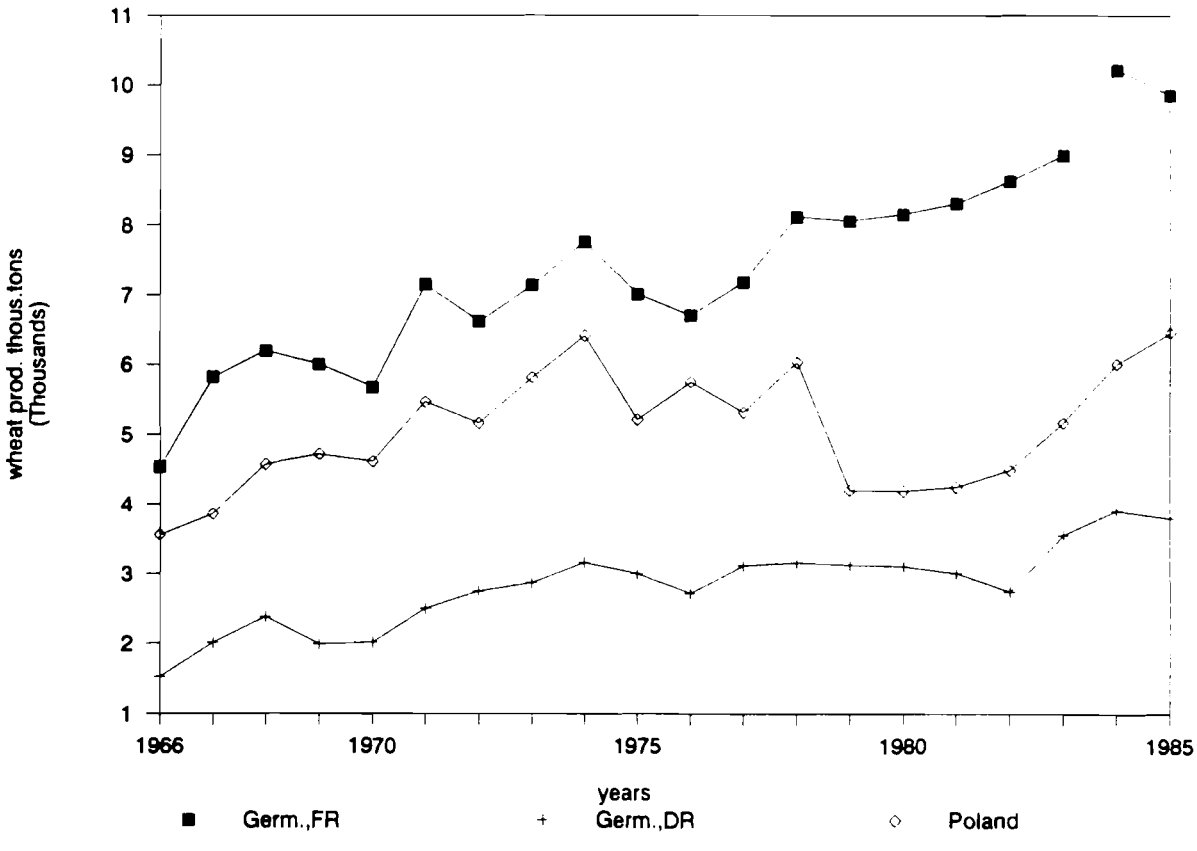

Fig.40c Wheat Yield, kg/ha

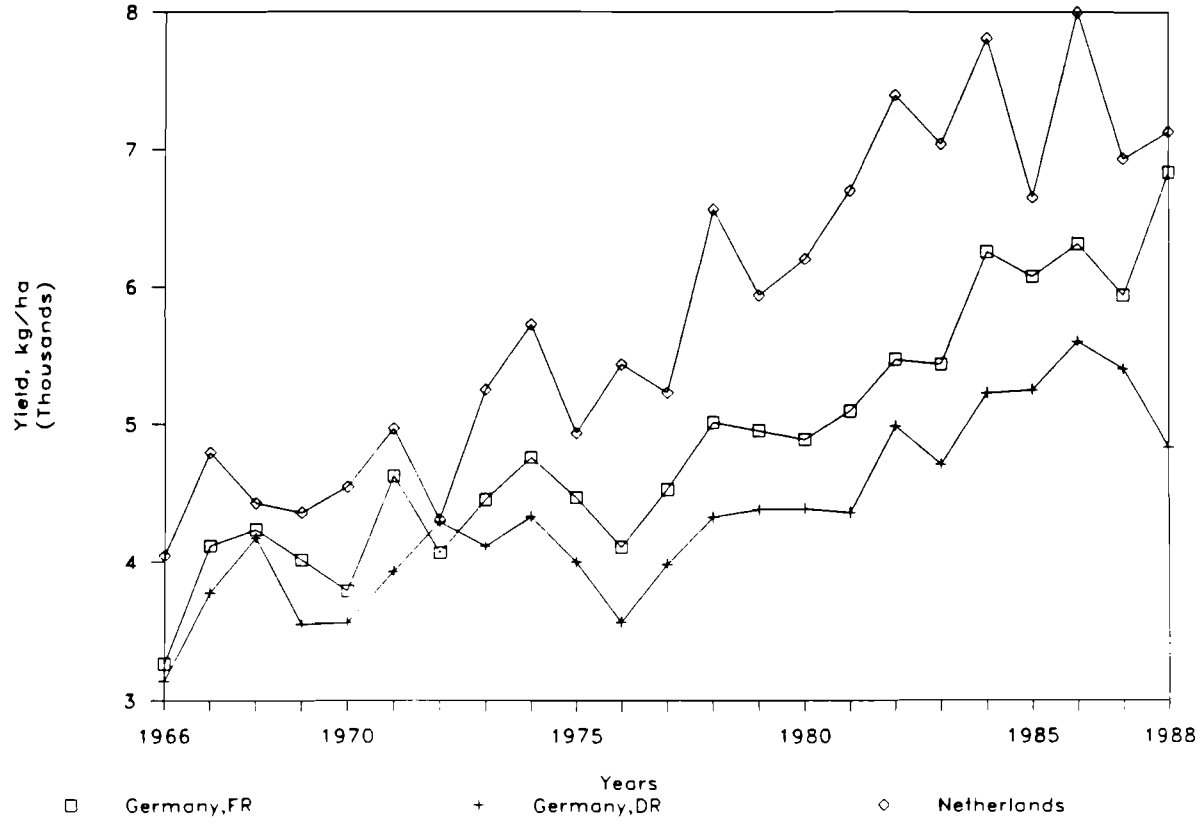

Fig.41a Pesticide production

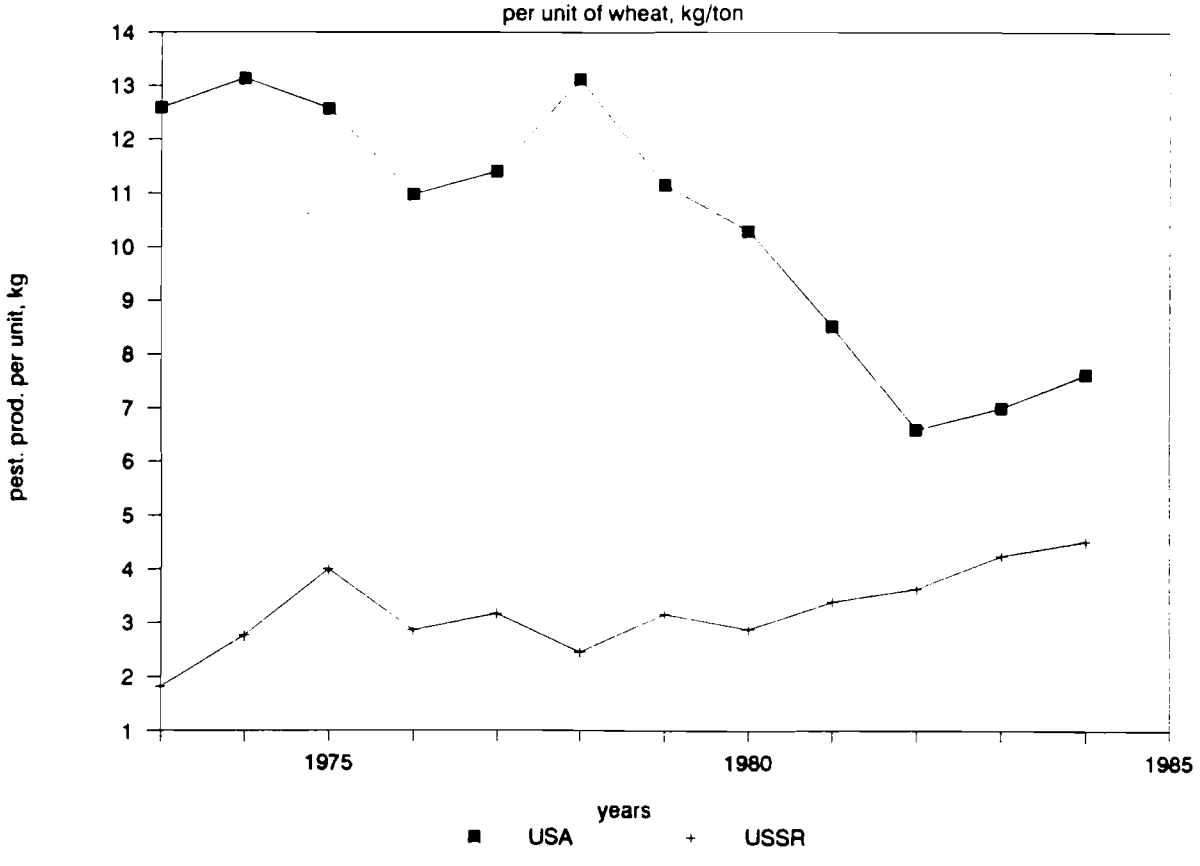

Fig.41b Wheat production, mln.tons

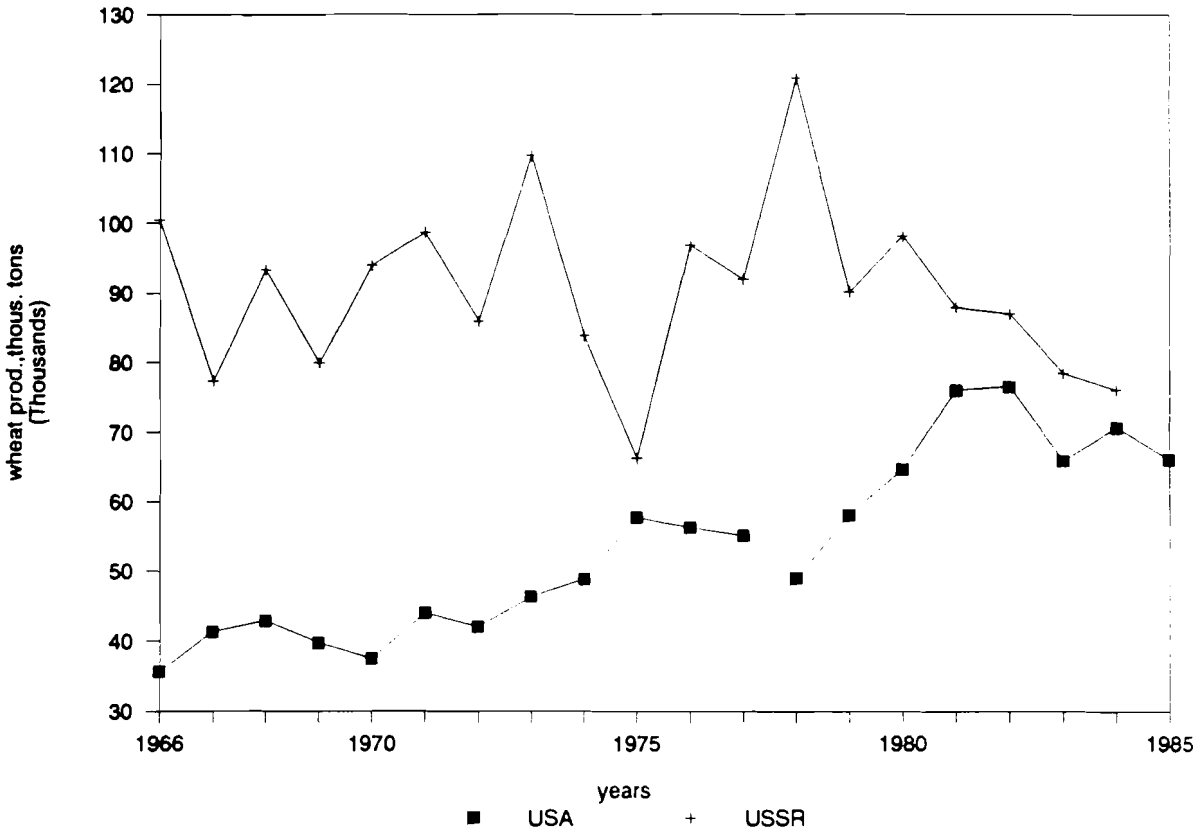

Fig.41c Wheat yield, kg/ha

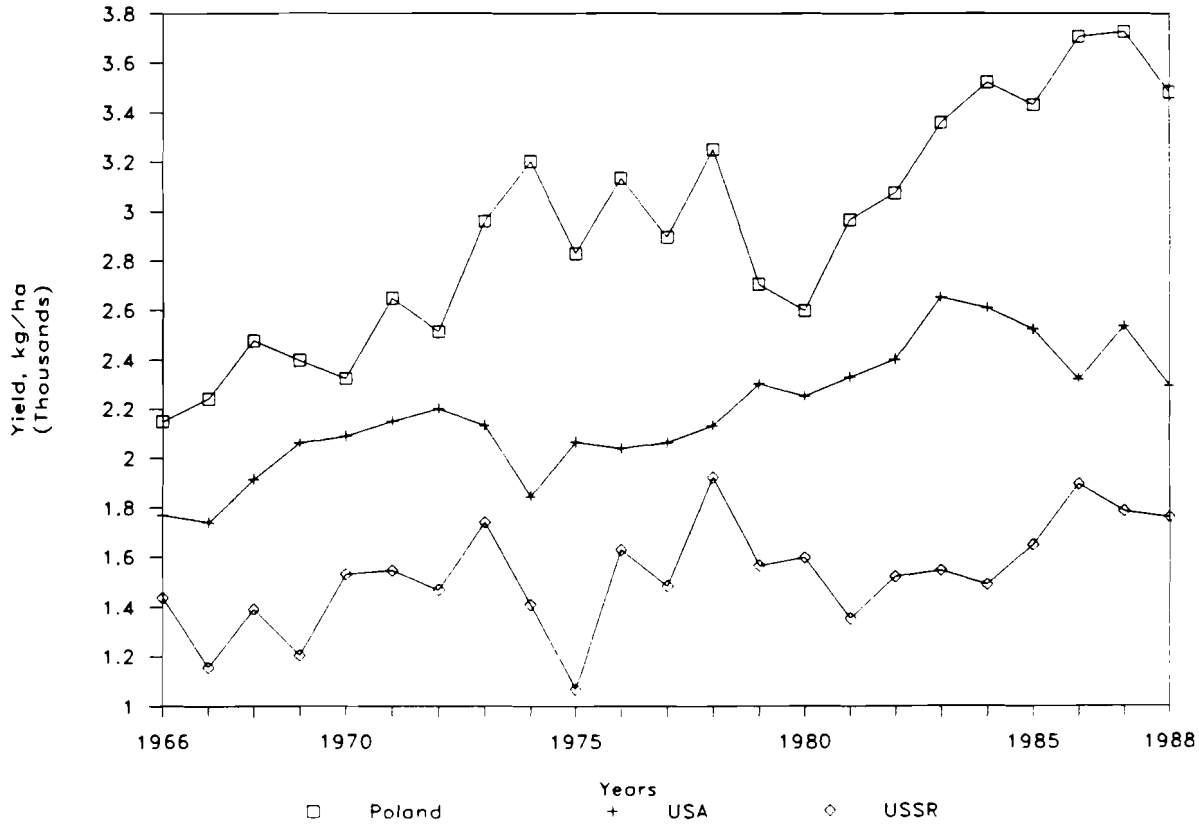

Fig.42a Pesticide production

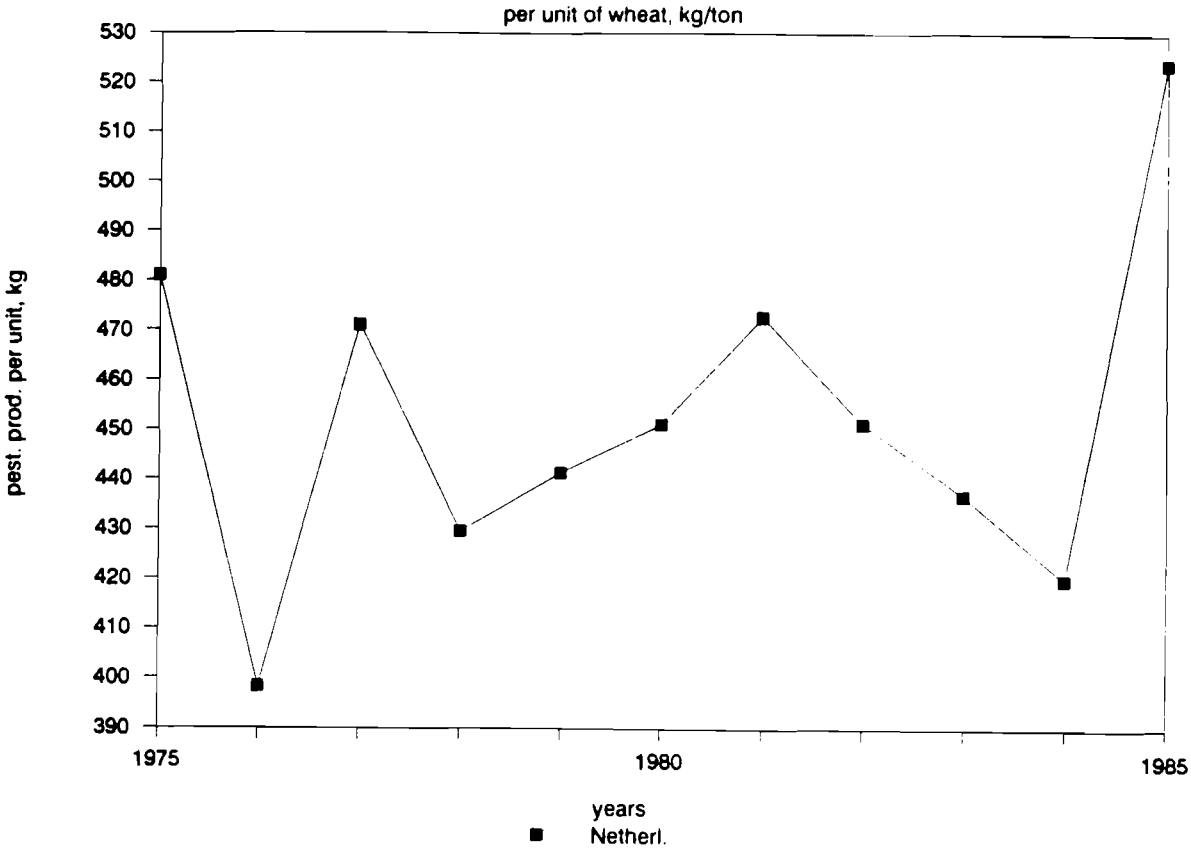

Fig.42b Wheat production, mln.tons

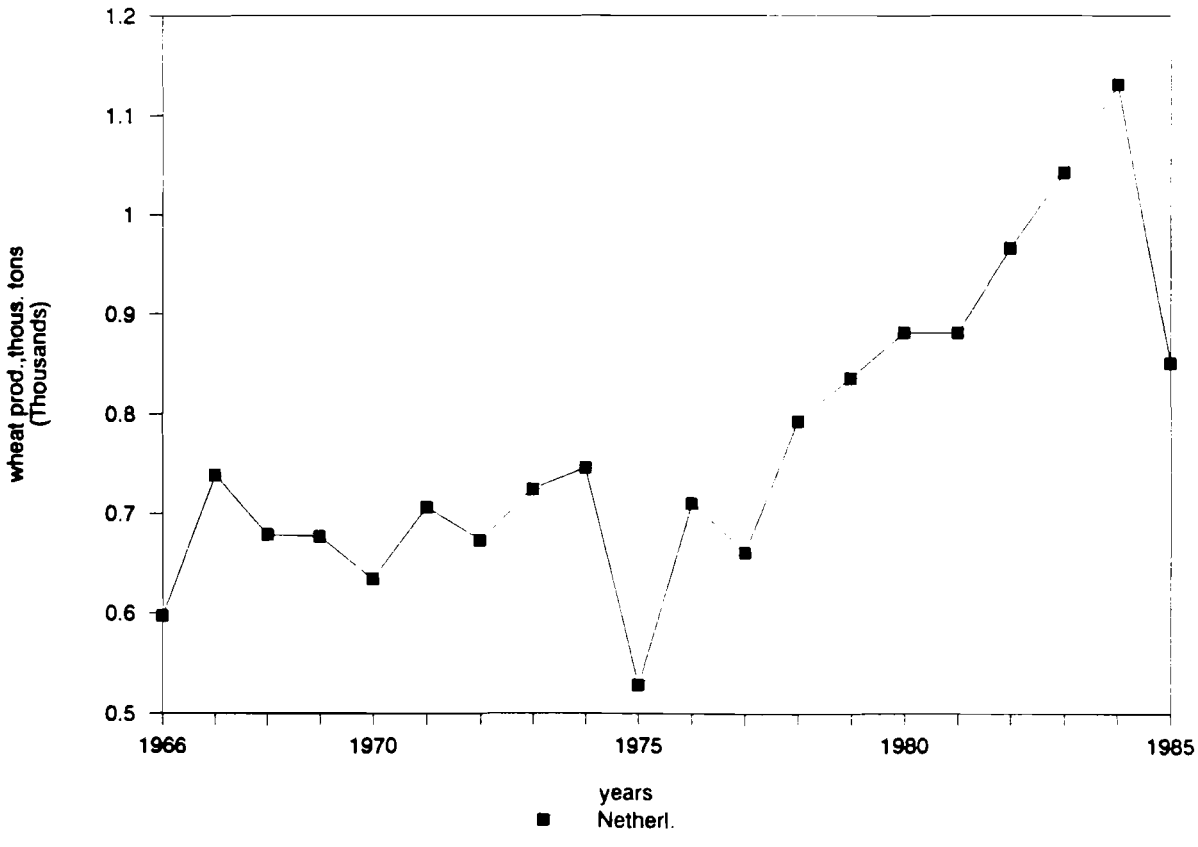

Fig.43a Pesticide production

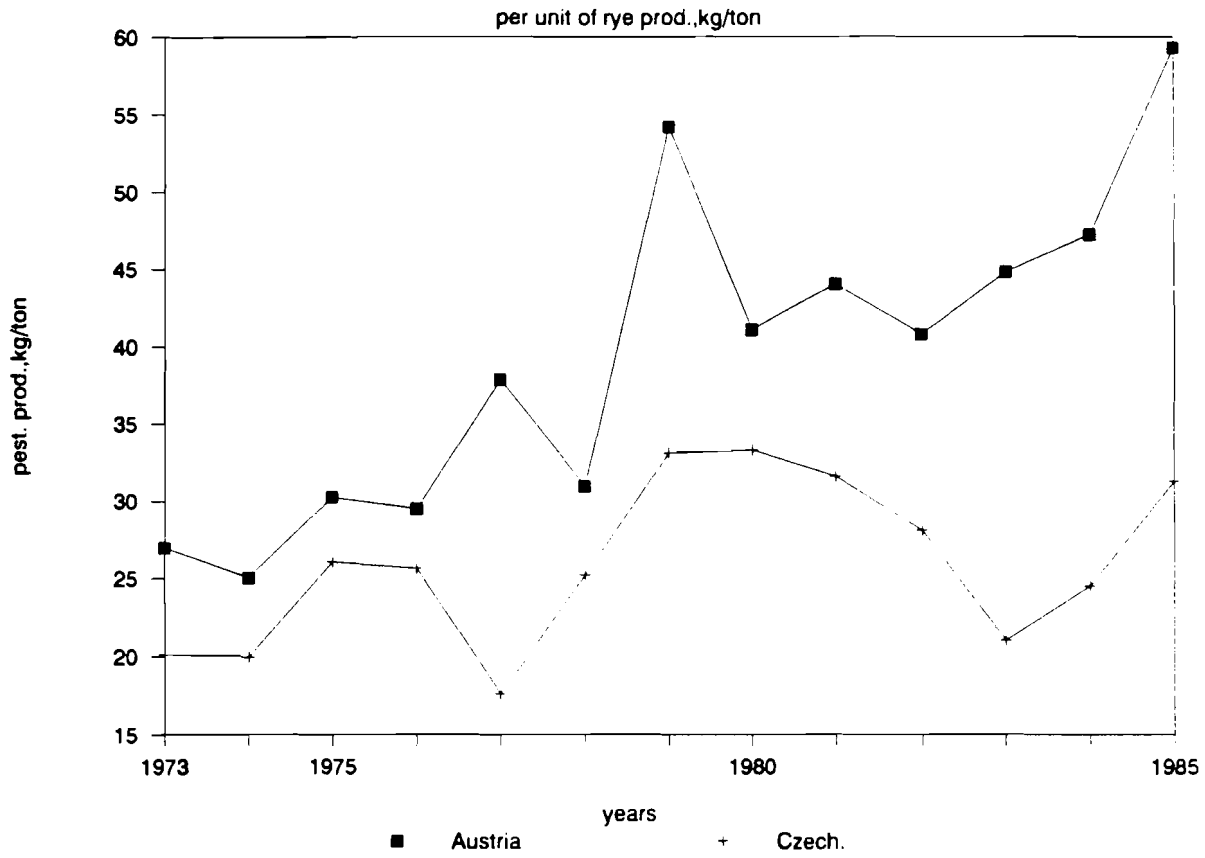

Fig.43b Rye production, thous. tons

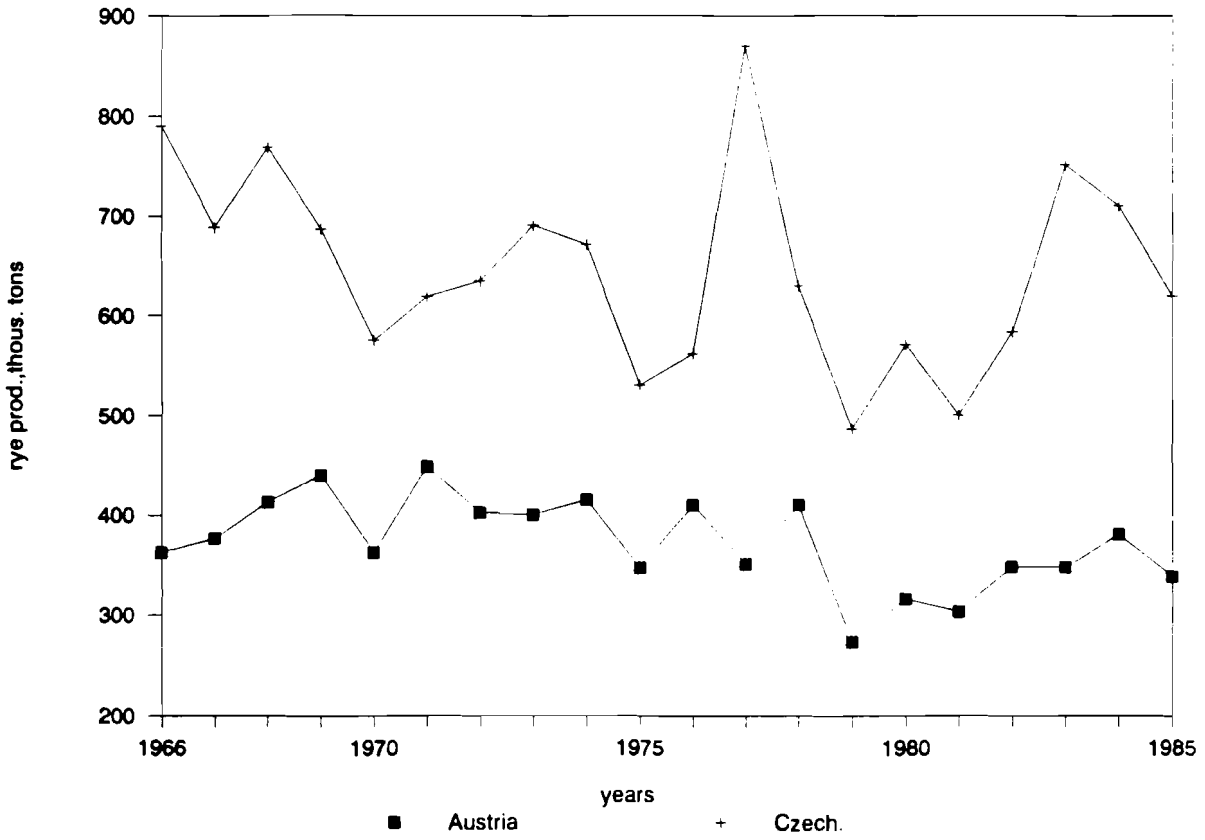

Fig.43c Rye yield, kg/ha

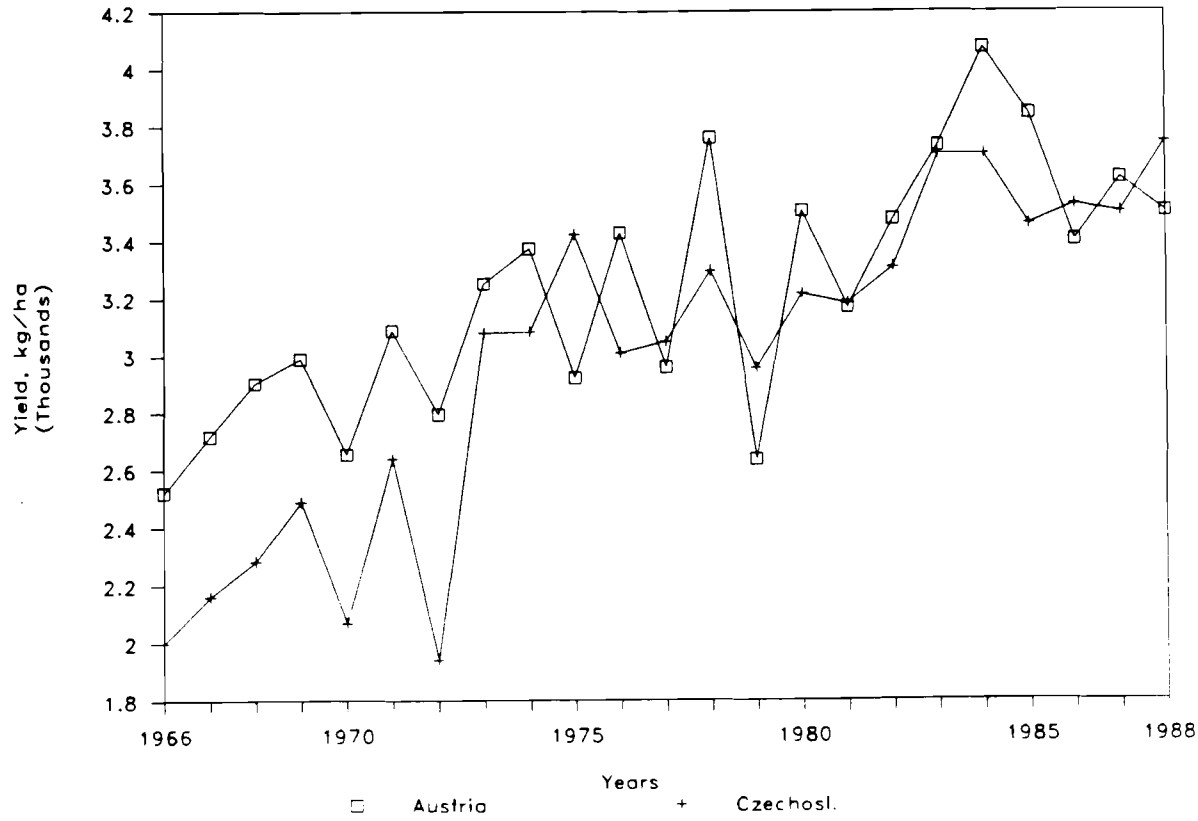

Fig.44a Pesticide production

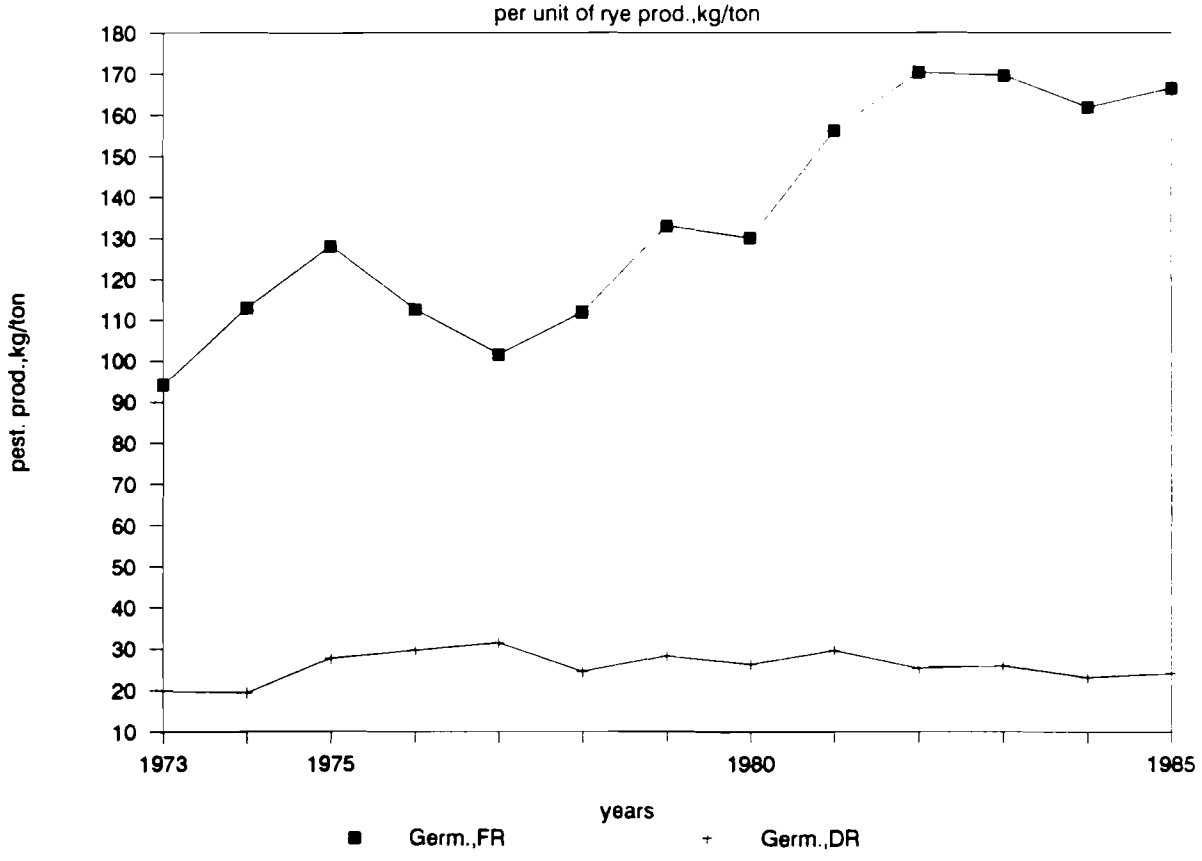

Fig.44b Rye production, thous. tons

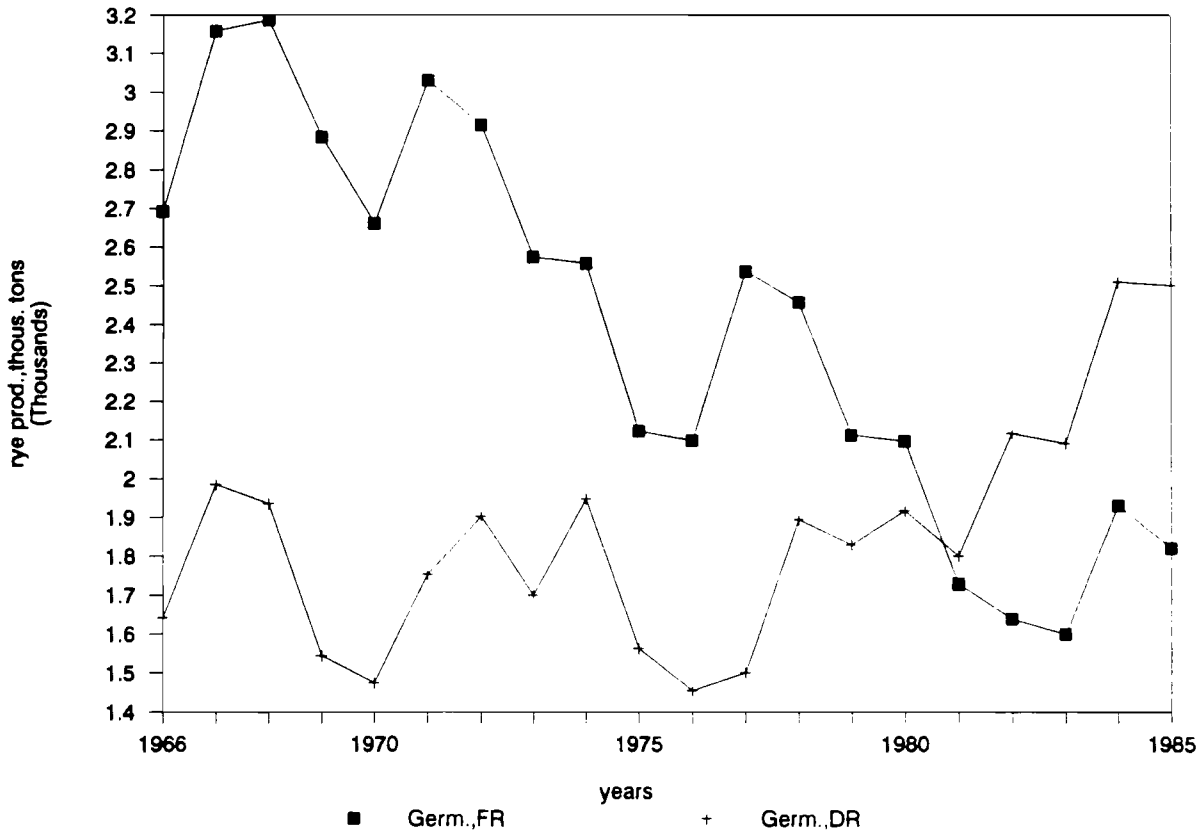

Fig.44c Rye yield, kg/ha

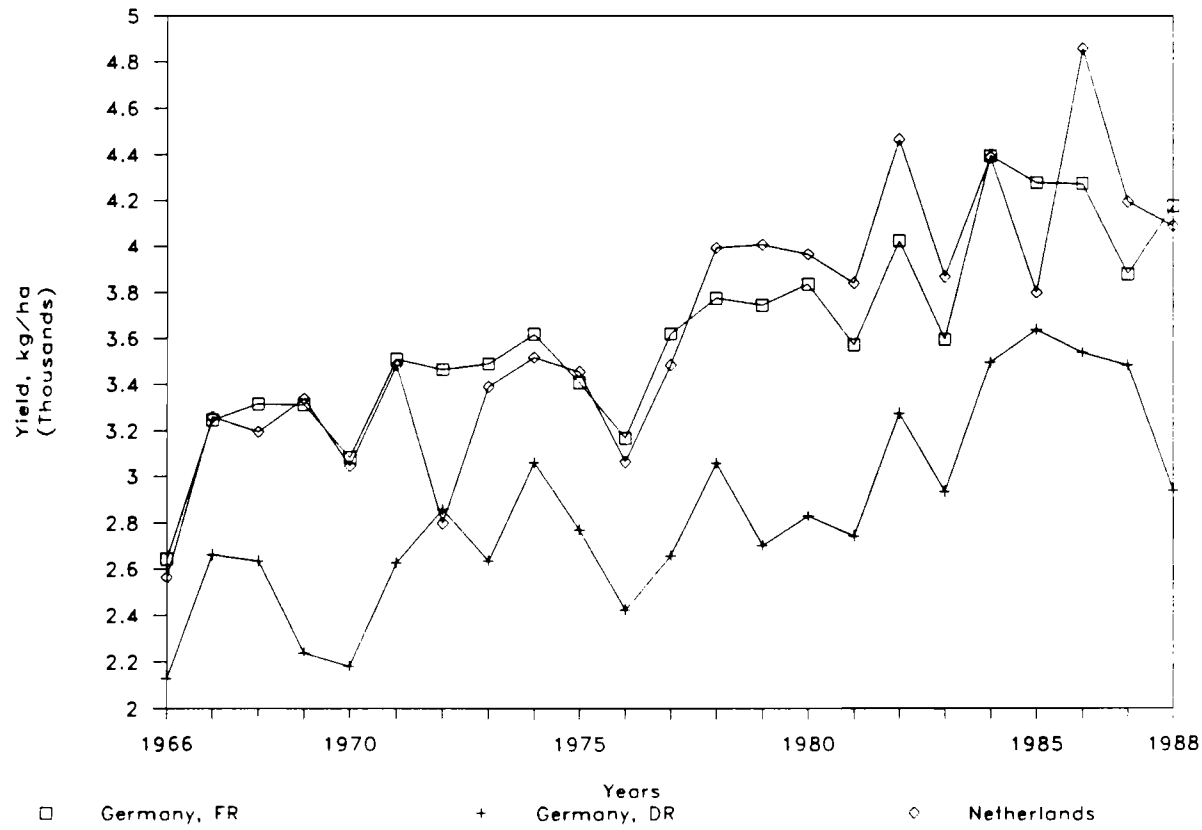

Fig.45a Pesticide production

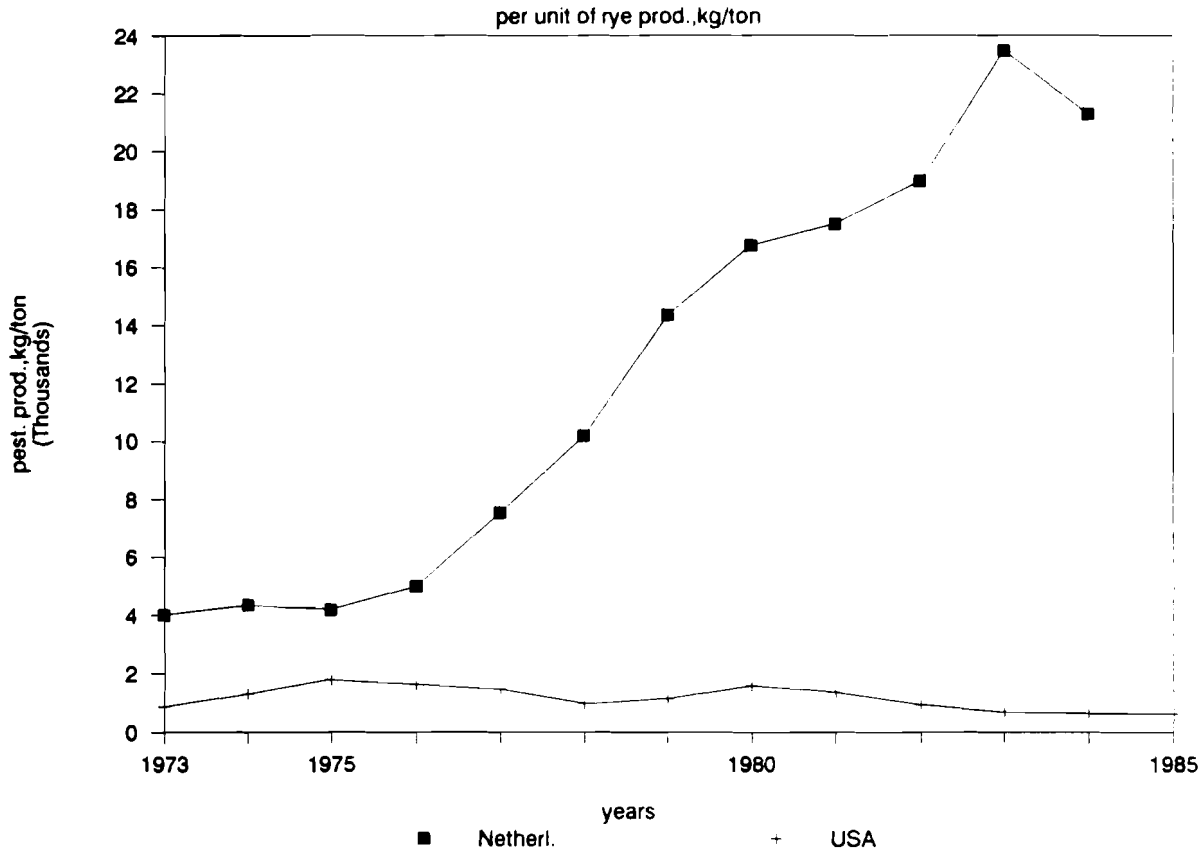

Fig.45b Rye production, mln.tons

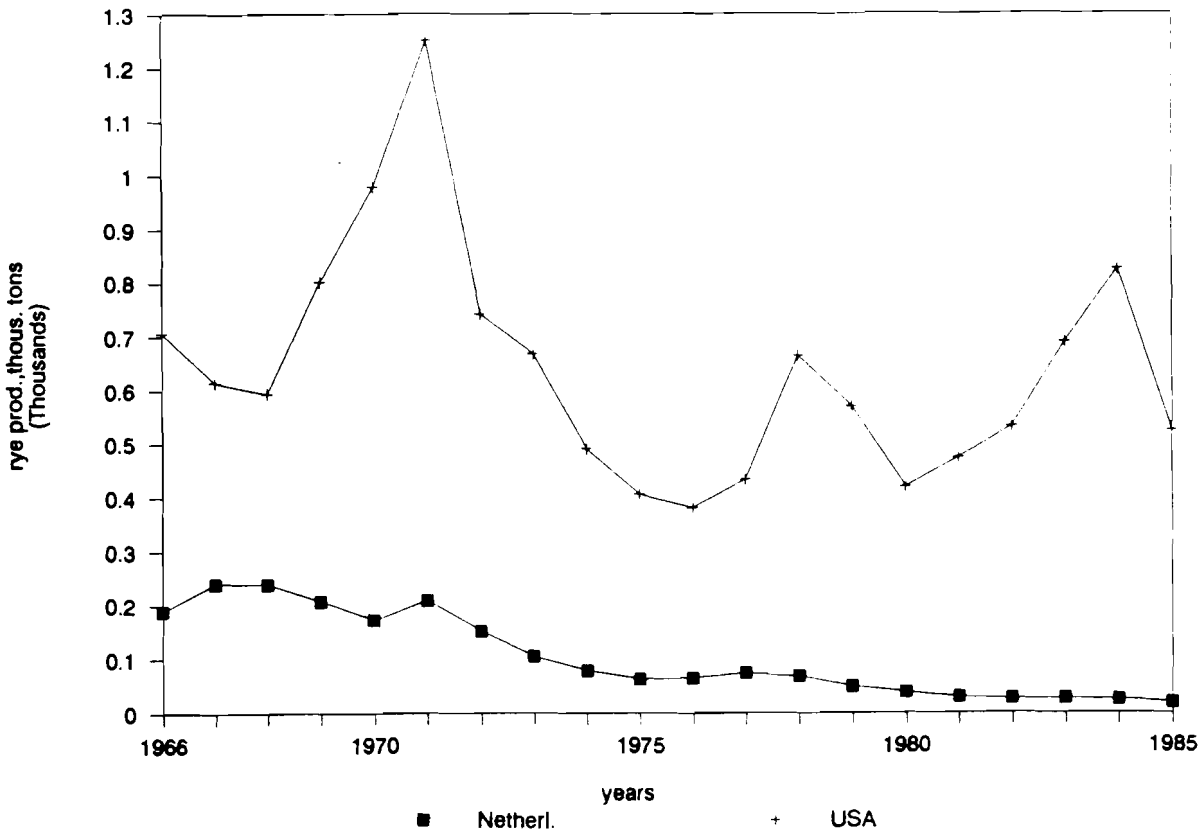

Fig.46a Pesticide production

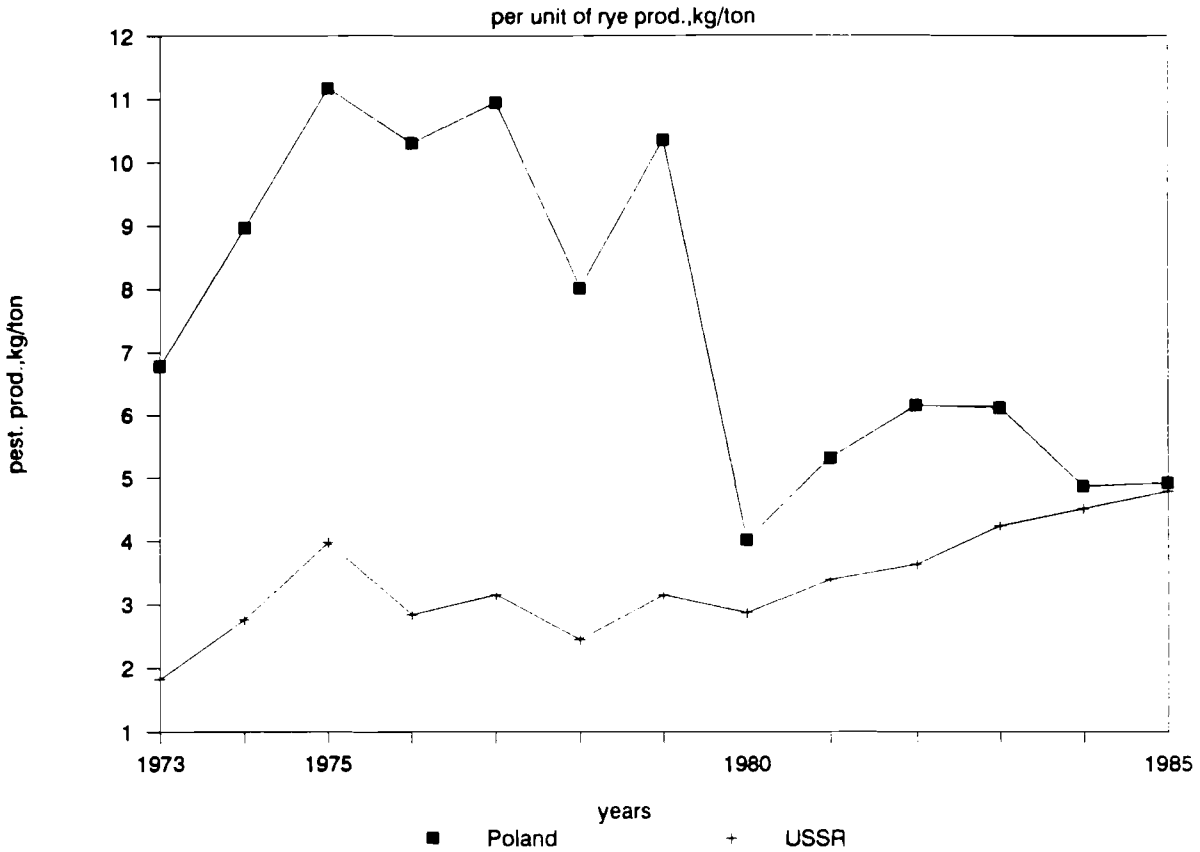

Fig.46b Rye production, mln.tons

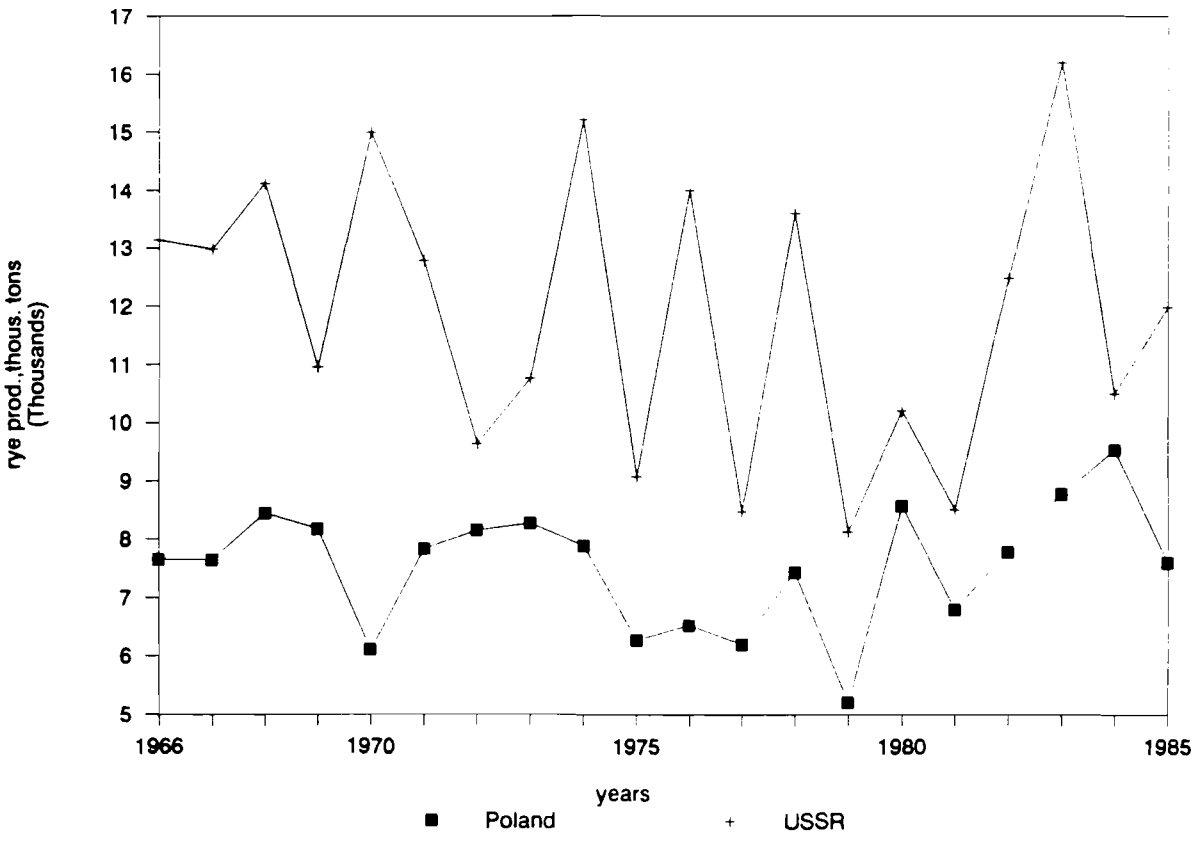

Fig.46c Rye yield. kg/ha

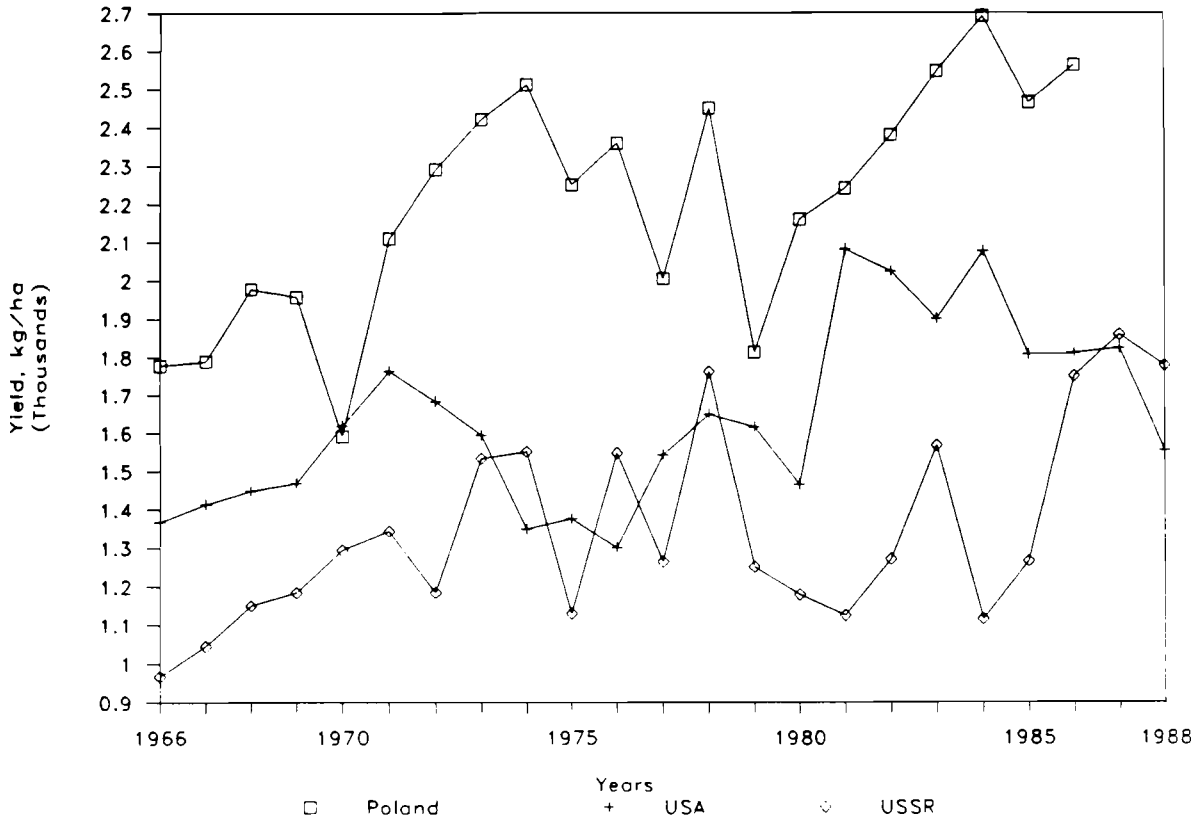

Fig.47a Production of Pesticides

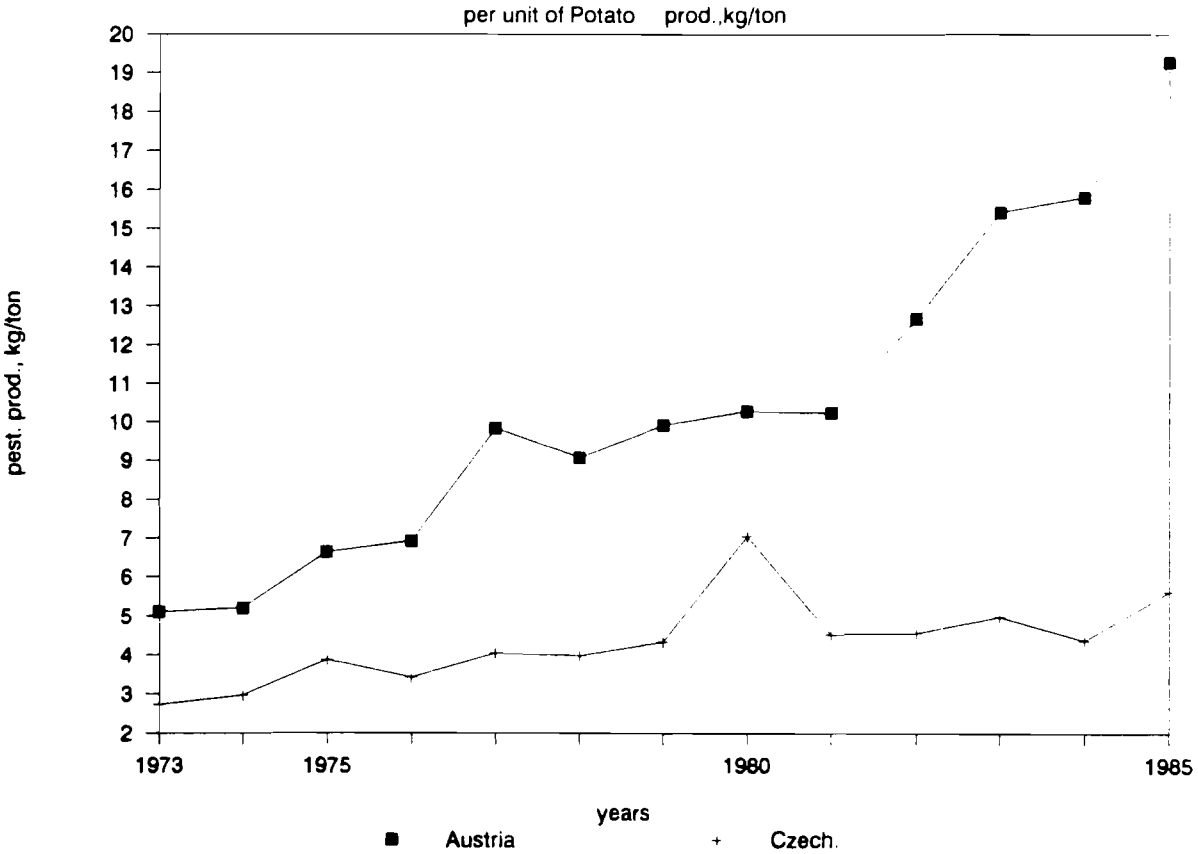

Fig.47b Potato Production

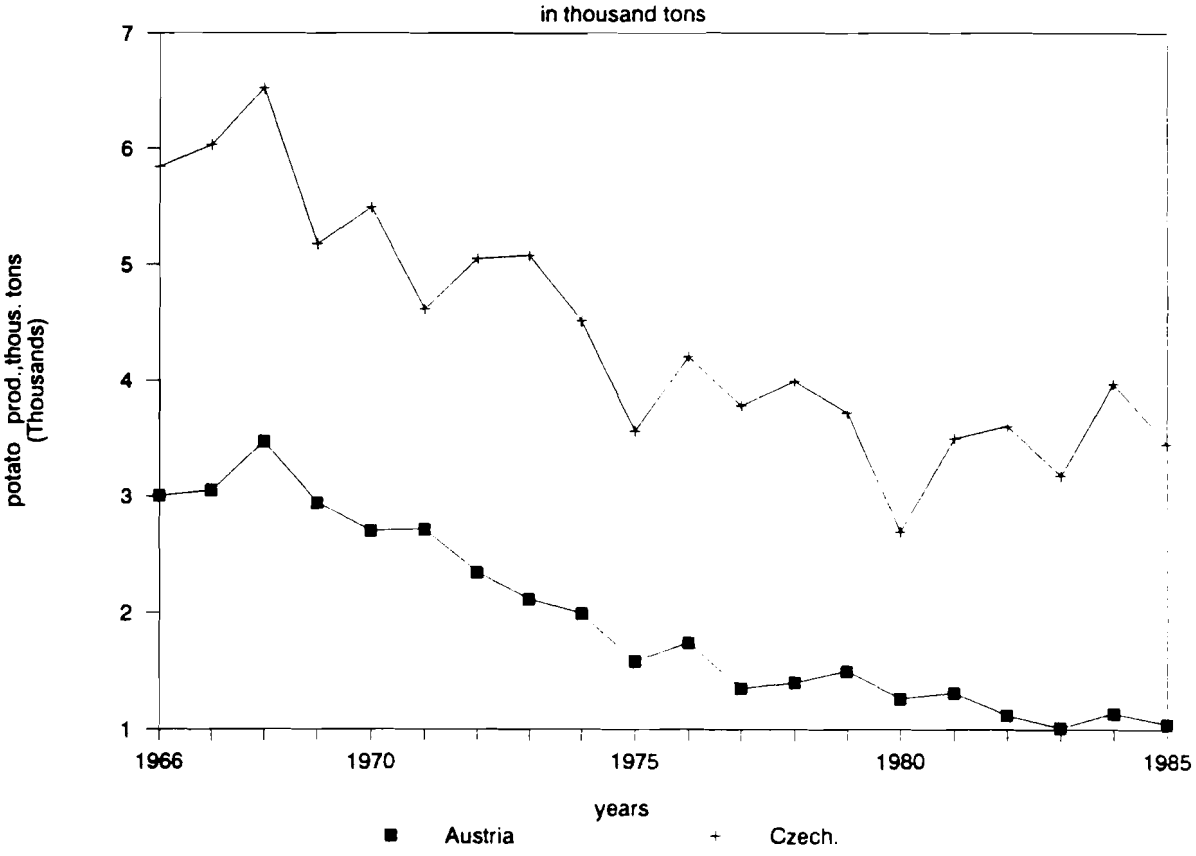

Fig.47c Potato yield. kg/ha

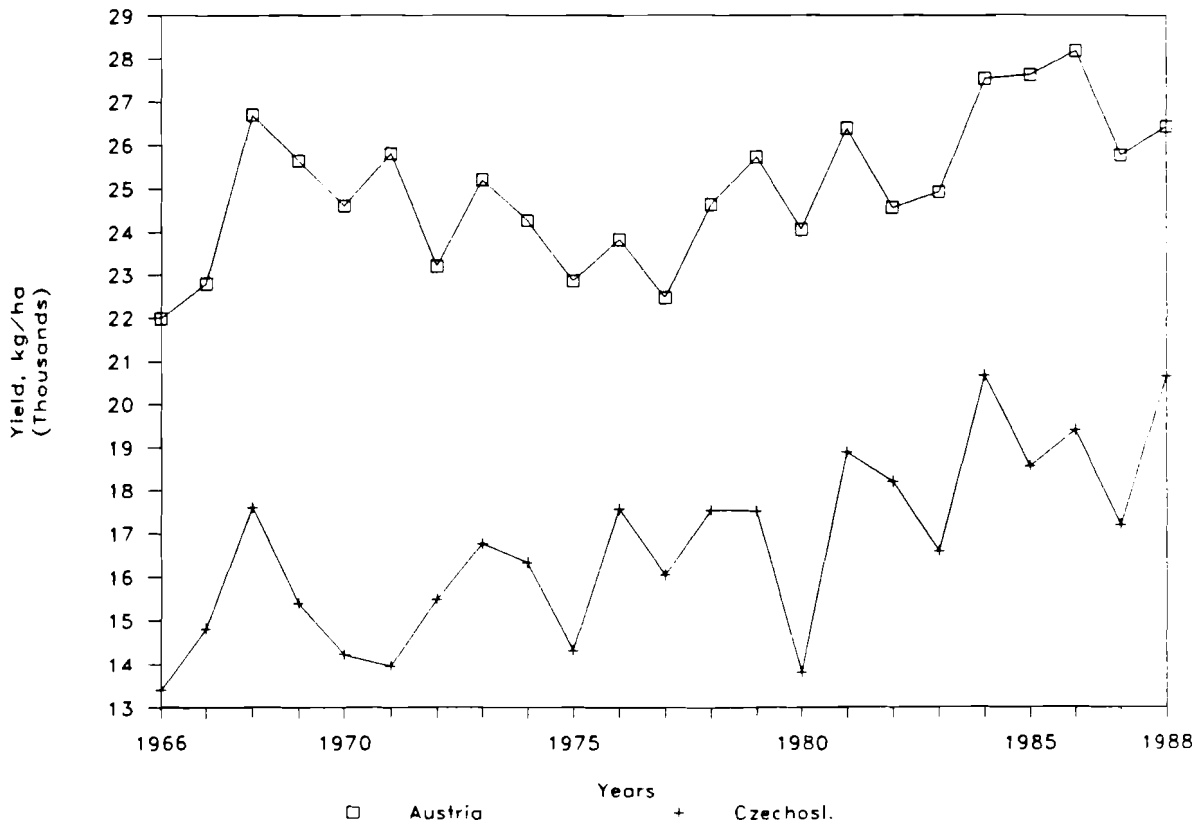

Fig.48a Production of Pesticides

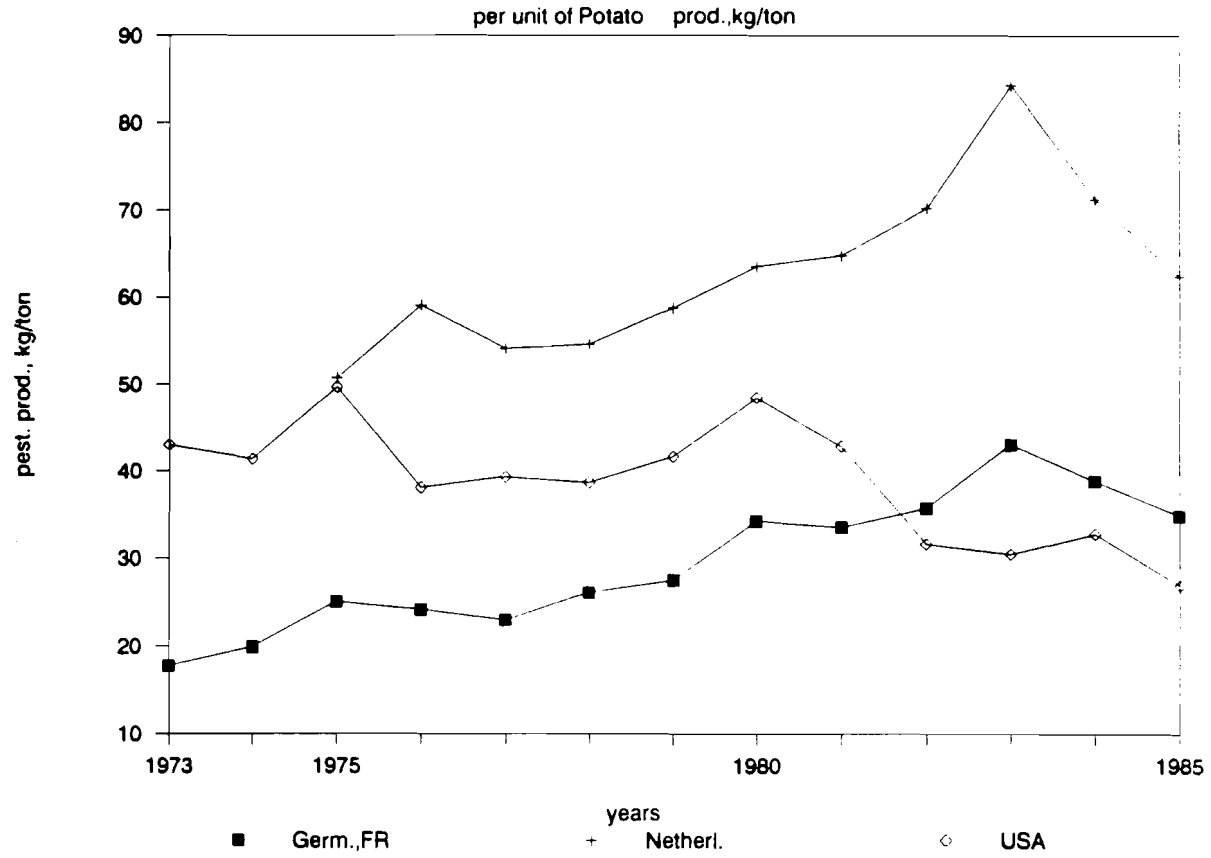

Fig.48b Potato Production

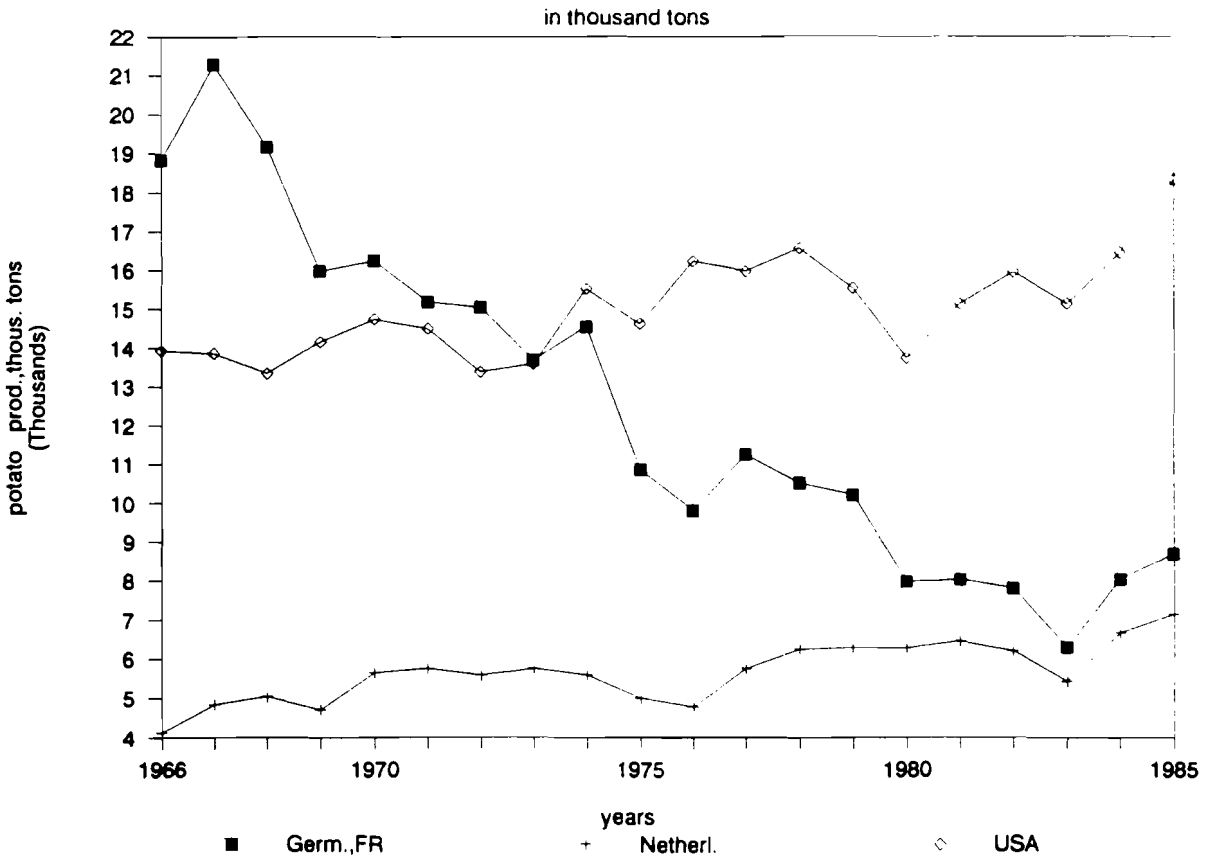

Fig.48c Potato yield, kg/ha

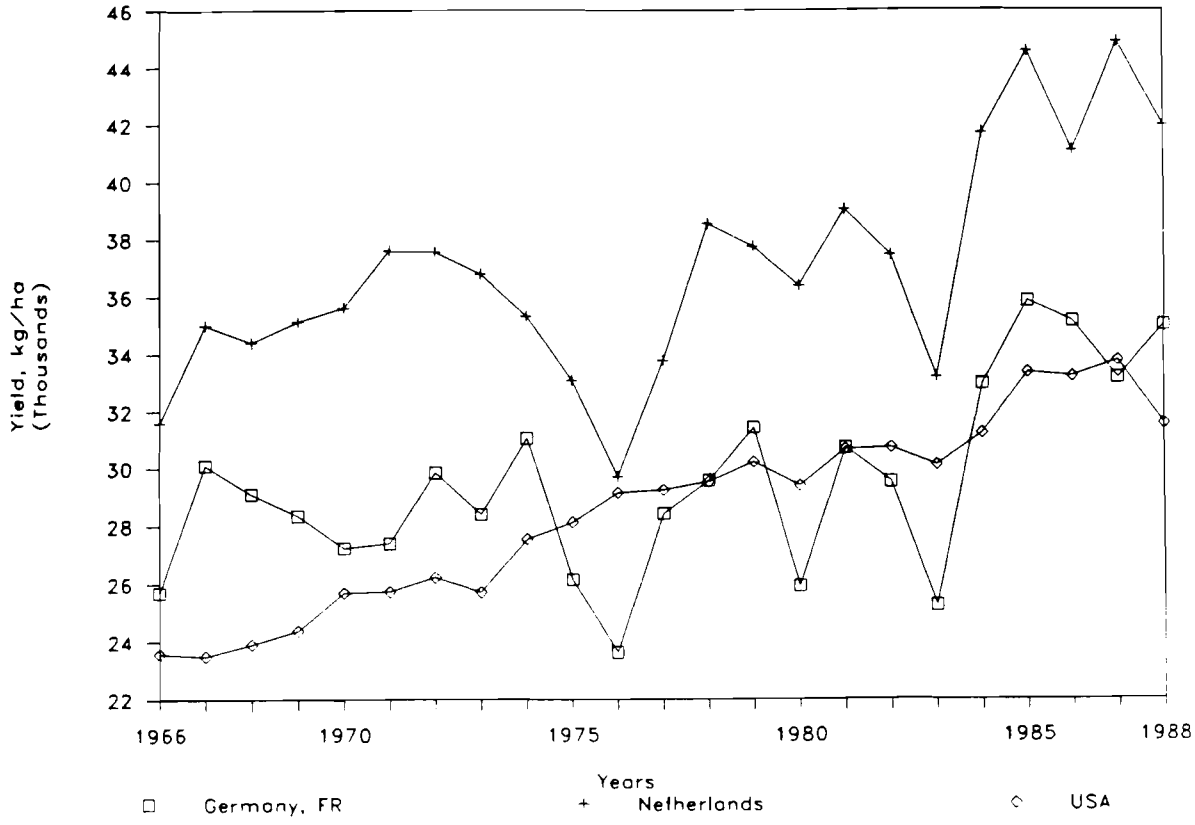

Fig.49a Production of Pesticides

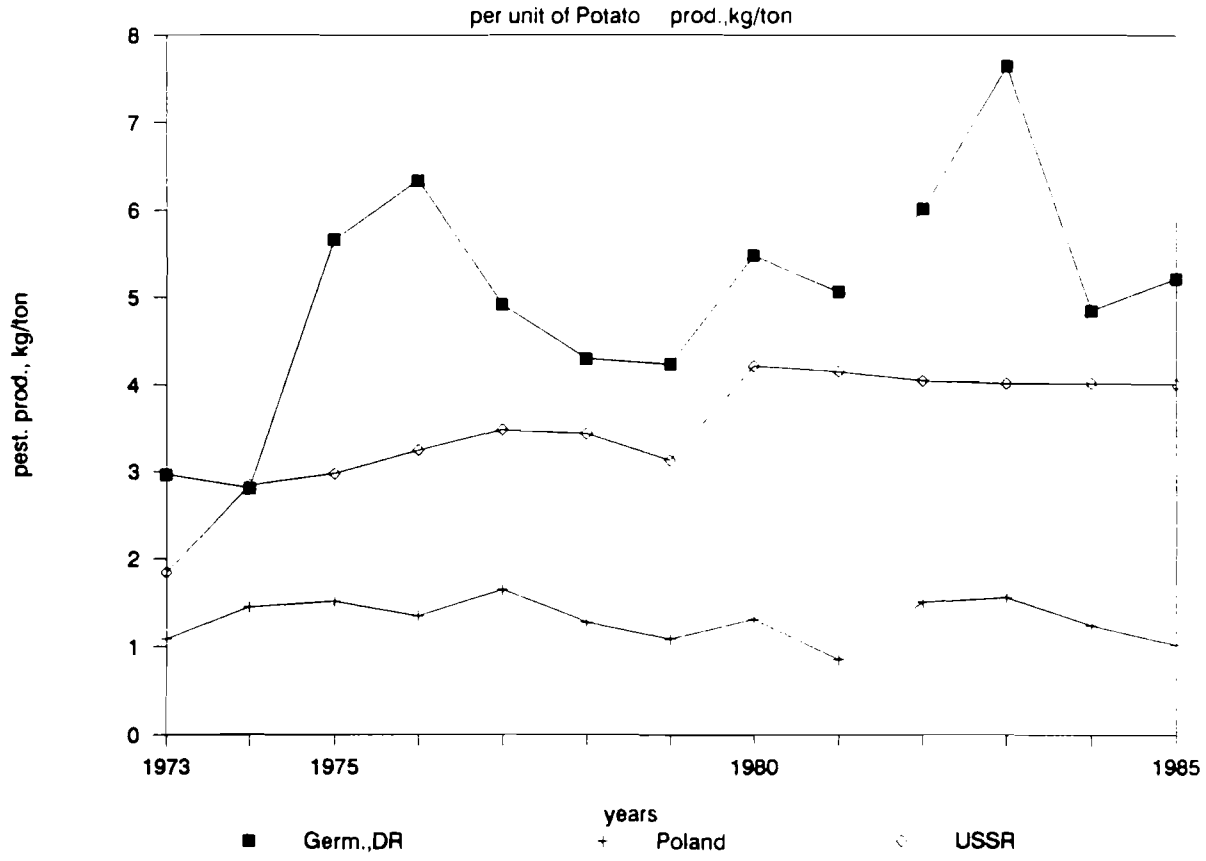

Fig.49b Potato Production

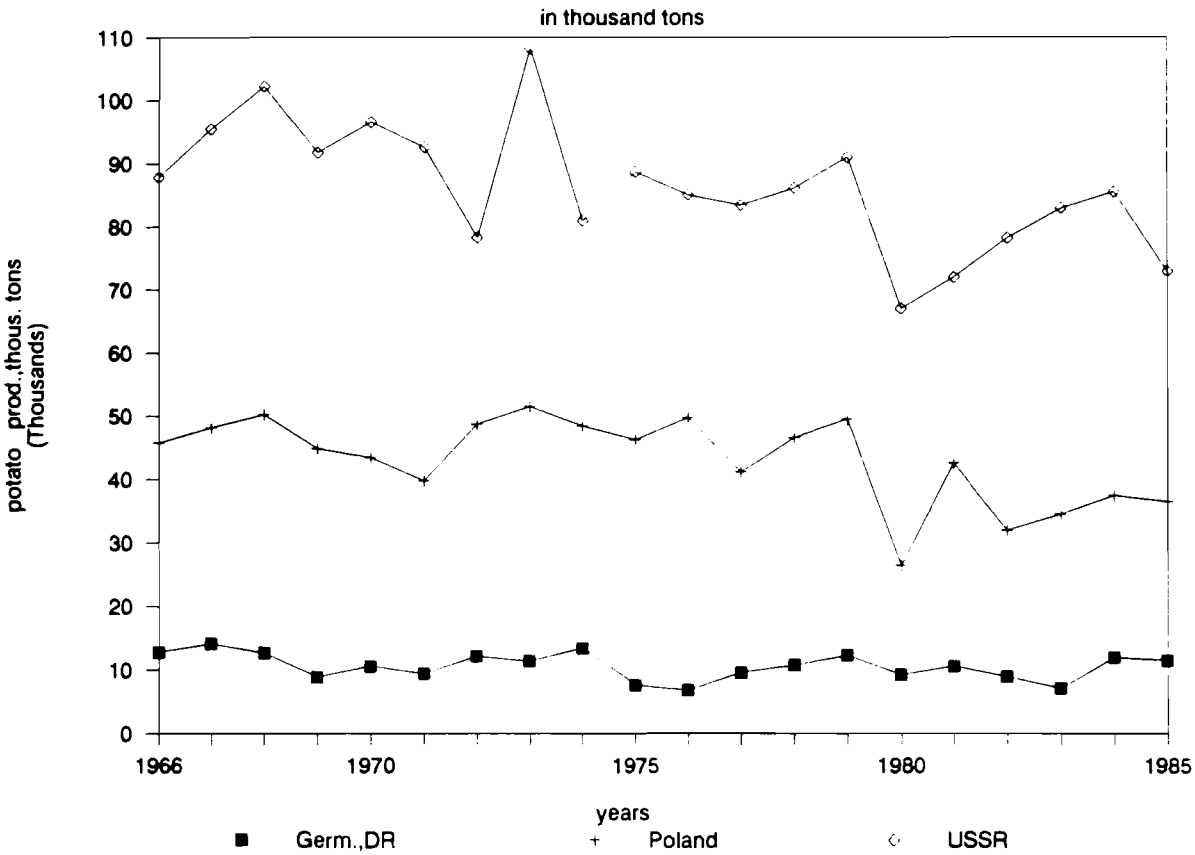

Fig.49c Potato Yield, kg/ha

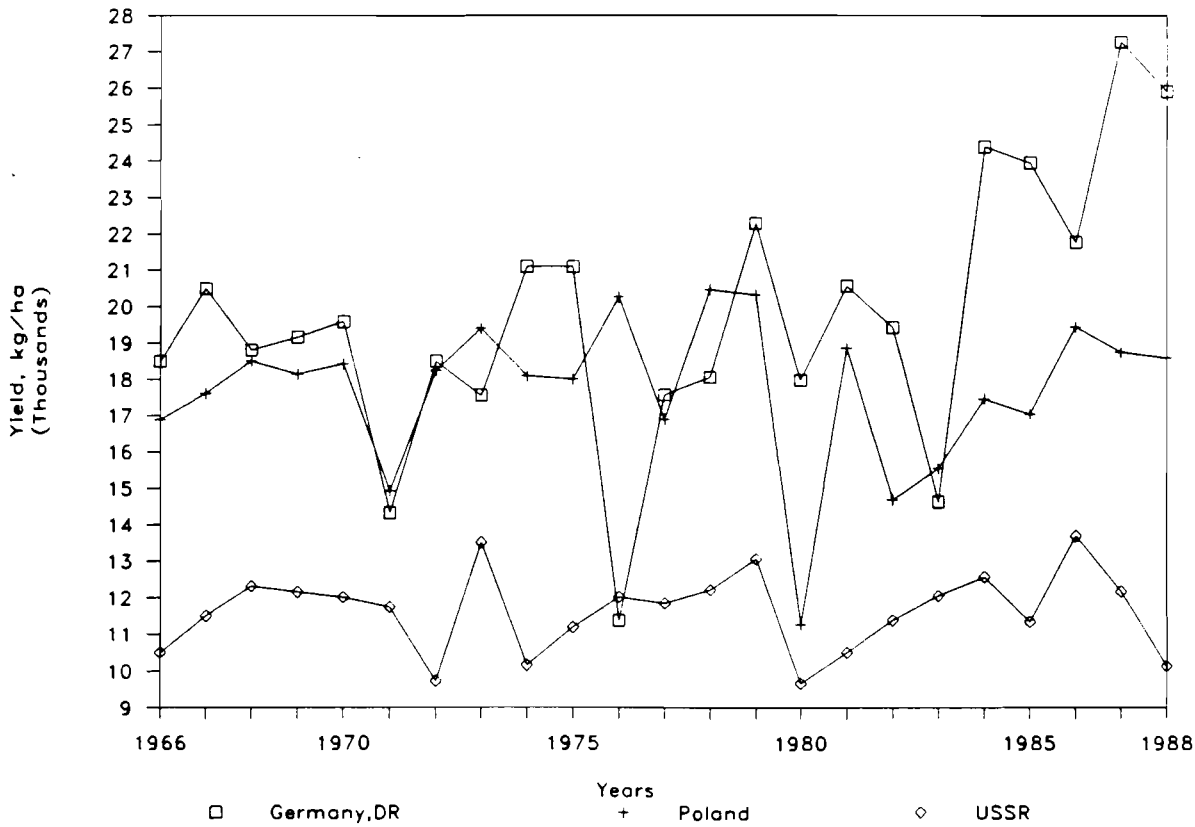

Fig.50a Pesticides Production

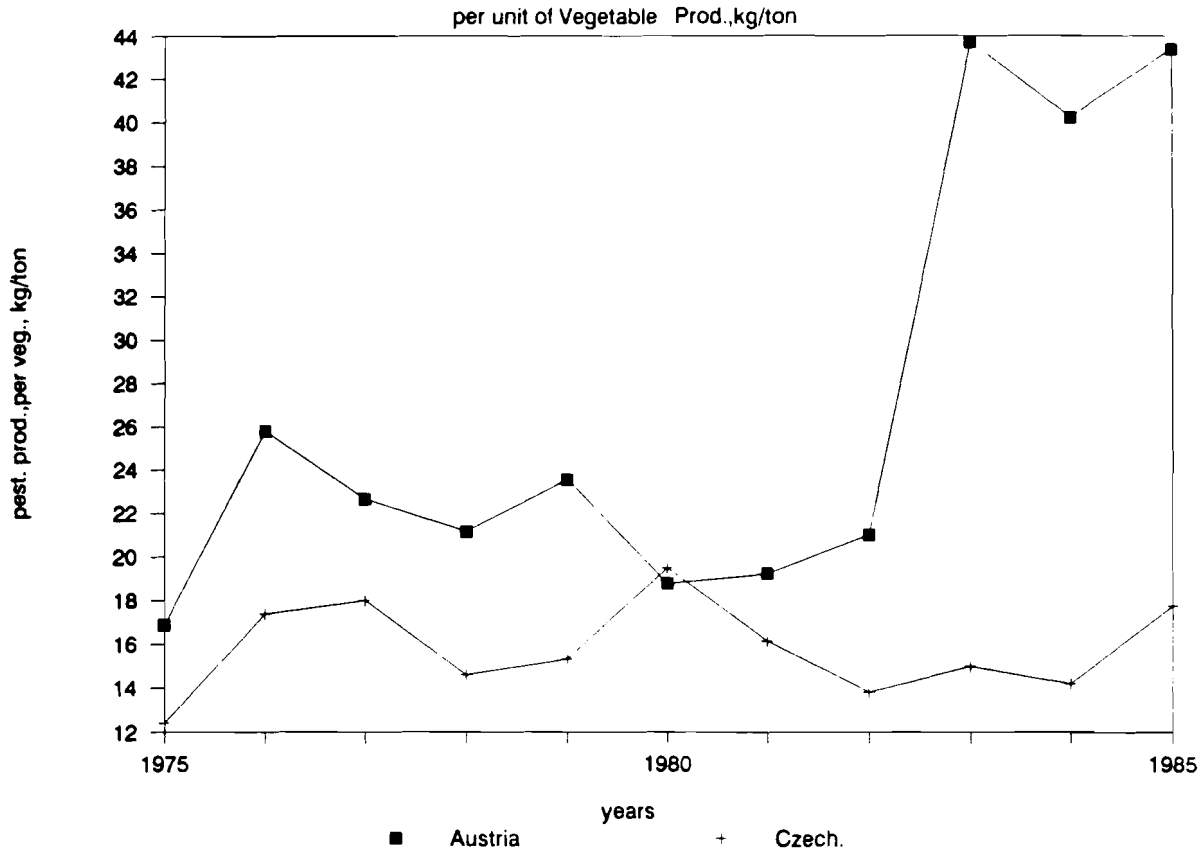

Fig.50b Vegetable Production

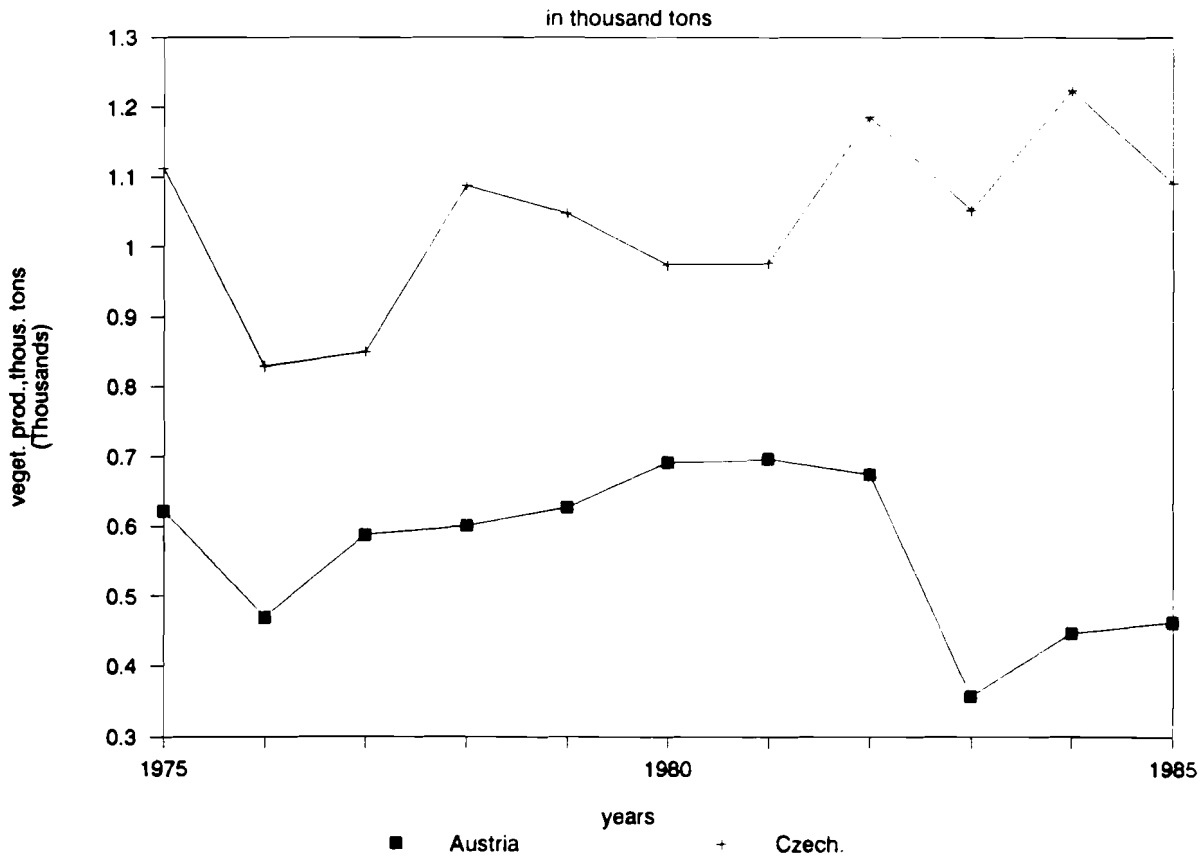

Fig.51a Pesticides Production

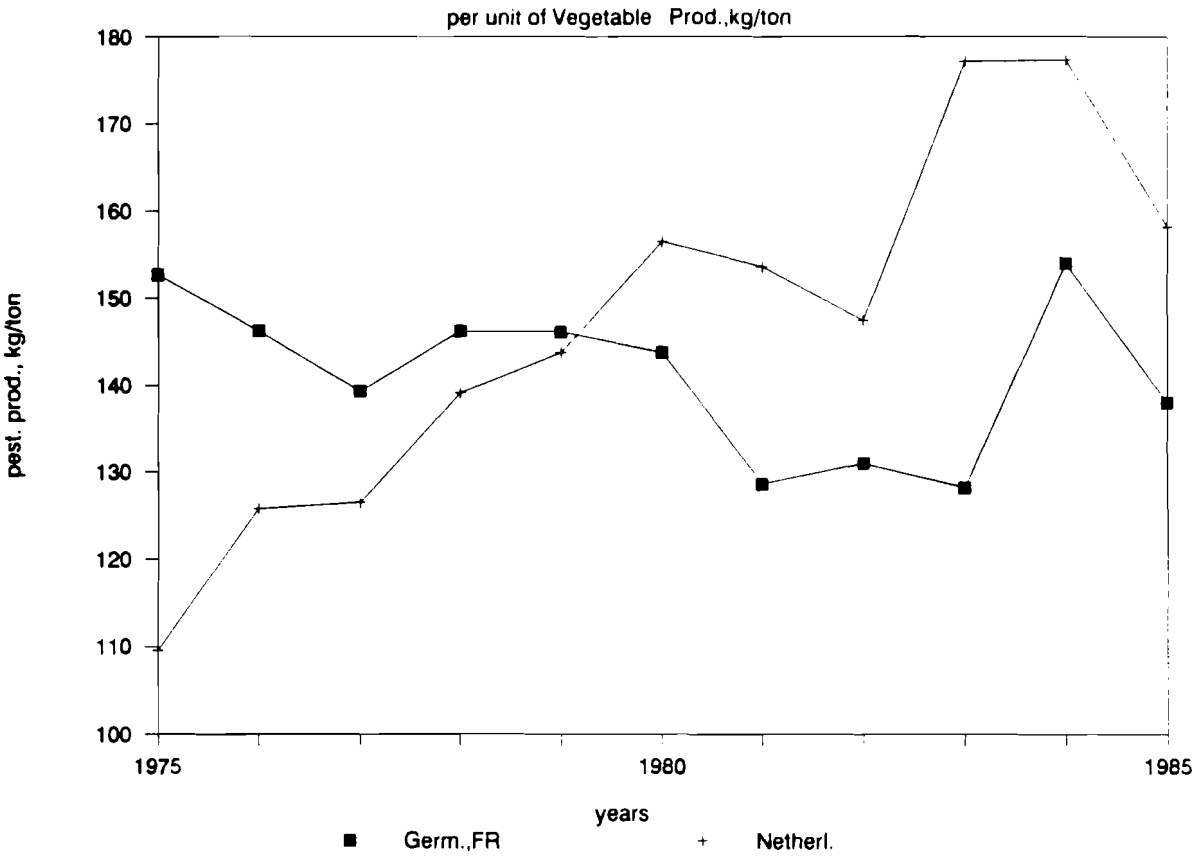

Fig.51b Vegetable Production

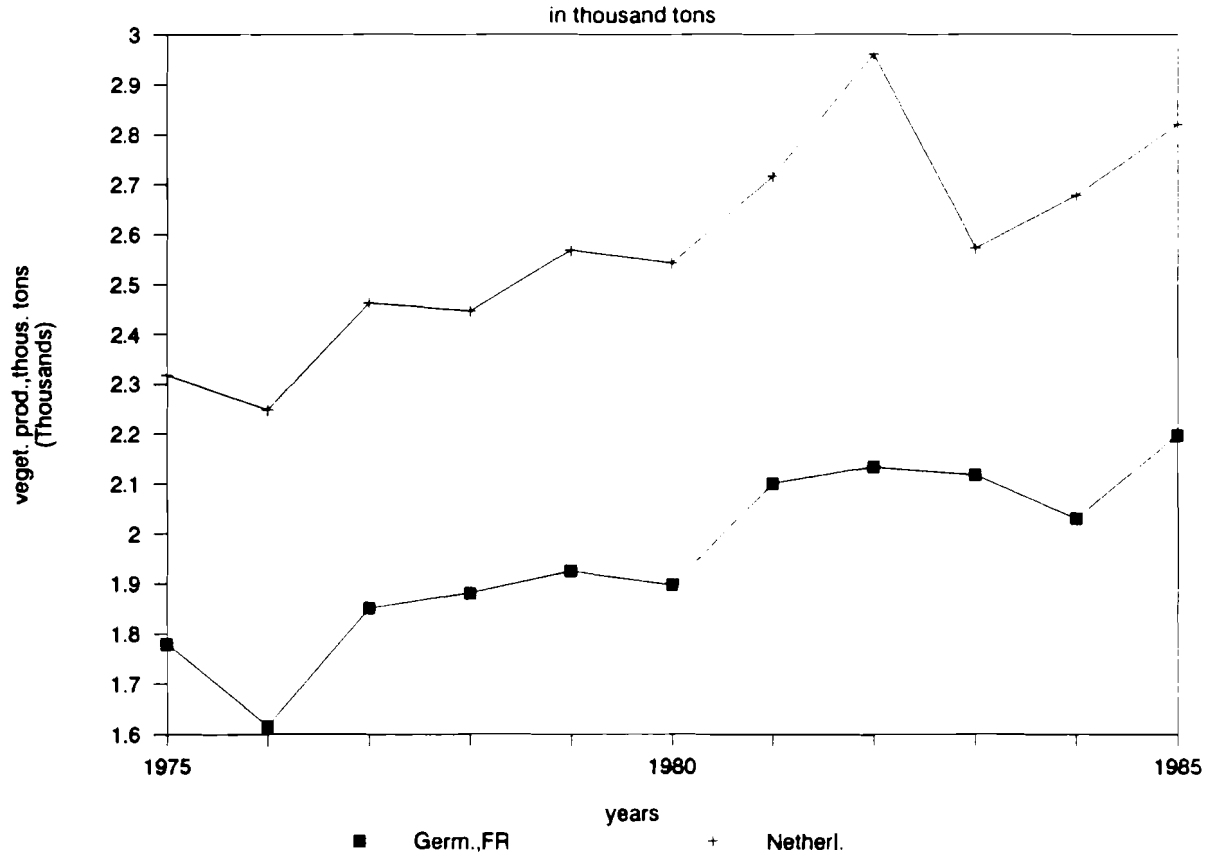

Fig.52a Pesticides Production

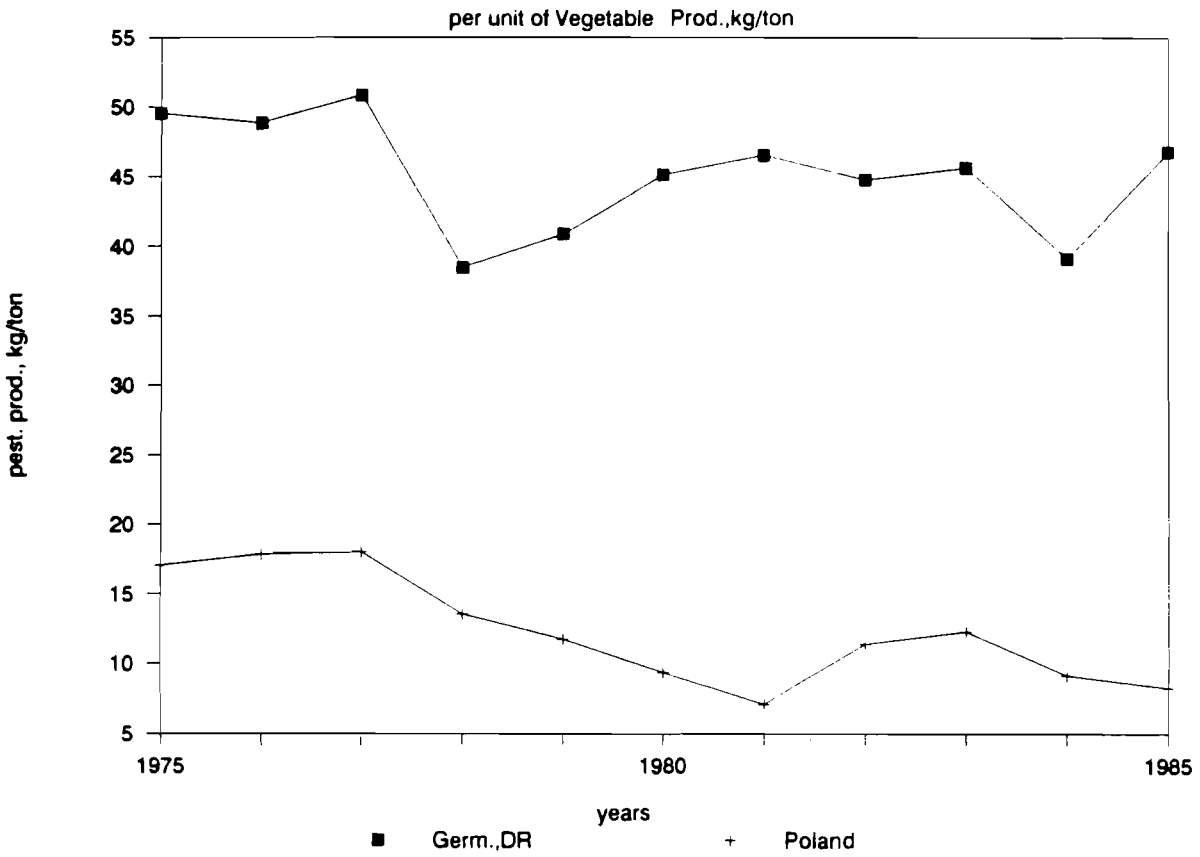

Fig.52b Vegetable Production

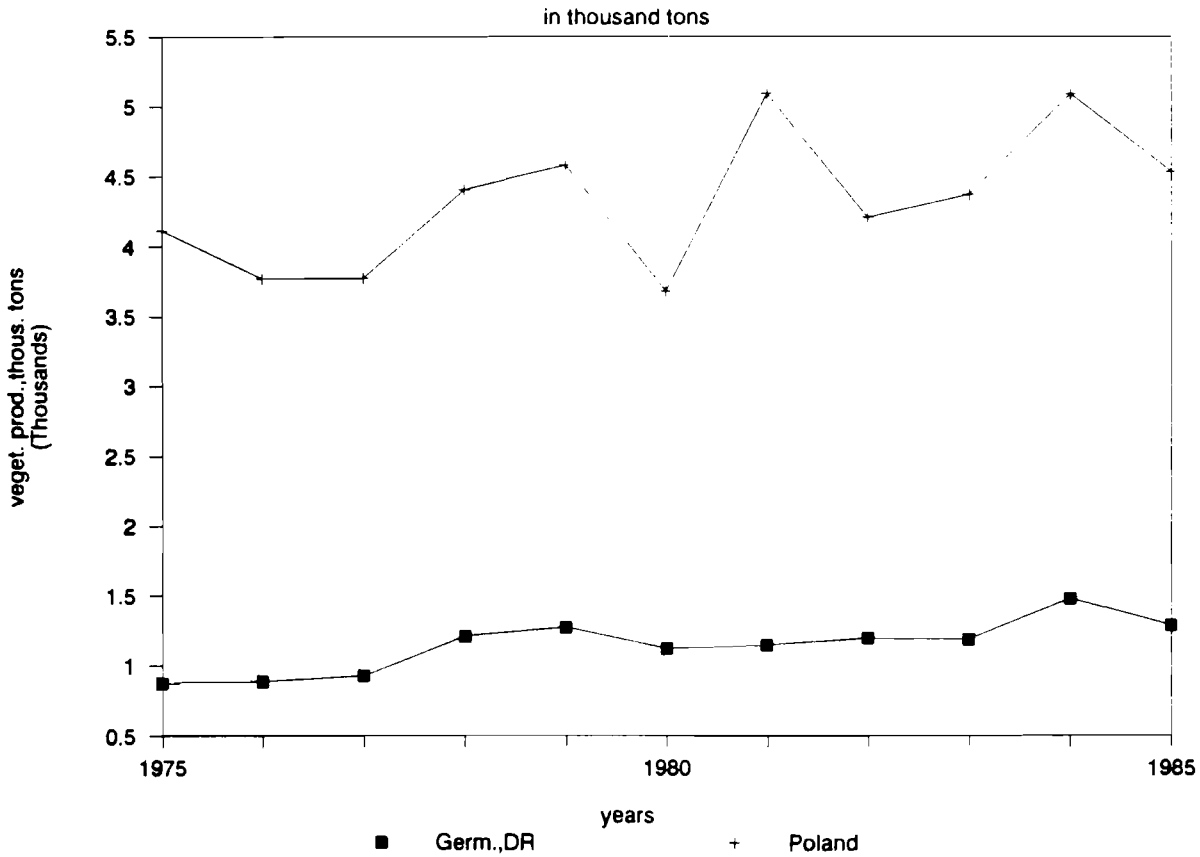

Fig.53a Pesticides Production

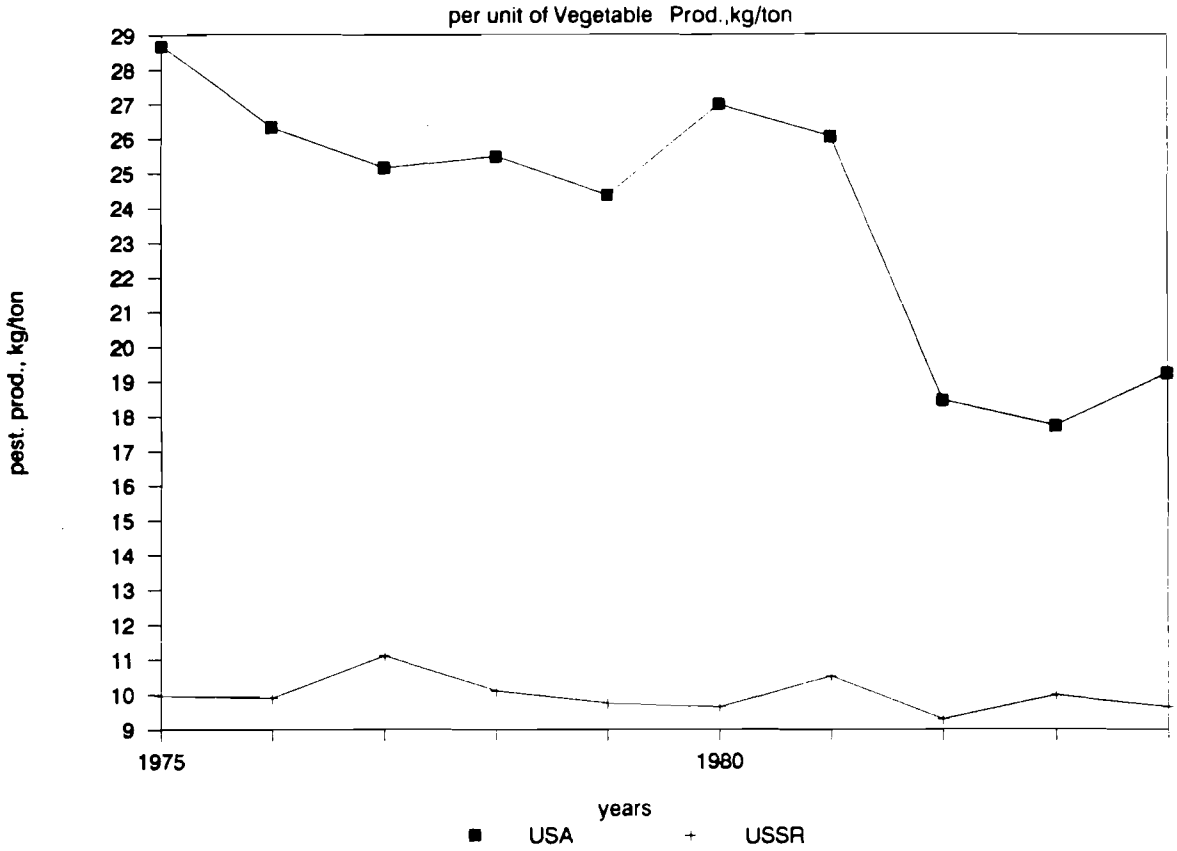

Fig.53b Vegetable Production

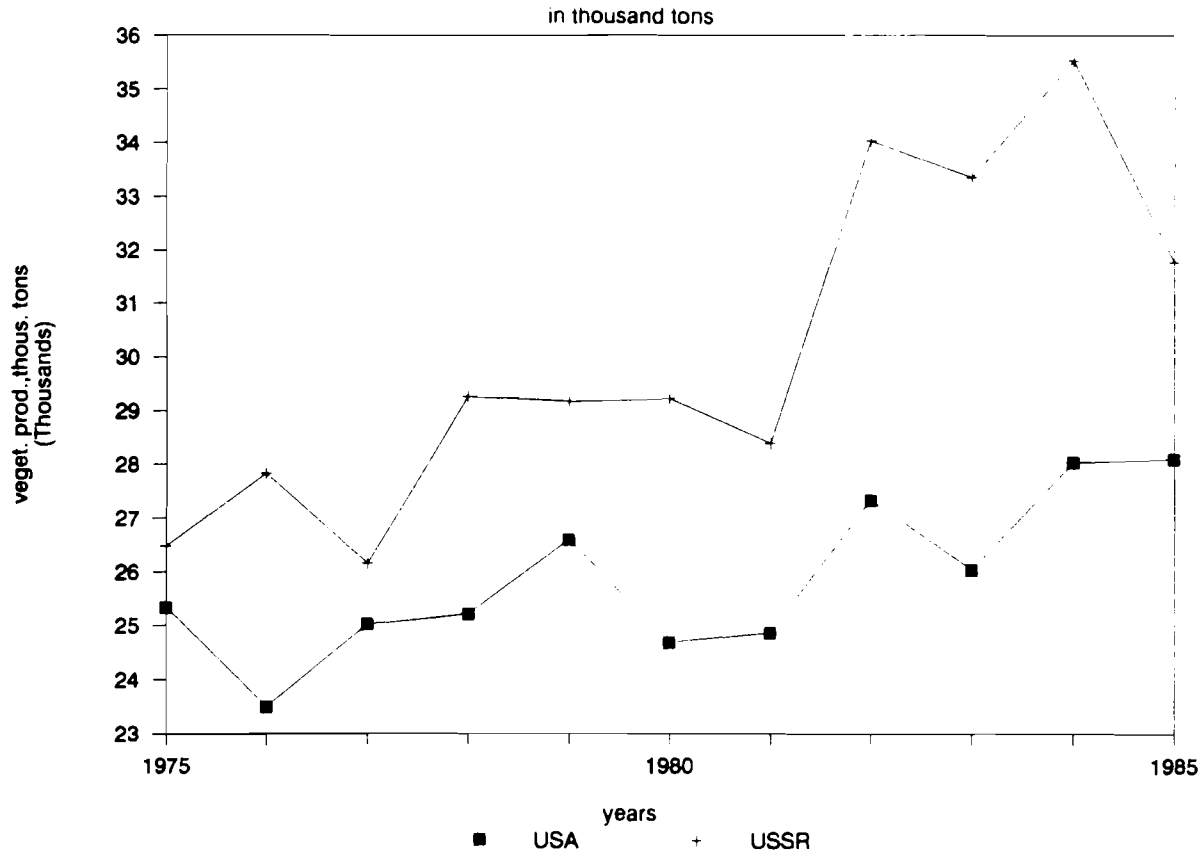

Fig.54a Pesticides Production

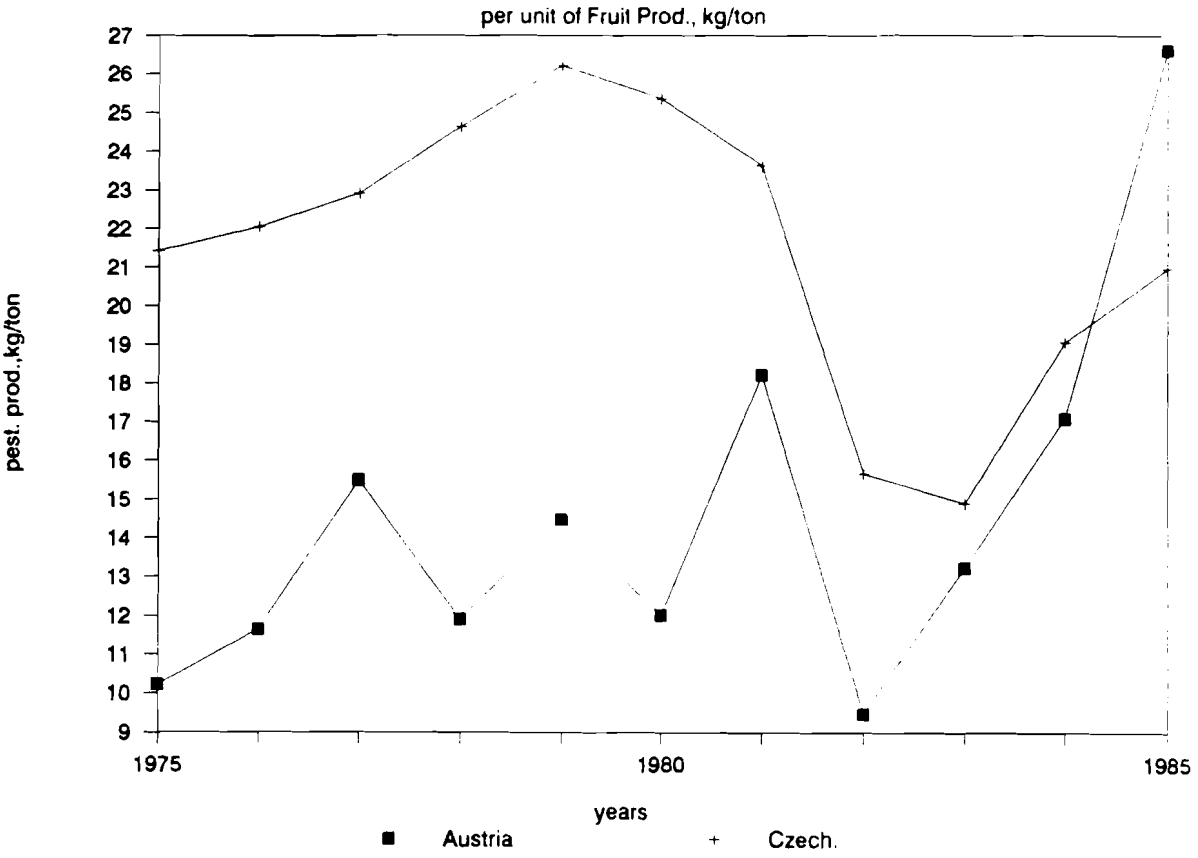

Fig.54b Fruit Production

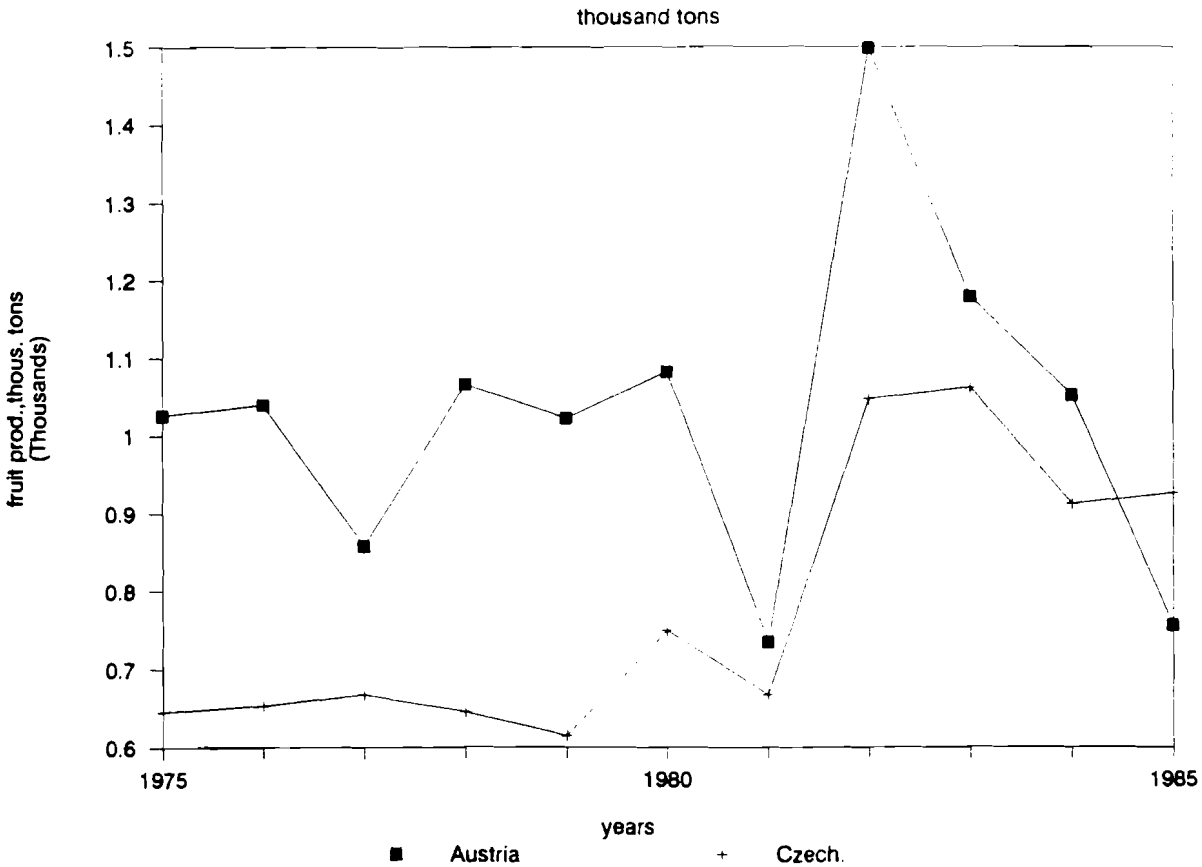

Fig.55a Pesticides Production

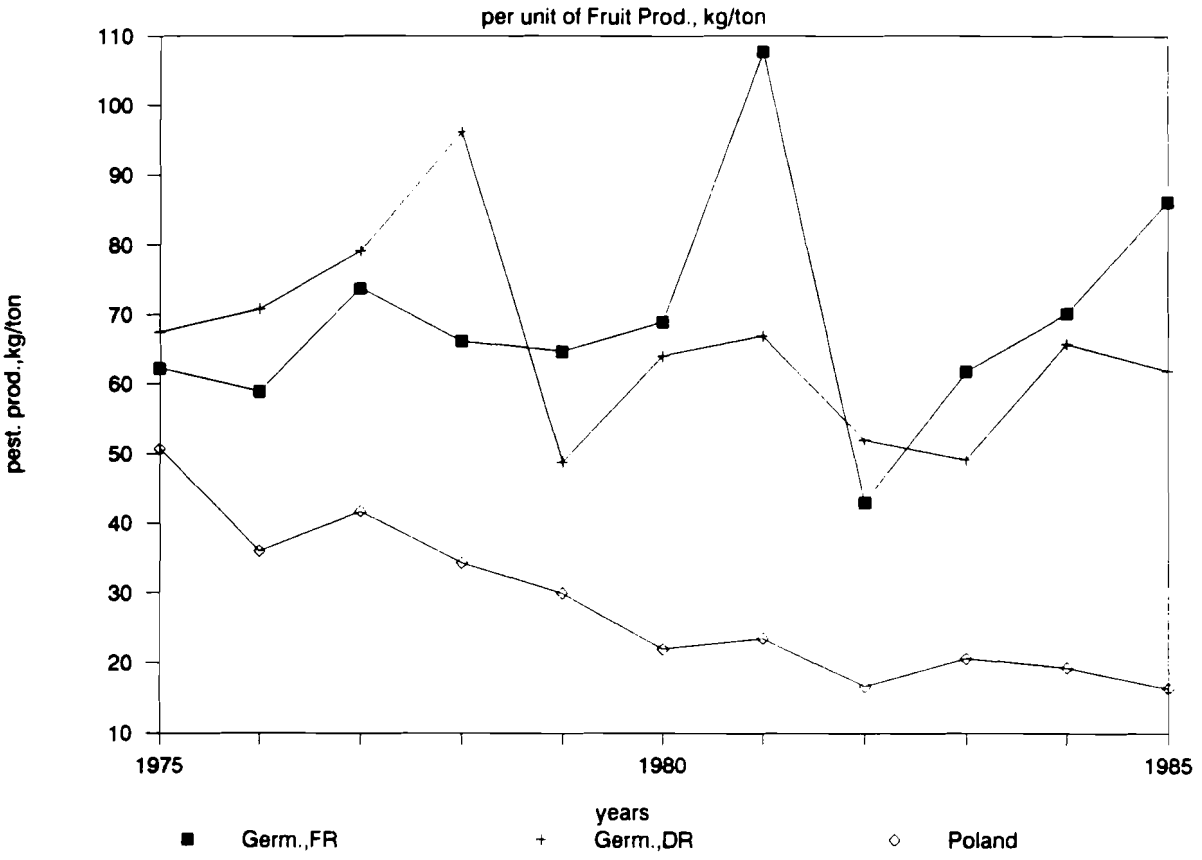

Fig.55b Fruit Production

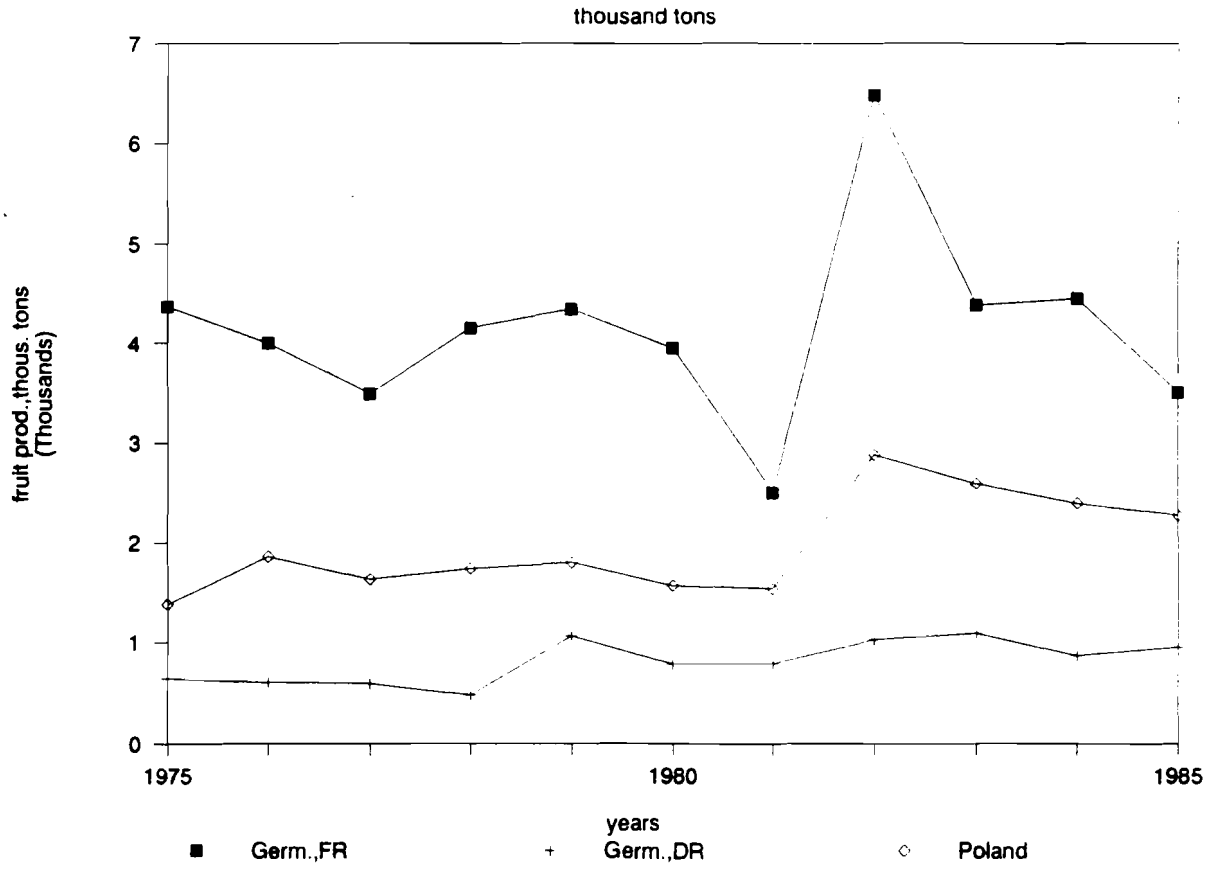

Fig.56a Pesticides Production

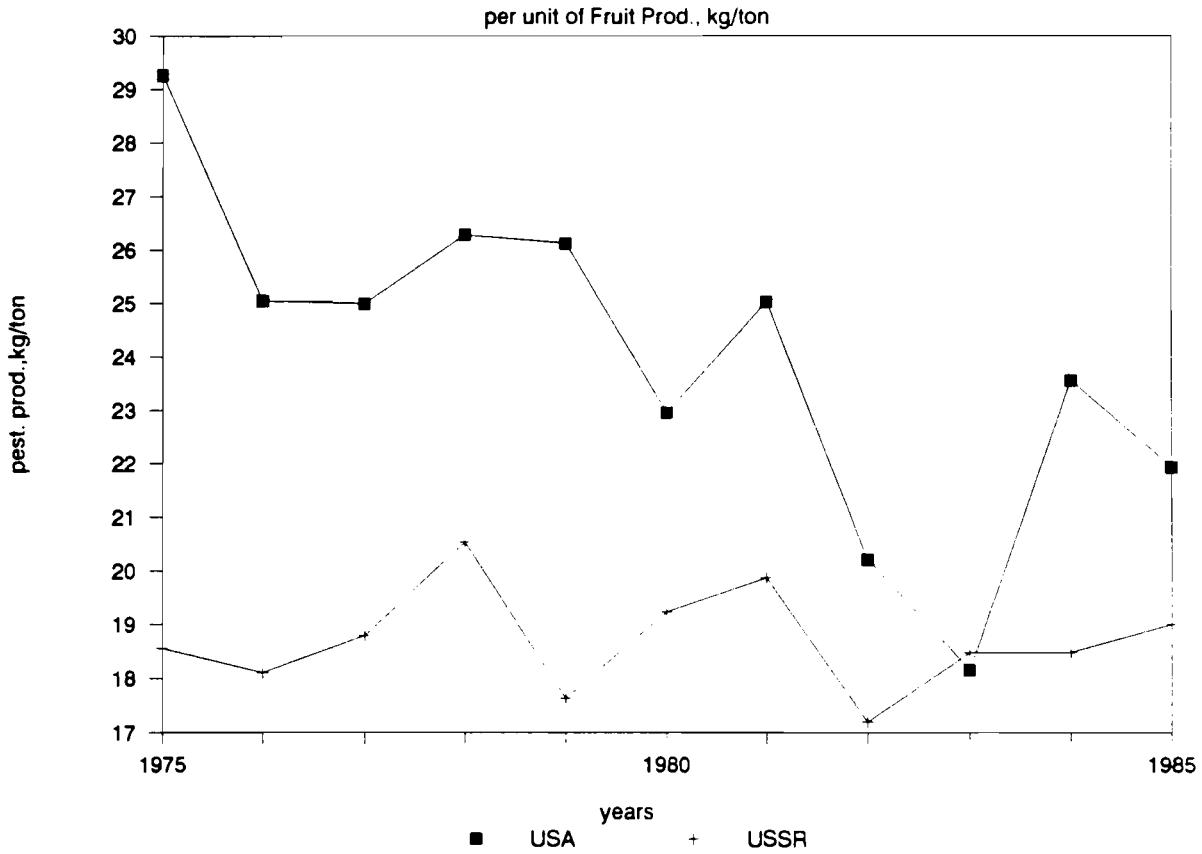

Fig.56b Fruit Production

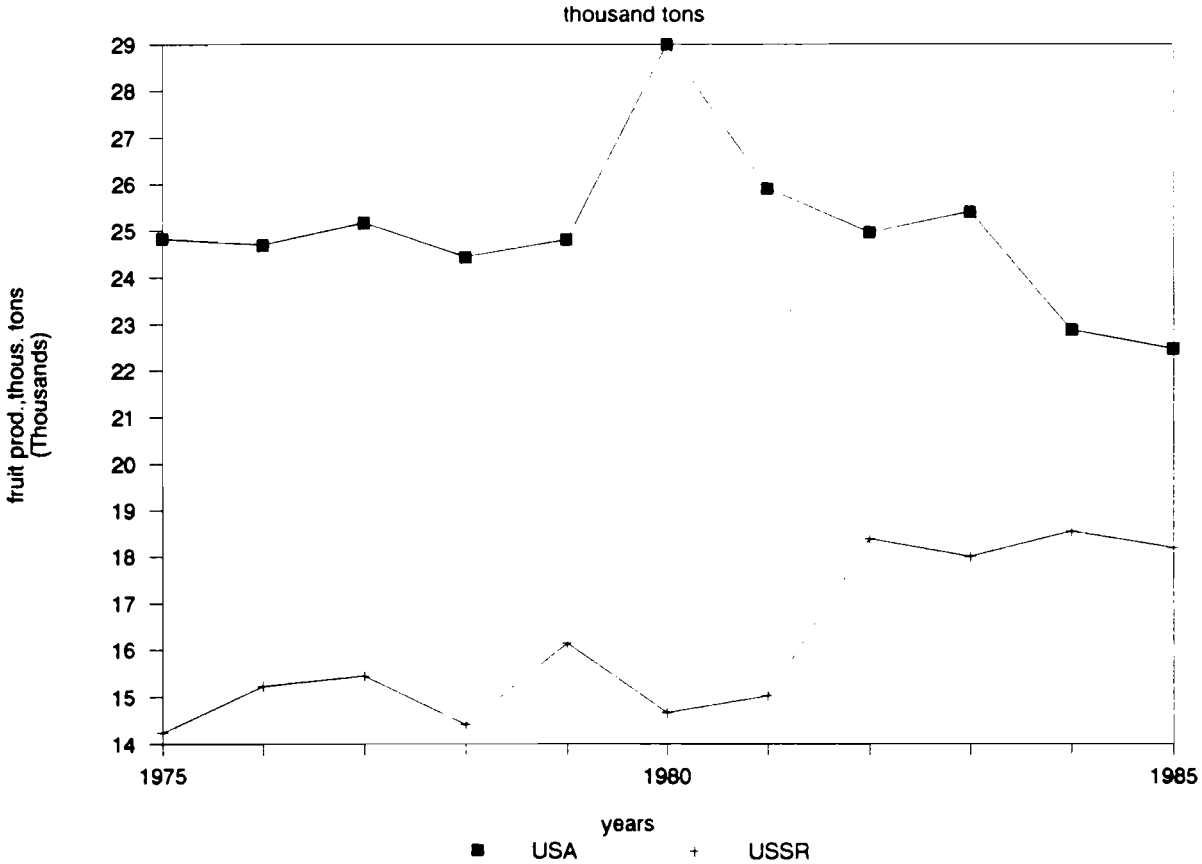

Fig.57a Pesticides Production

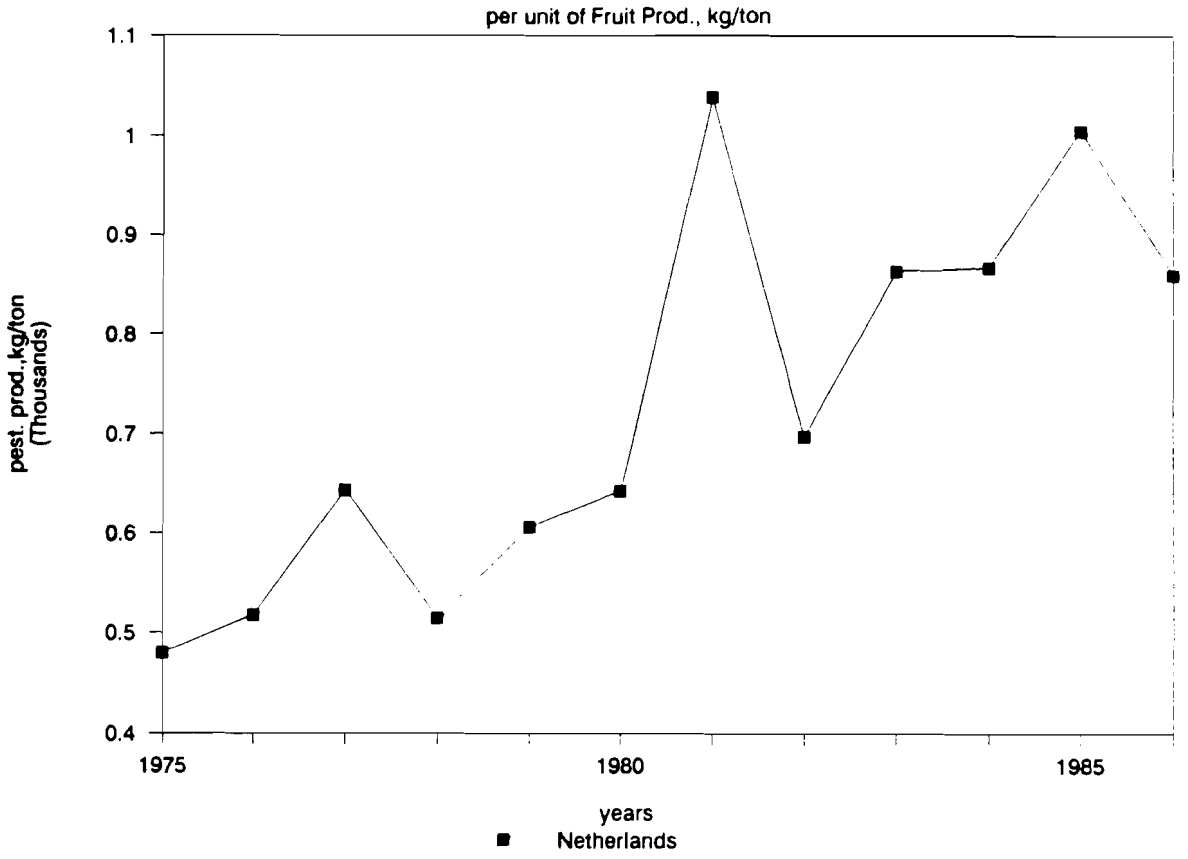

Fig.57b Fruit Production

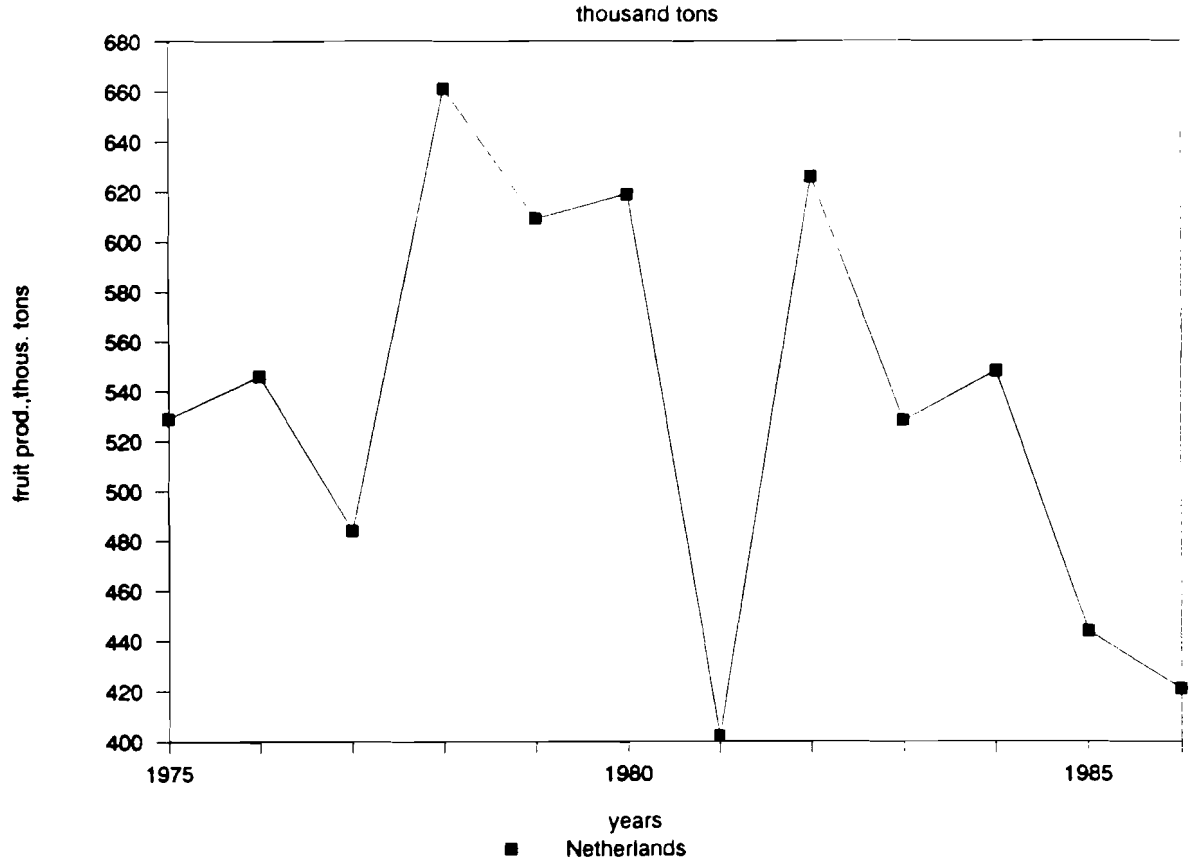

Fig.58 Pesticides Consumption

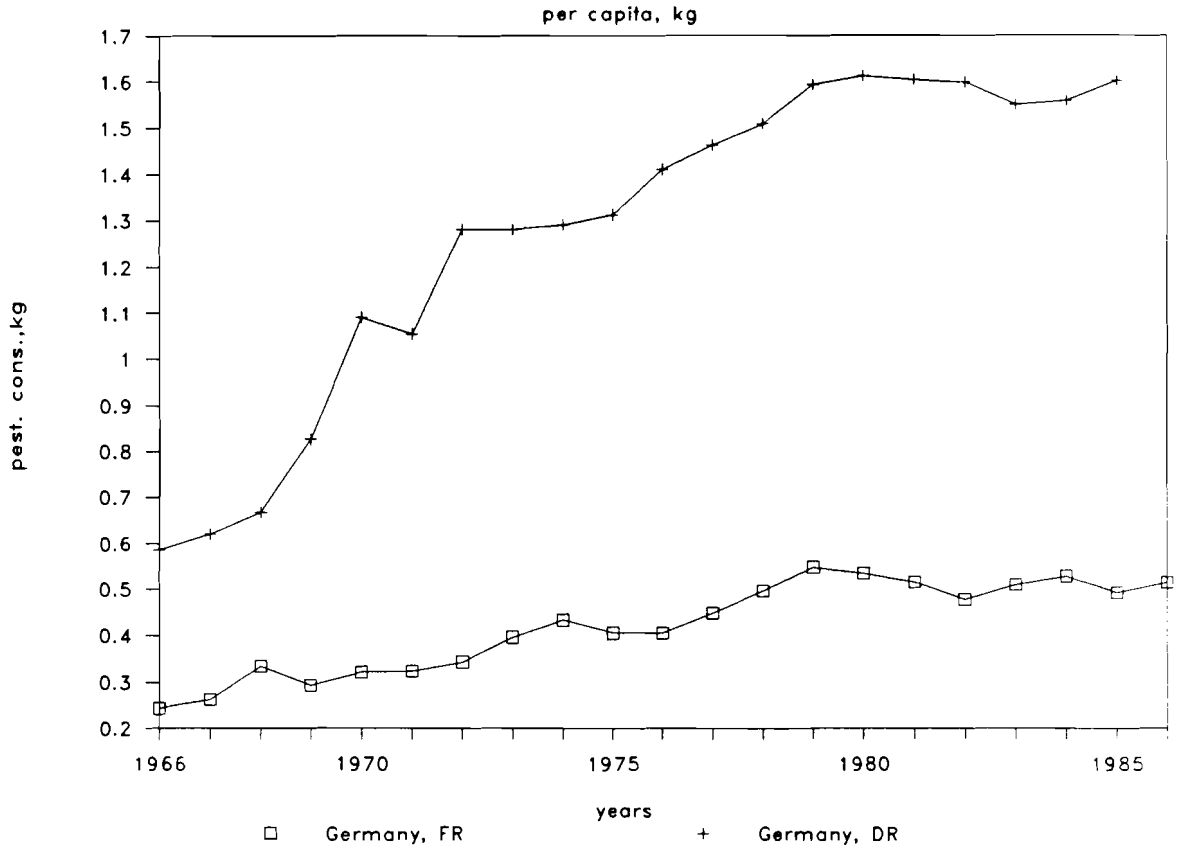

Fig.59 Pesticides Consumption

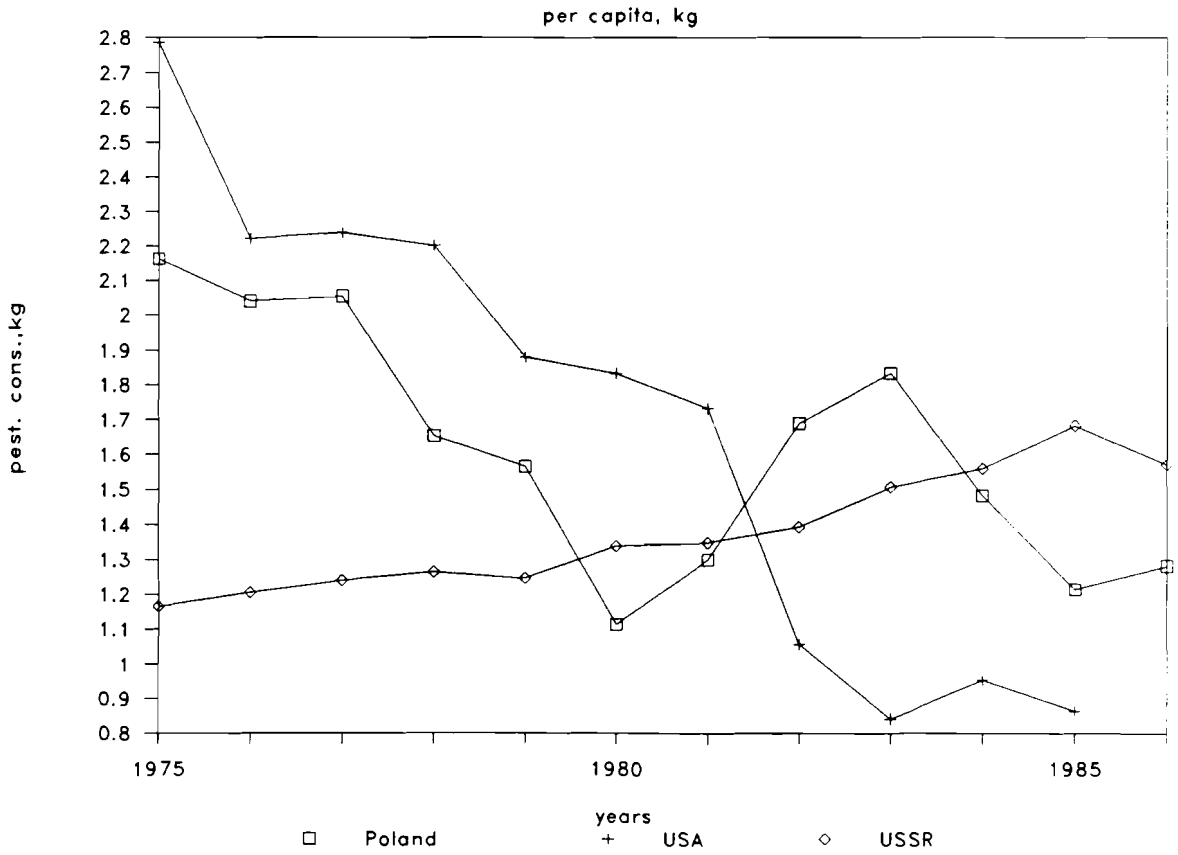

Fig.60 Pesticides Consumption

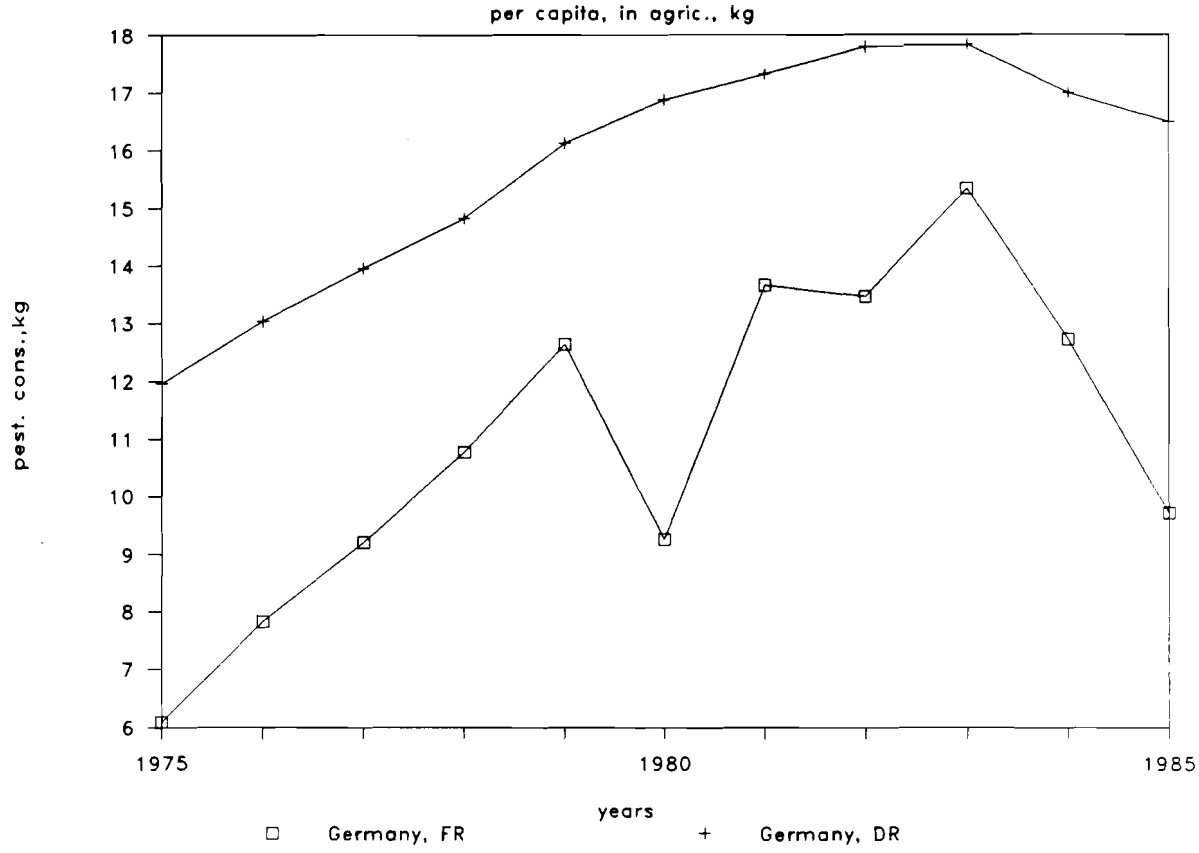

Fig.61 Pesticides Consumption

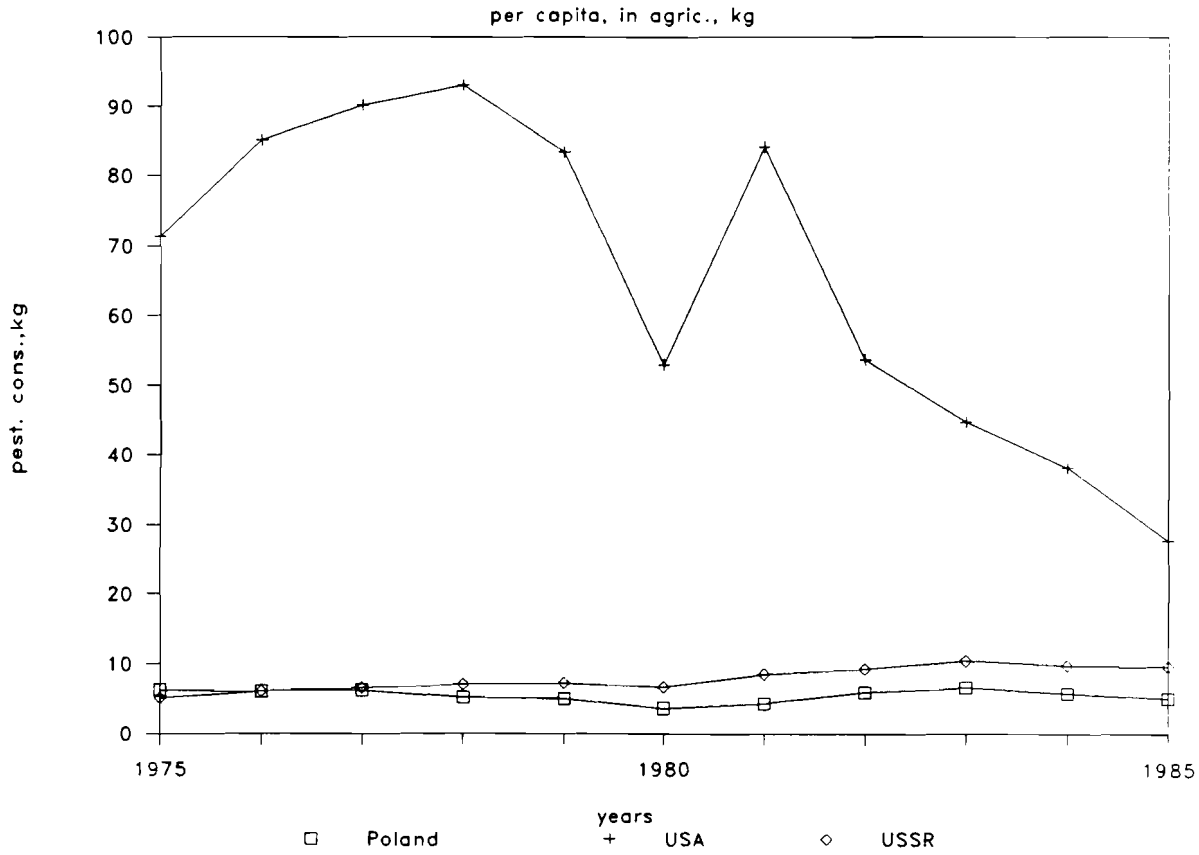

Fig.62 Pesticides Consumption

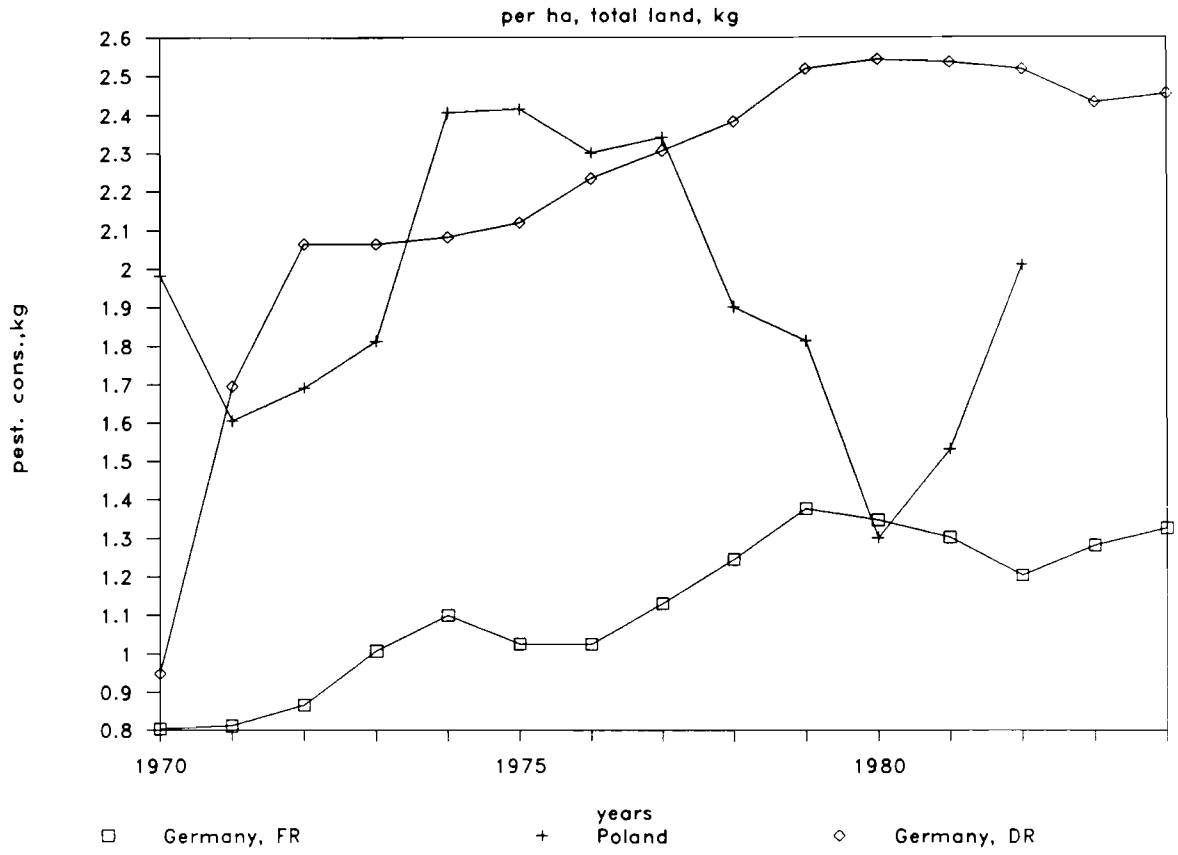

Fig.63 Pesticides Consumption

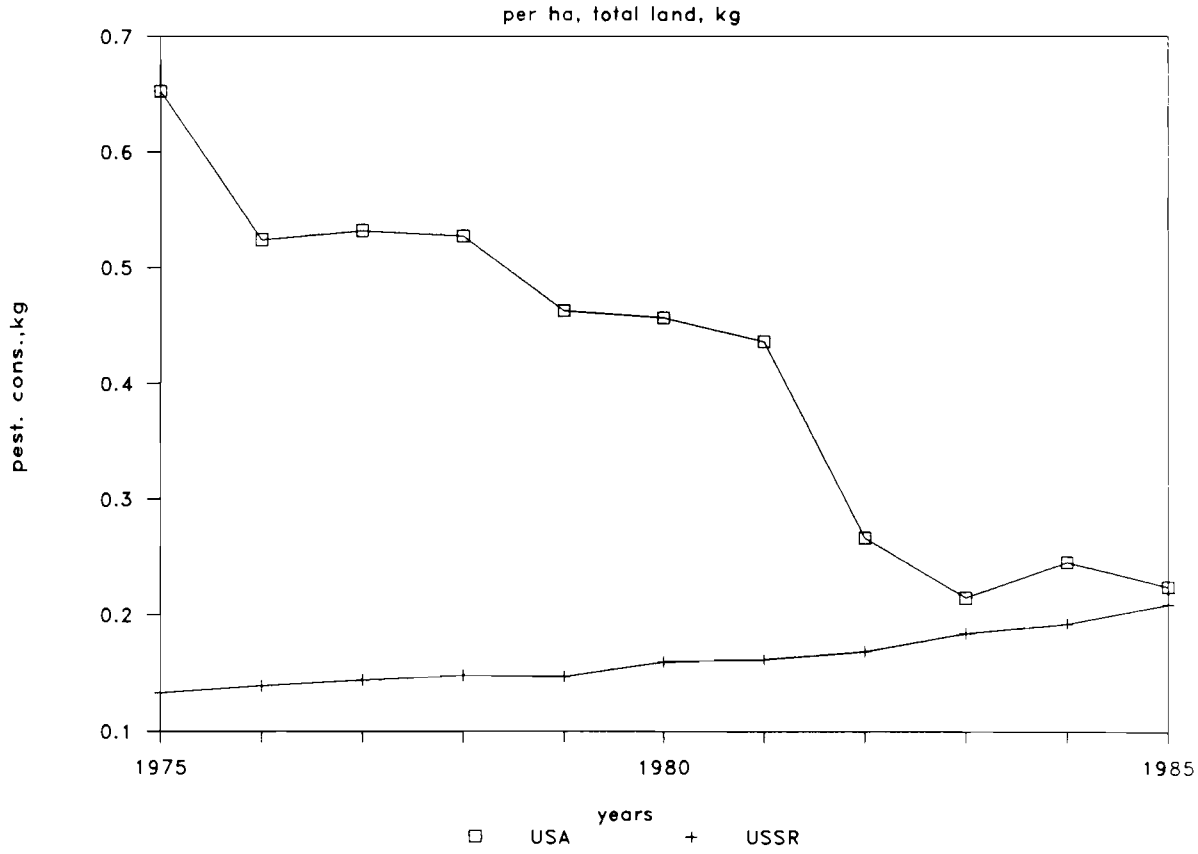

Fig.64 Pesticide consumption

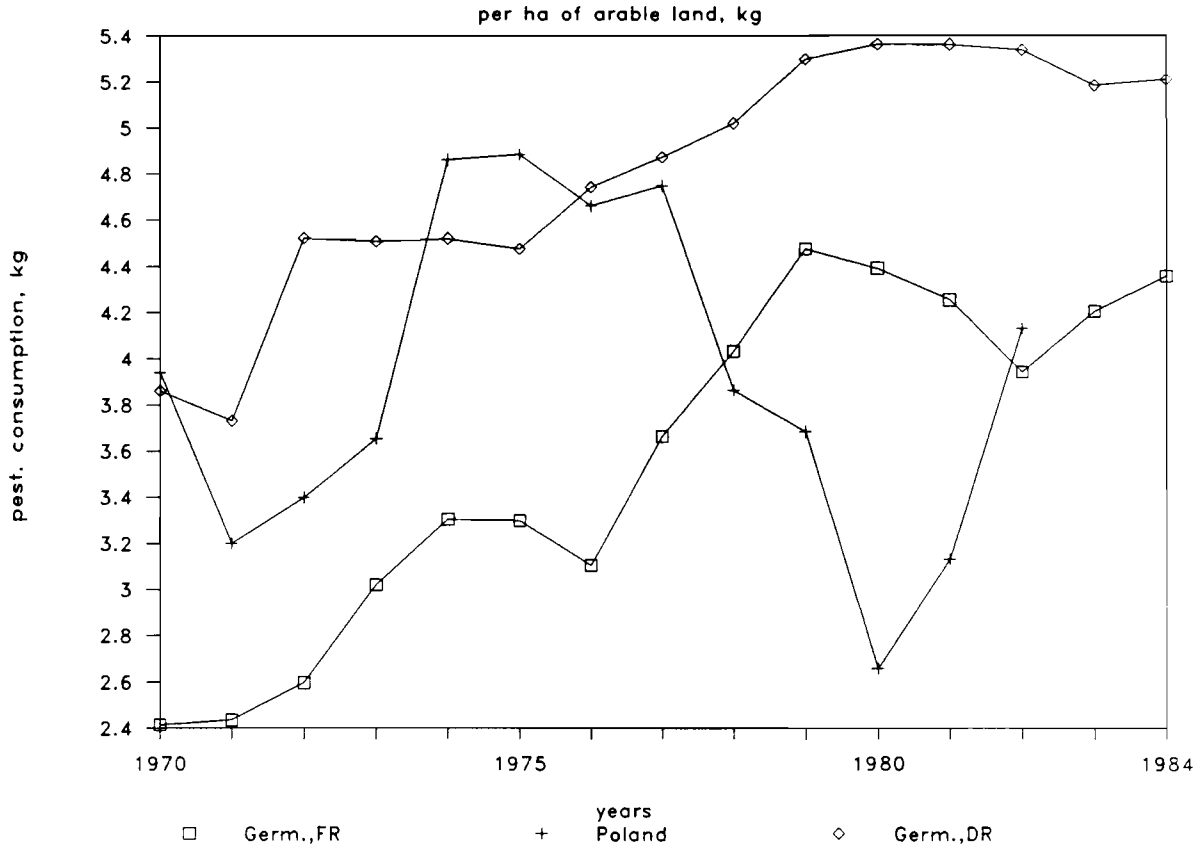

Fig.65 Pesticide consumption

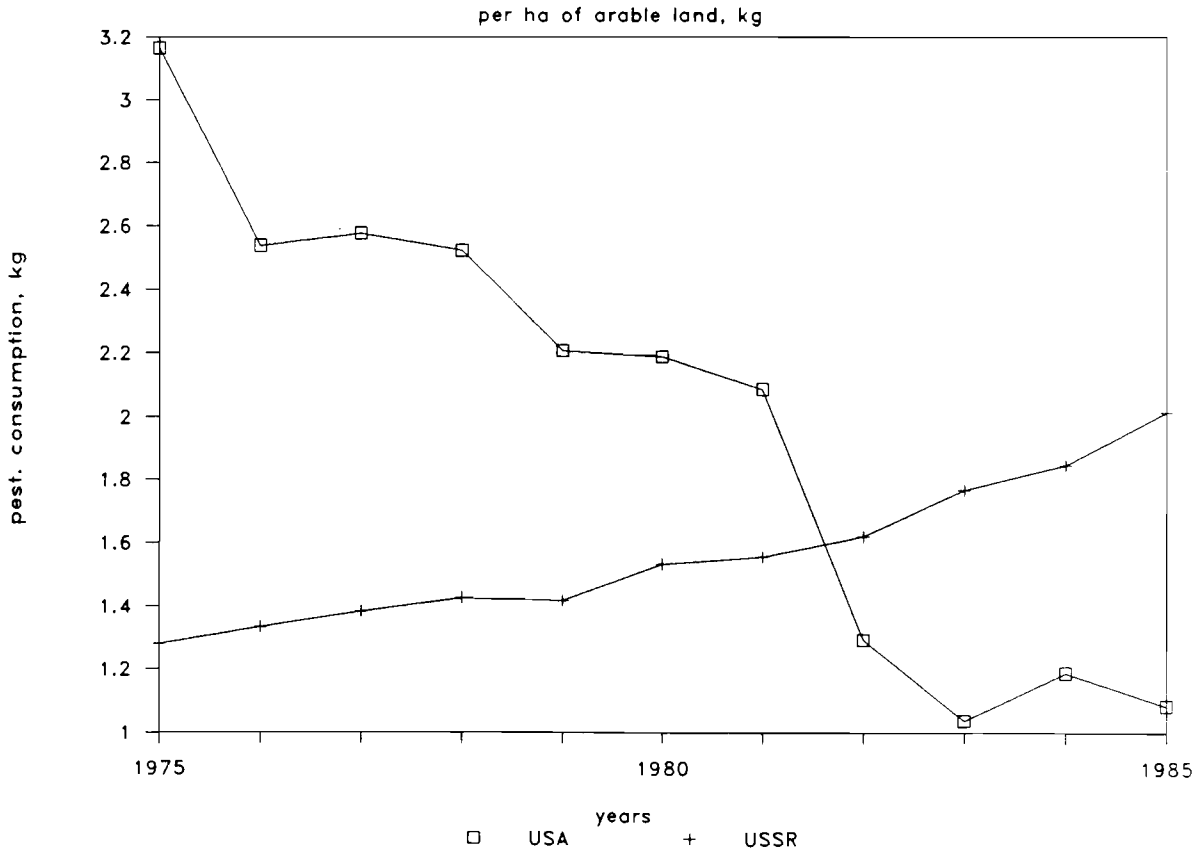

Fig.66 Pesticide consumption

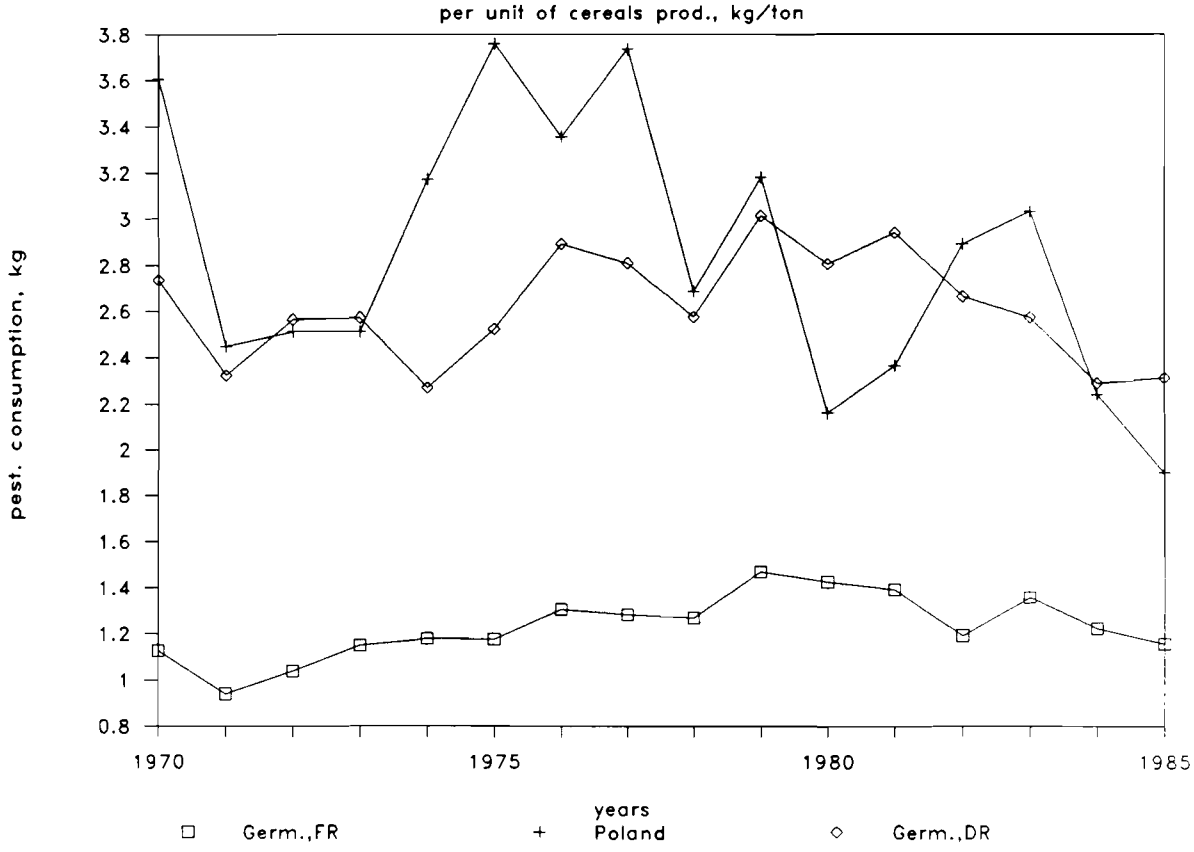

Fig.67 Pesticide consumption

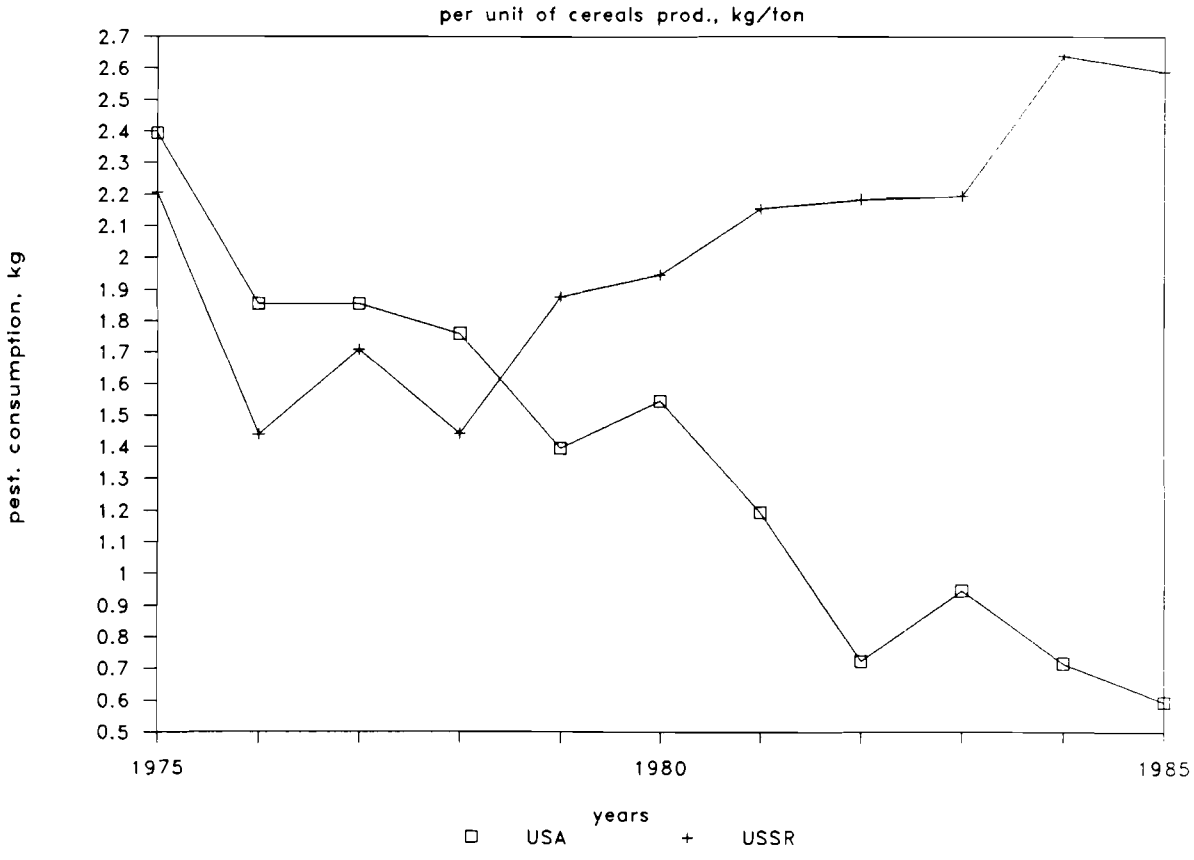

Fig.68 Pesticide consumption

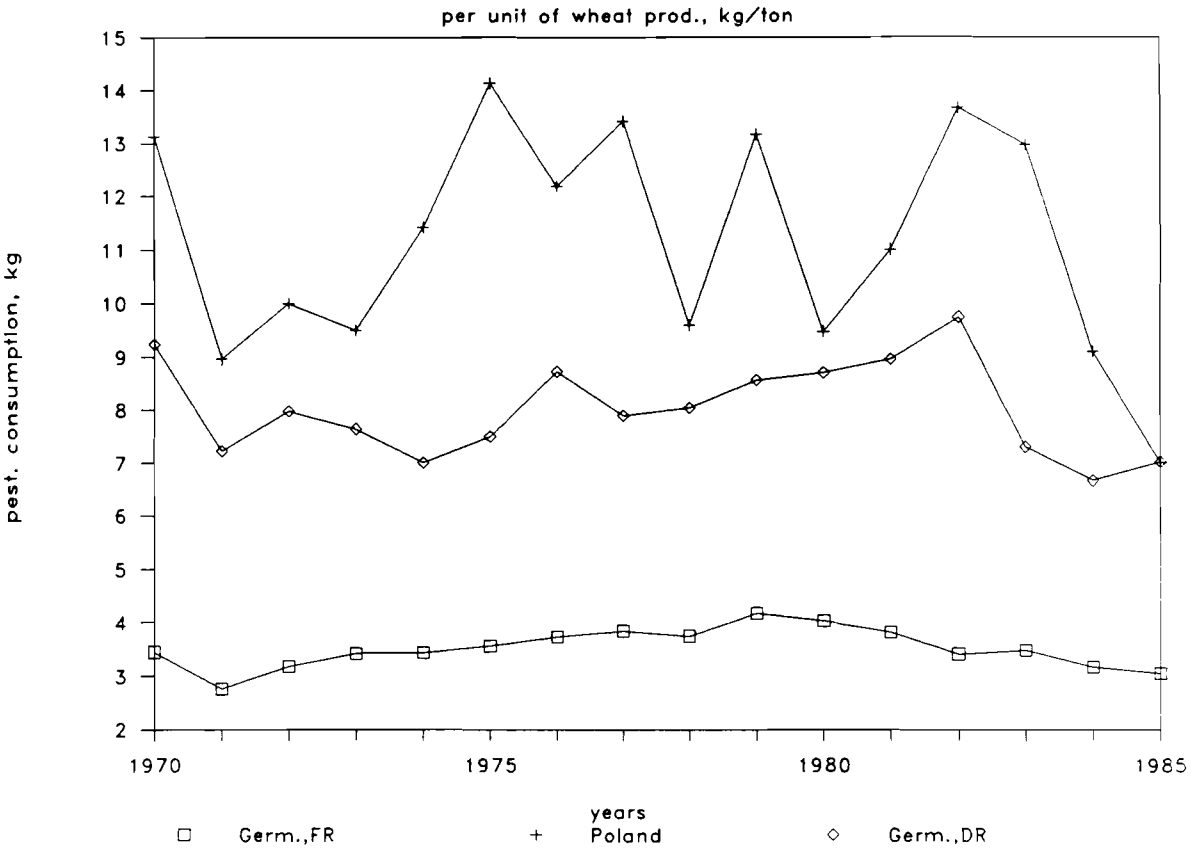

Fig.69 Pesticide consumption

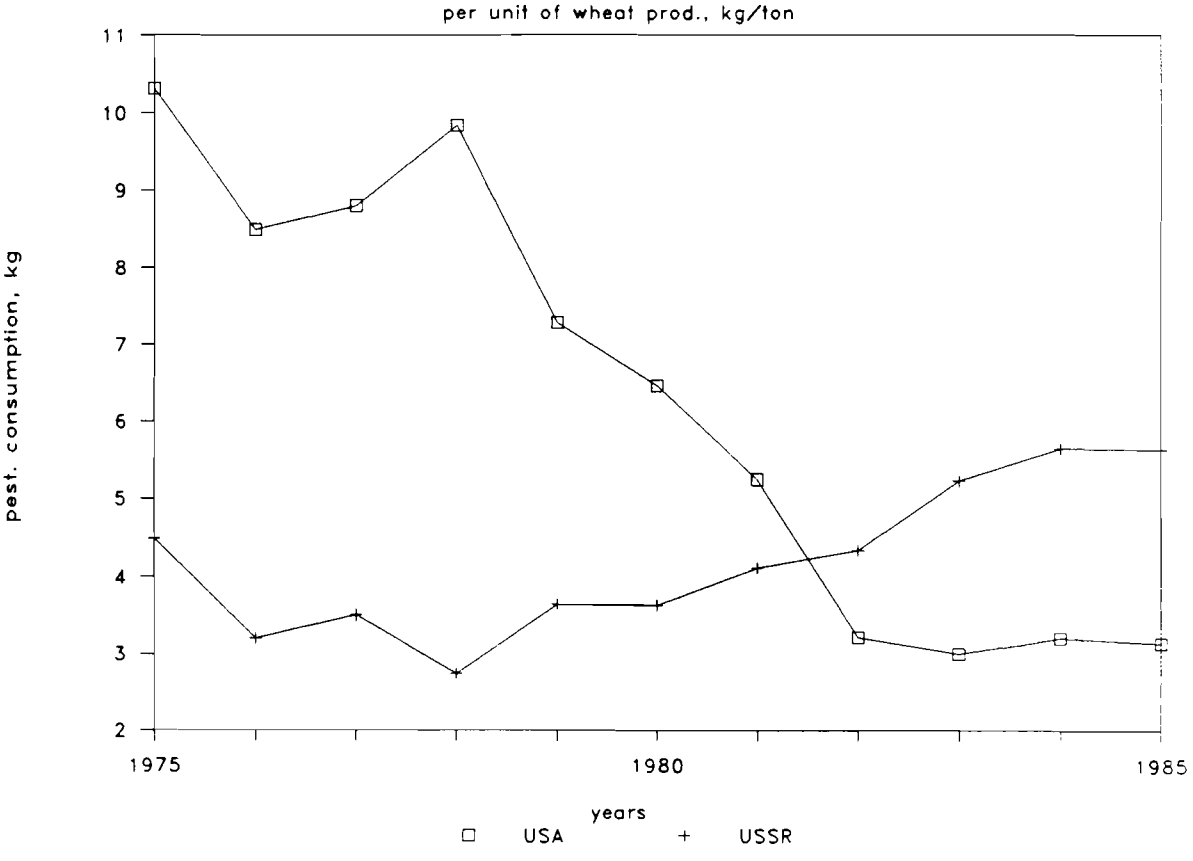

Fig.70 Pesticide consumption

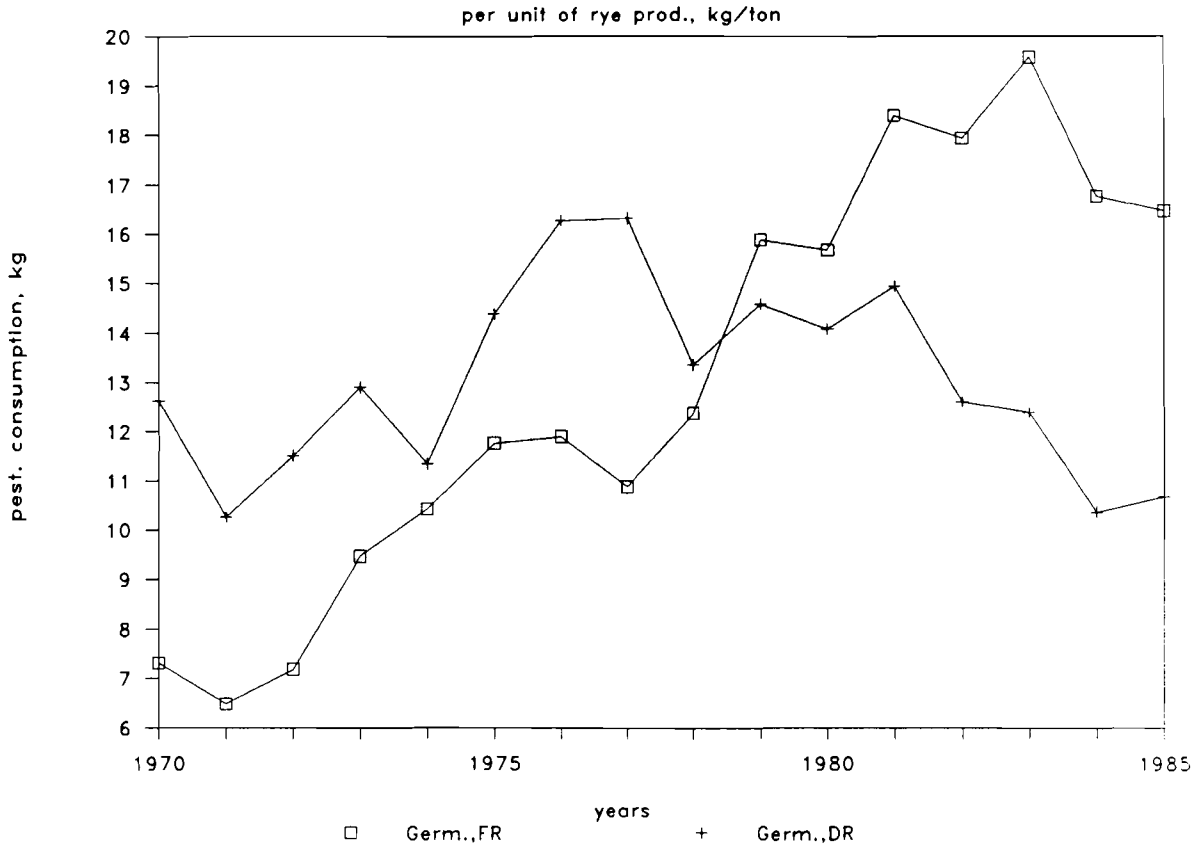

Fig.71 Pesticide consumption

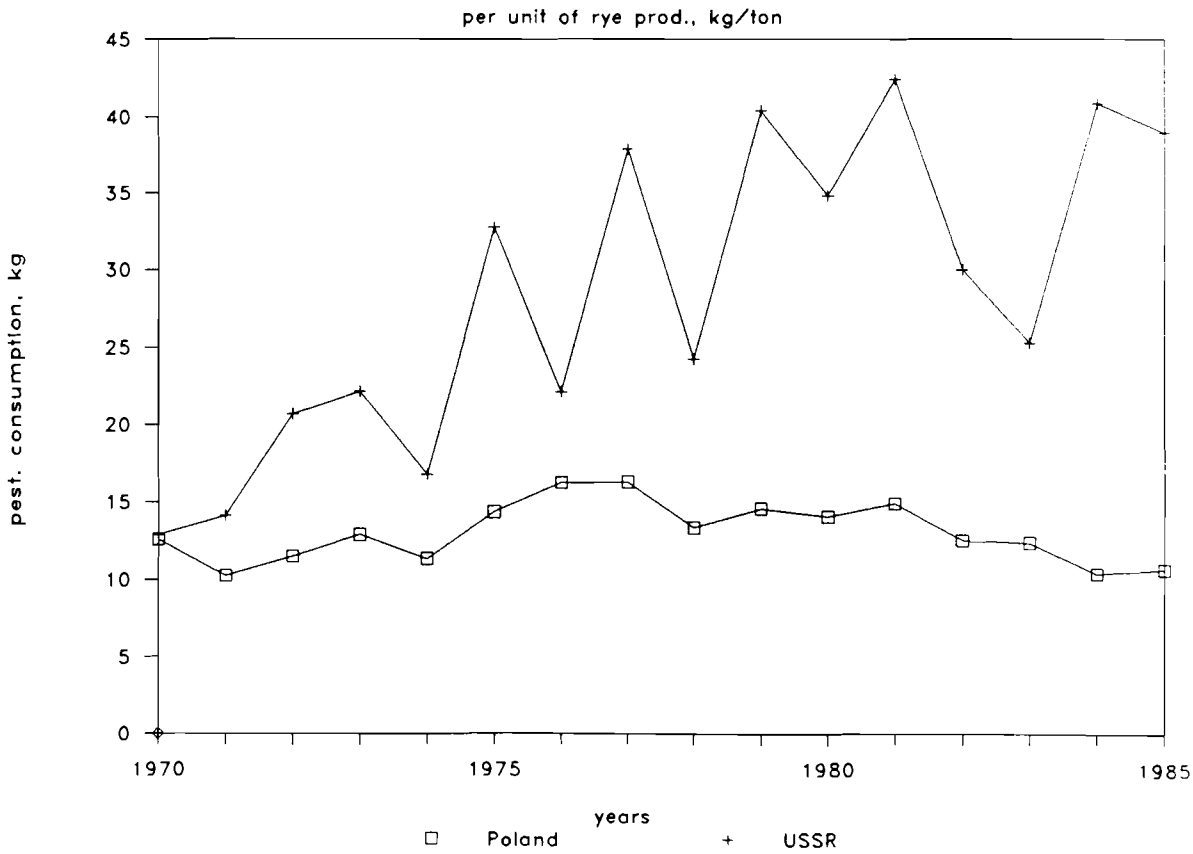

Fig.72 Pesticide consumption

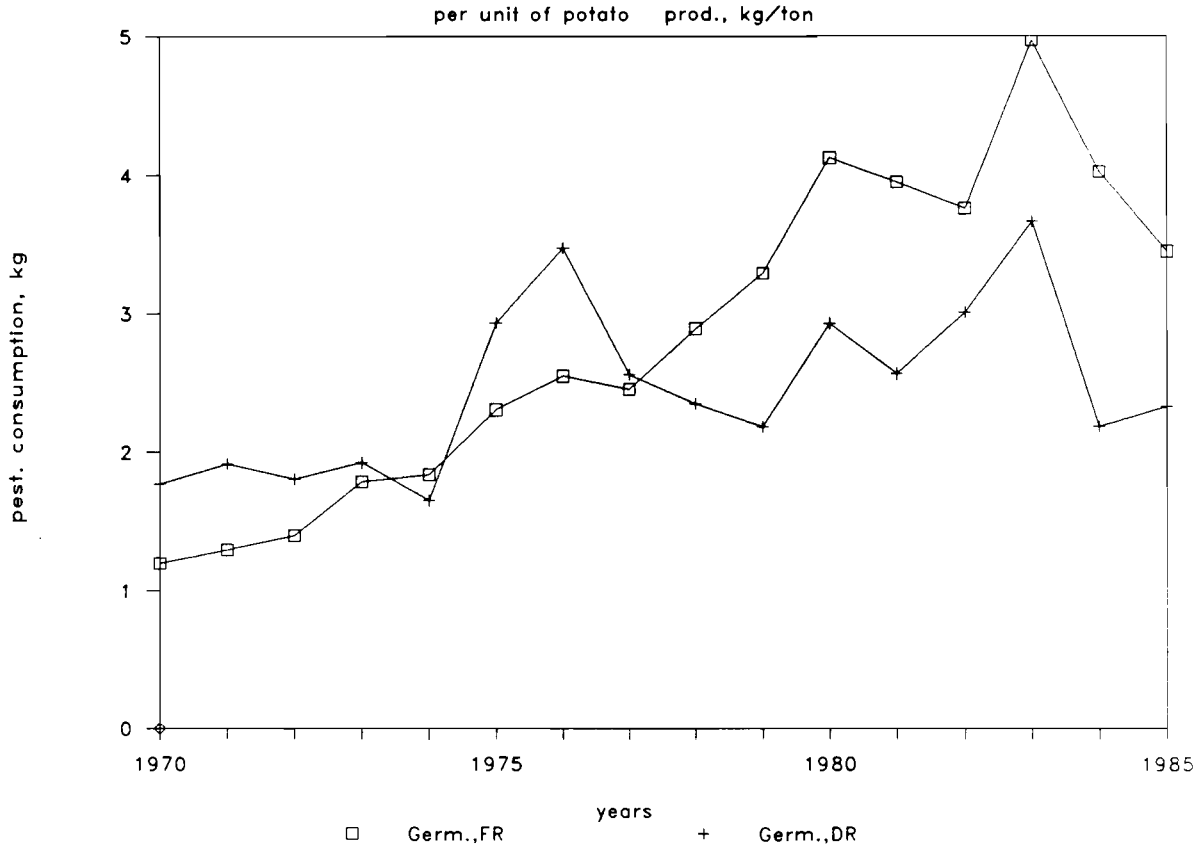

Fig.73 Pesticide consumption

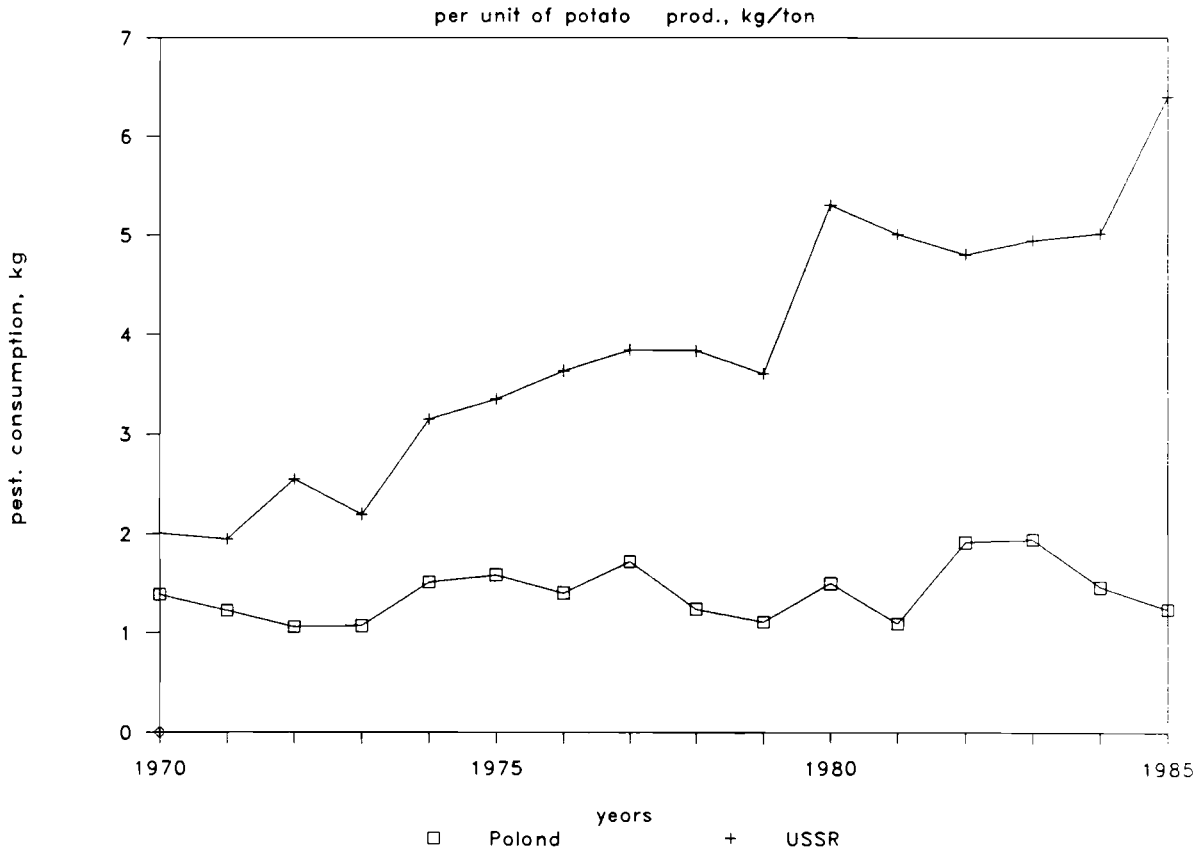

Fig.74 Pesticide consumption

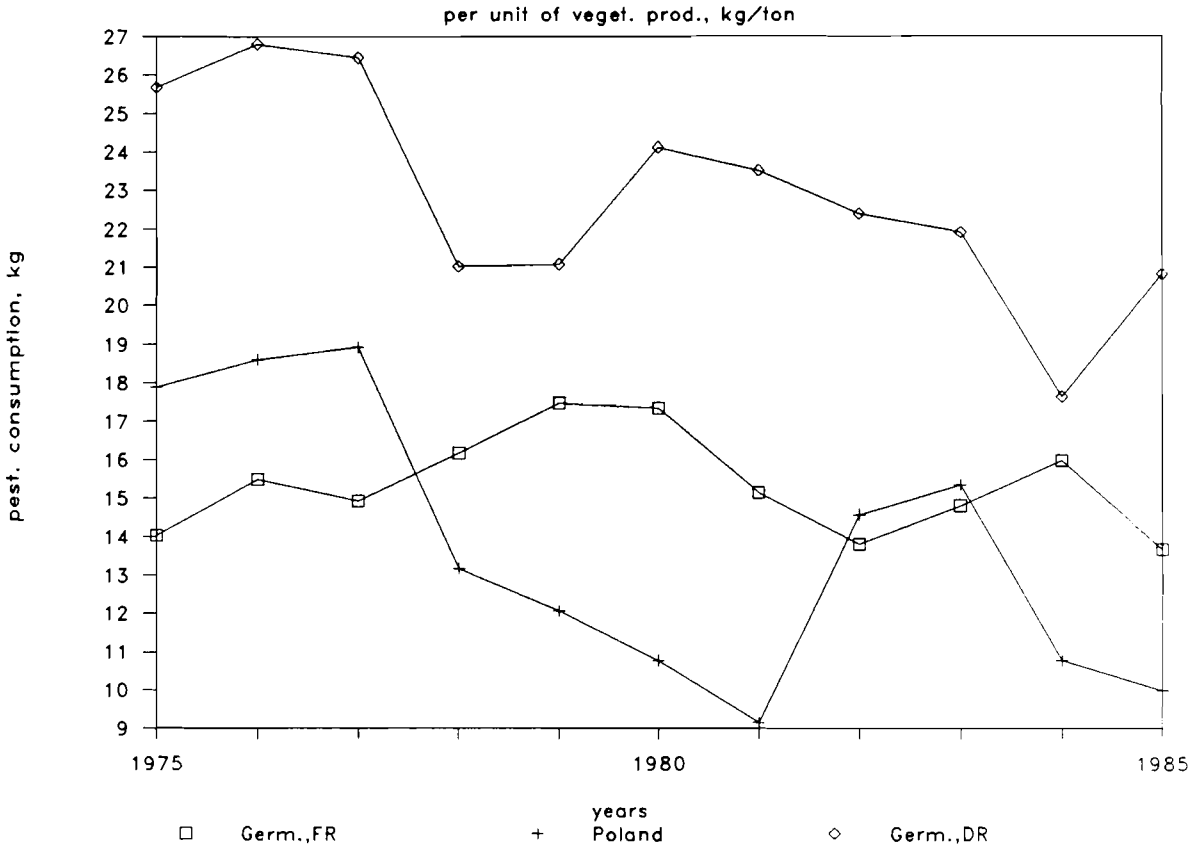

Fig.75 Pesticide consumption

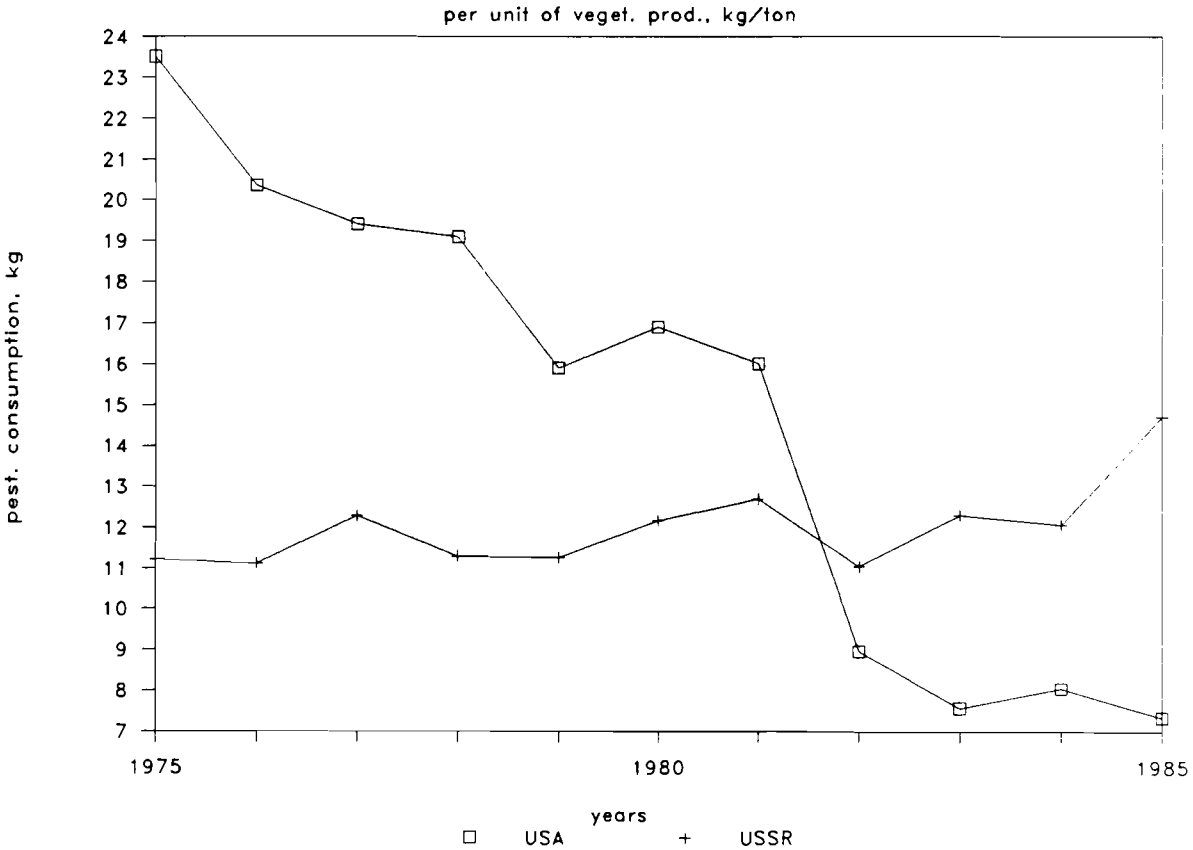

Fig.76 Pesticide consumption

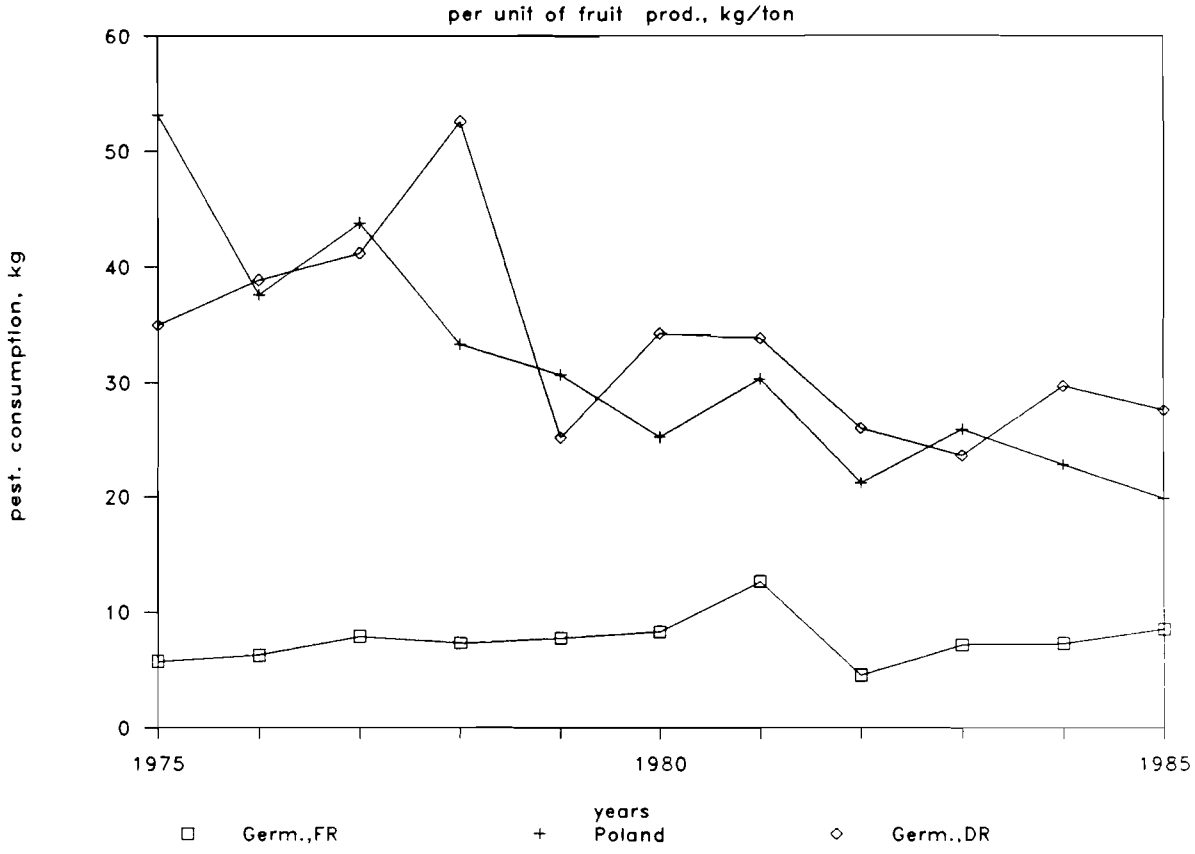

Fig.77 Pesticide consumption

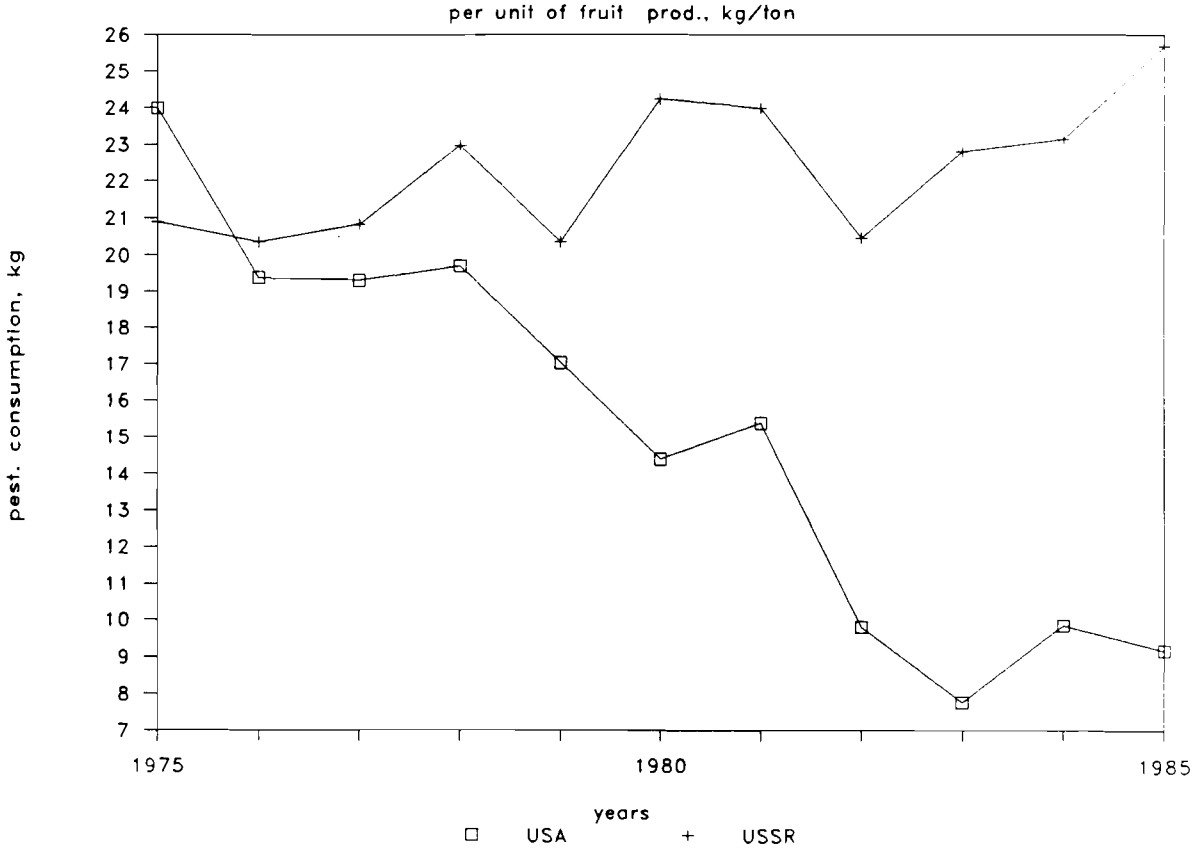

Fig.78 Pesticides Exports, thous. tons

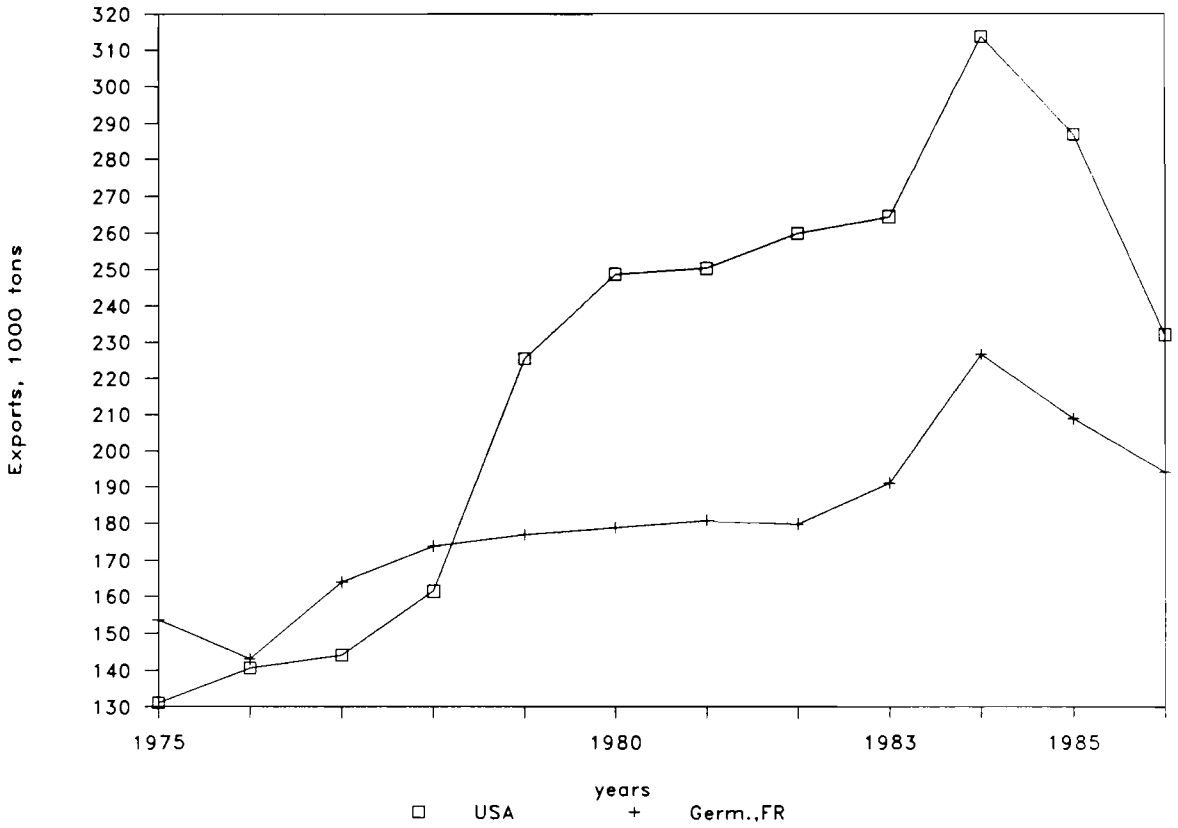

Fig.79 Pesticides Exports Share

in total Exports, %

Fig.80 Pesticides Export Prices

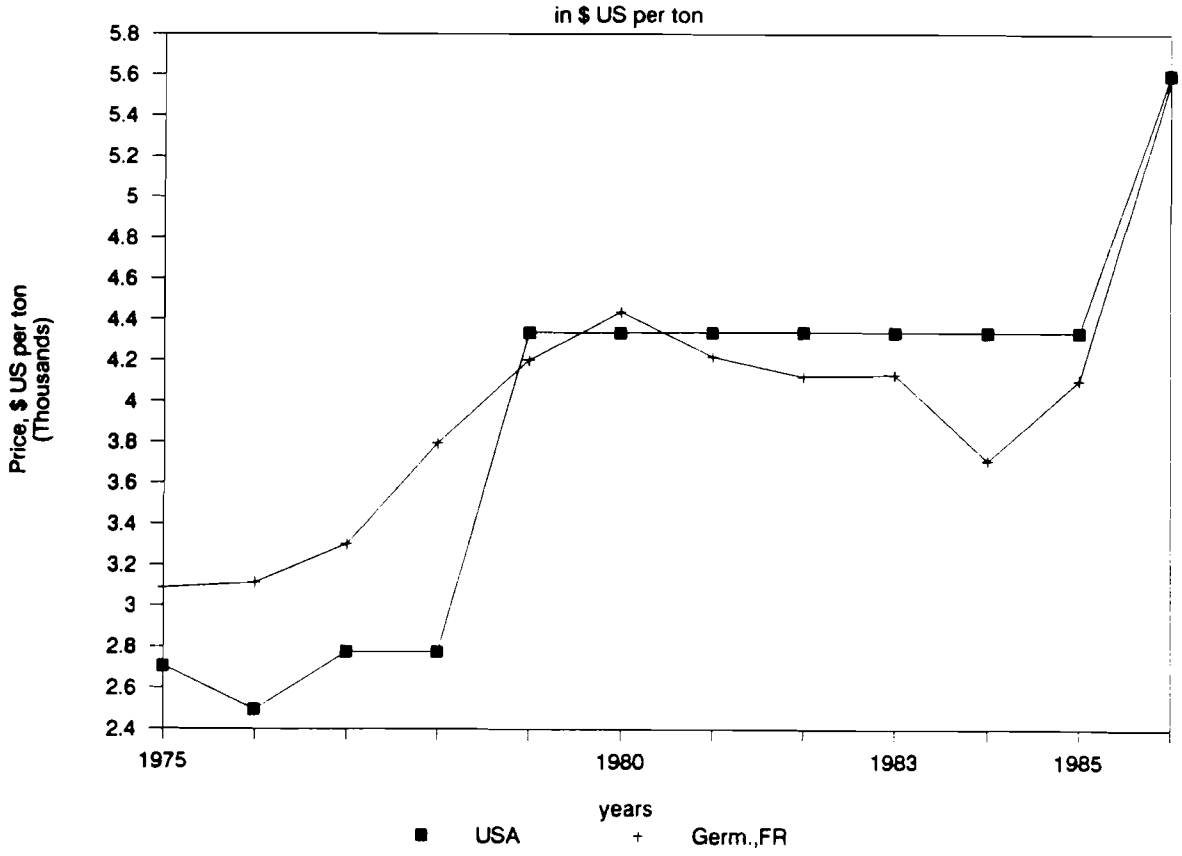

Fig.81 Pesticides Export Prices

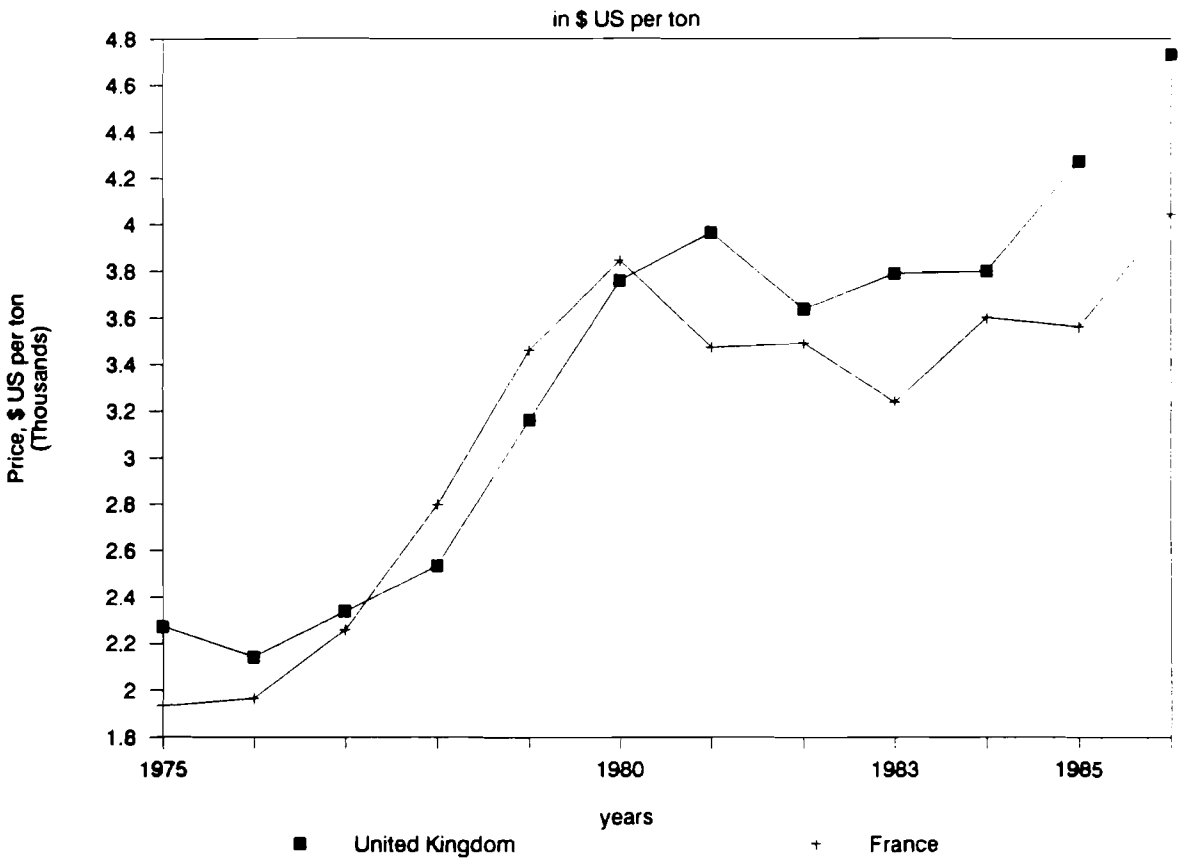

Fig.82 Pesticides Exports,thous.tons

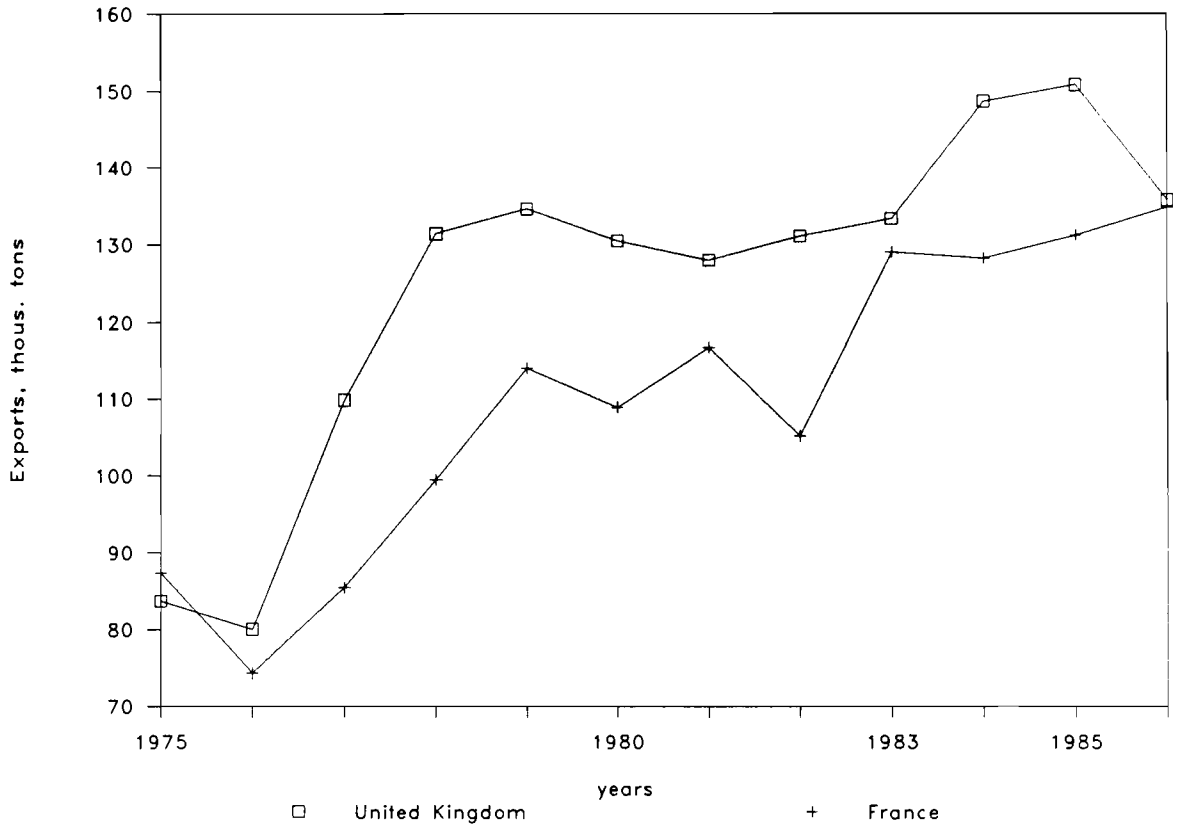

Fig.83 Pesticides Exports Share

in total Exports, %

Fig.84 Pesticides Exports,thous.tons

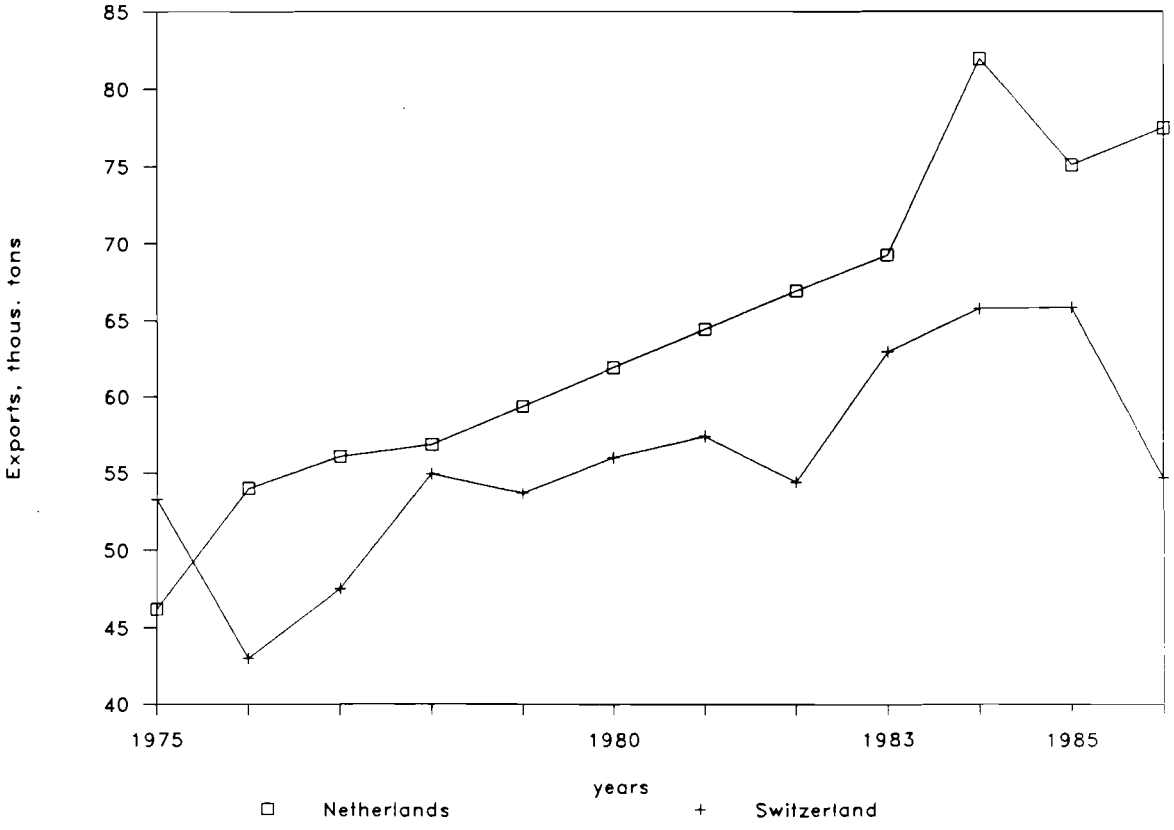

Fig.85 Pesticides Exports Share

in total Exports, %

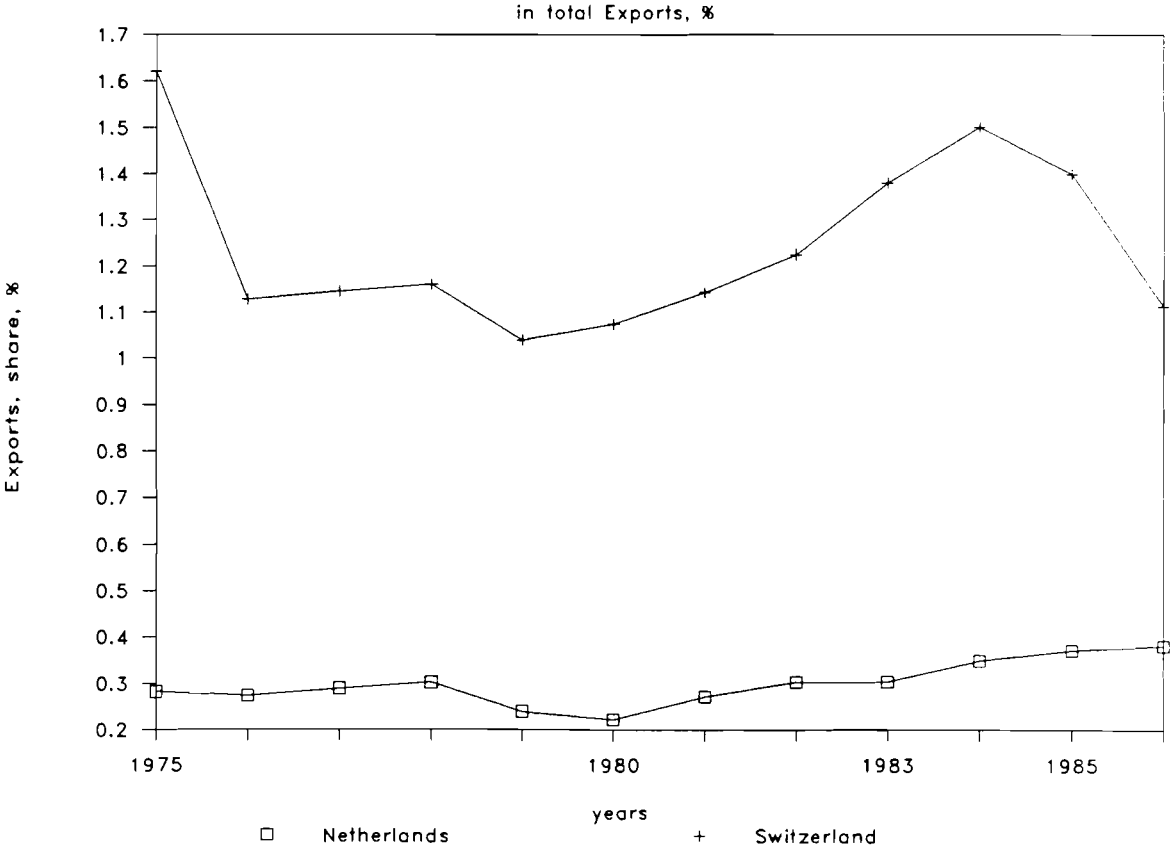

Fig.86 Pesticides Export Prices

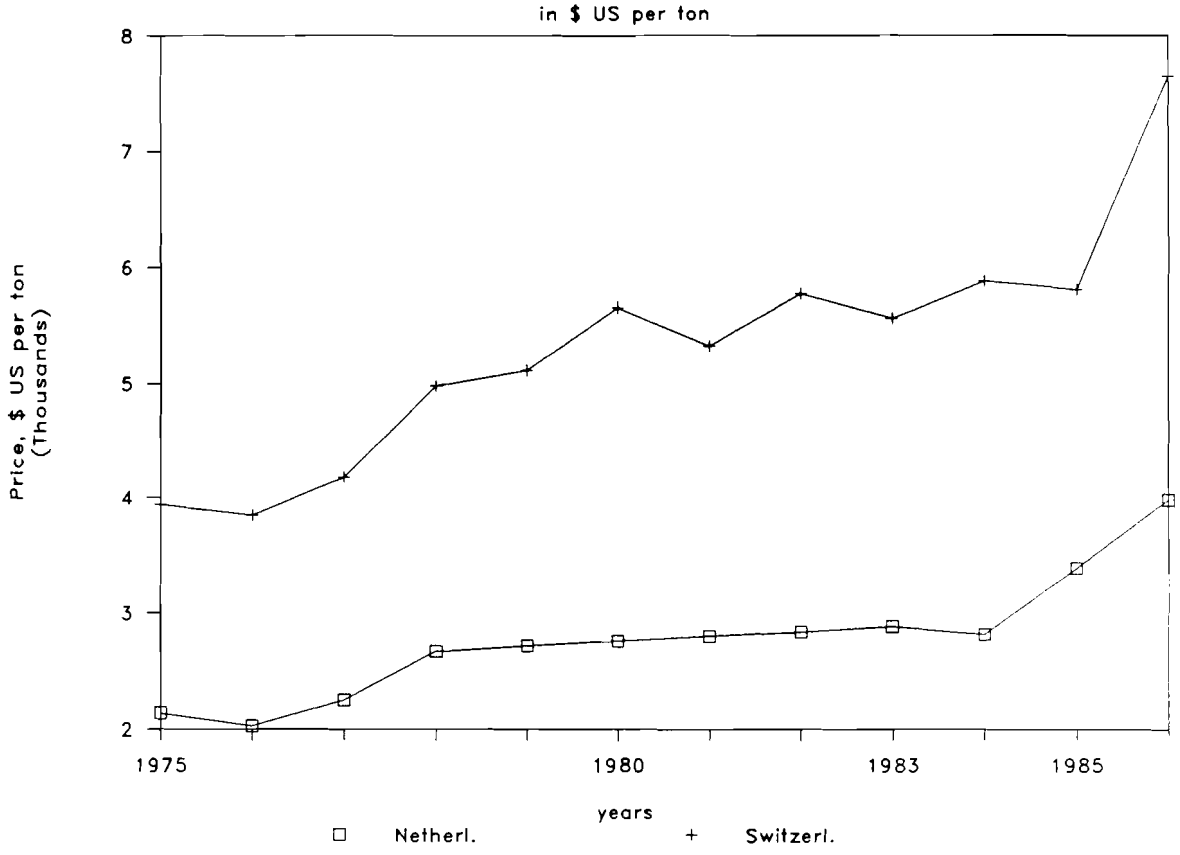

Fig.87 Pesticides Export Prices

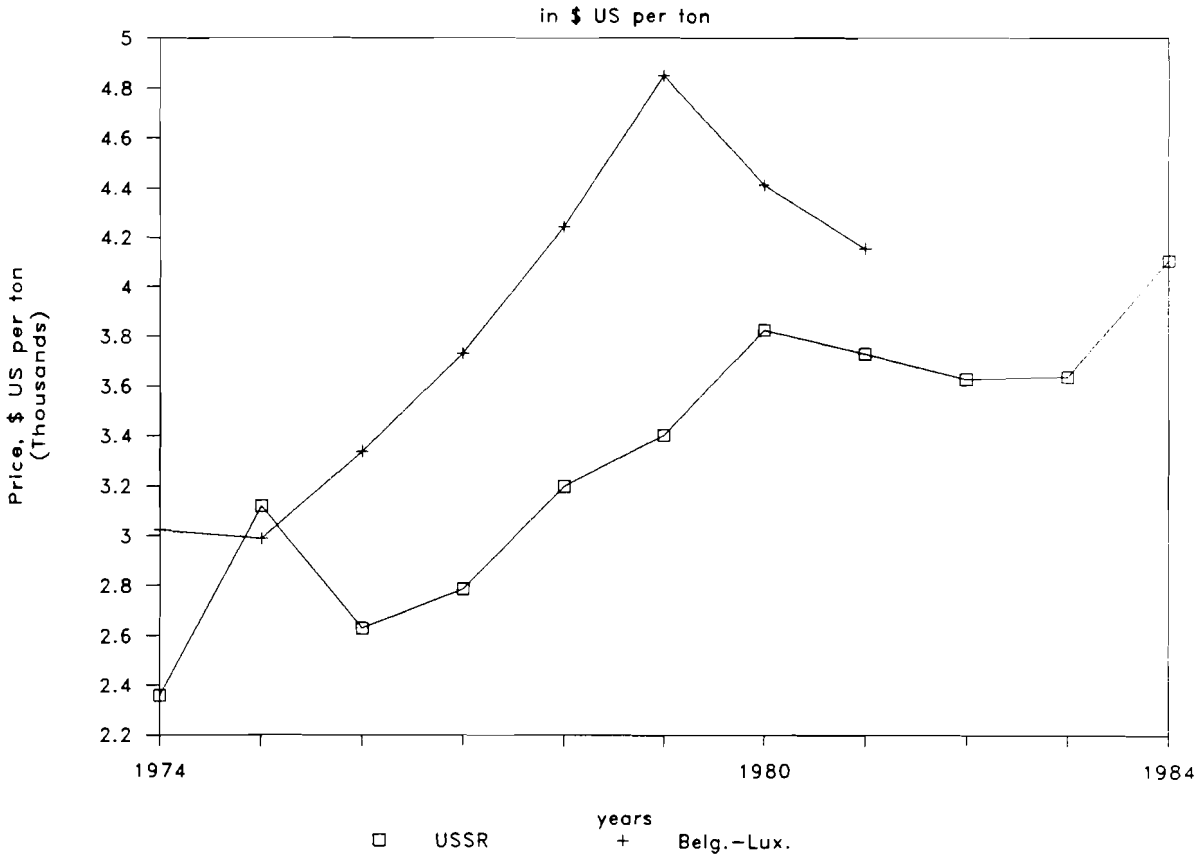

Fig.88 Pesticides Exports,thous.tons

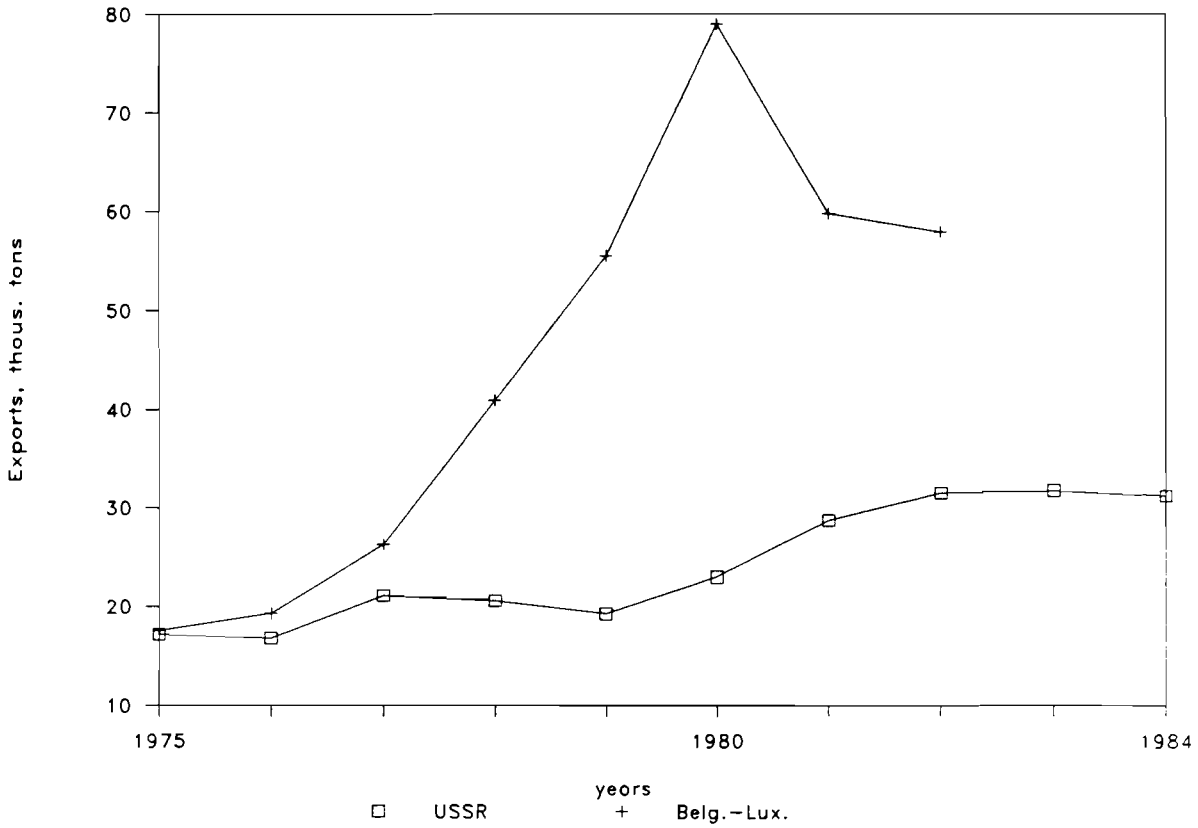

Fig.89 Pesticides Exports Share

in total Exports, %

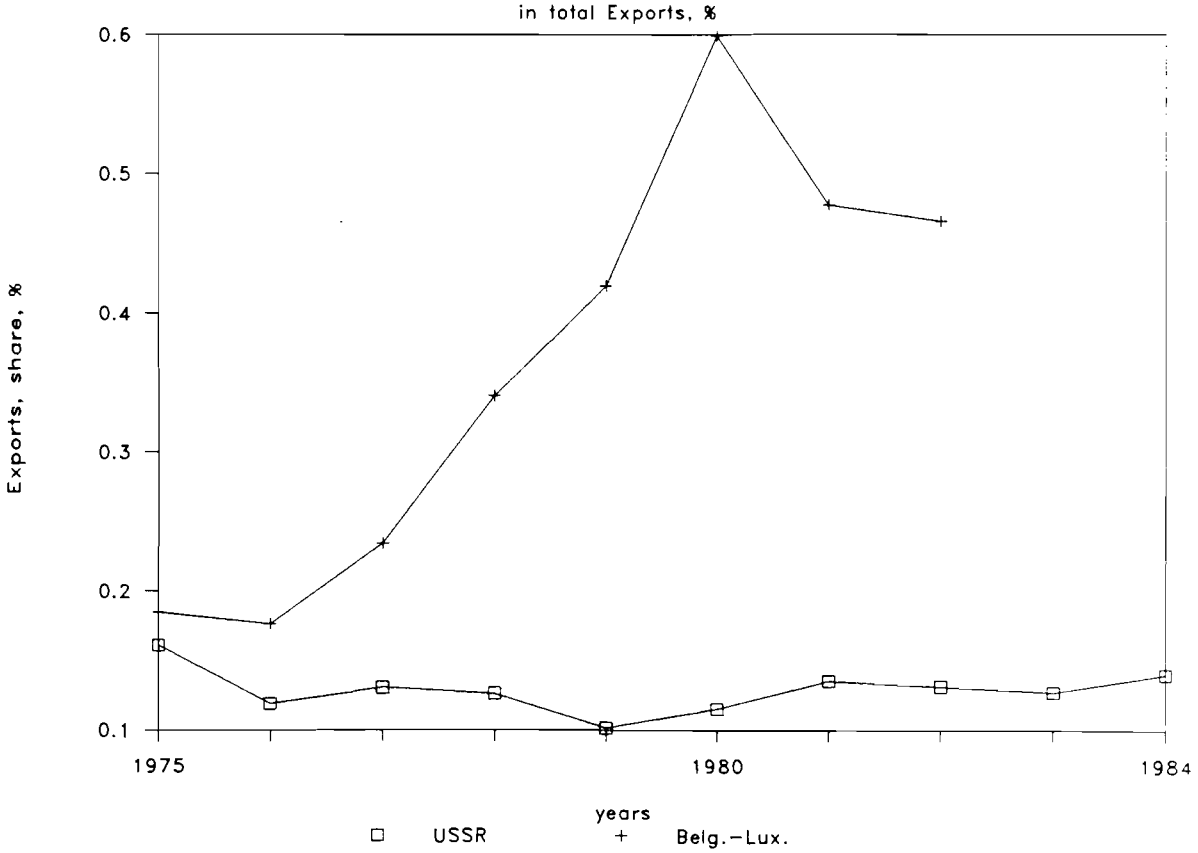

Fig.90 Pesticides Exports, thous.tons

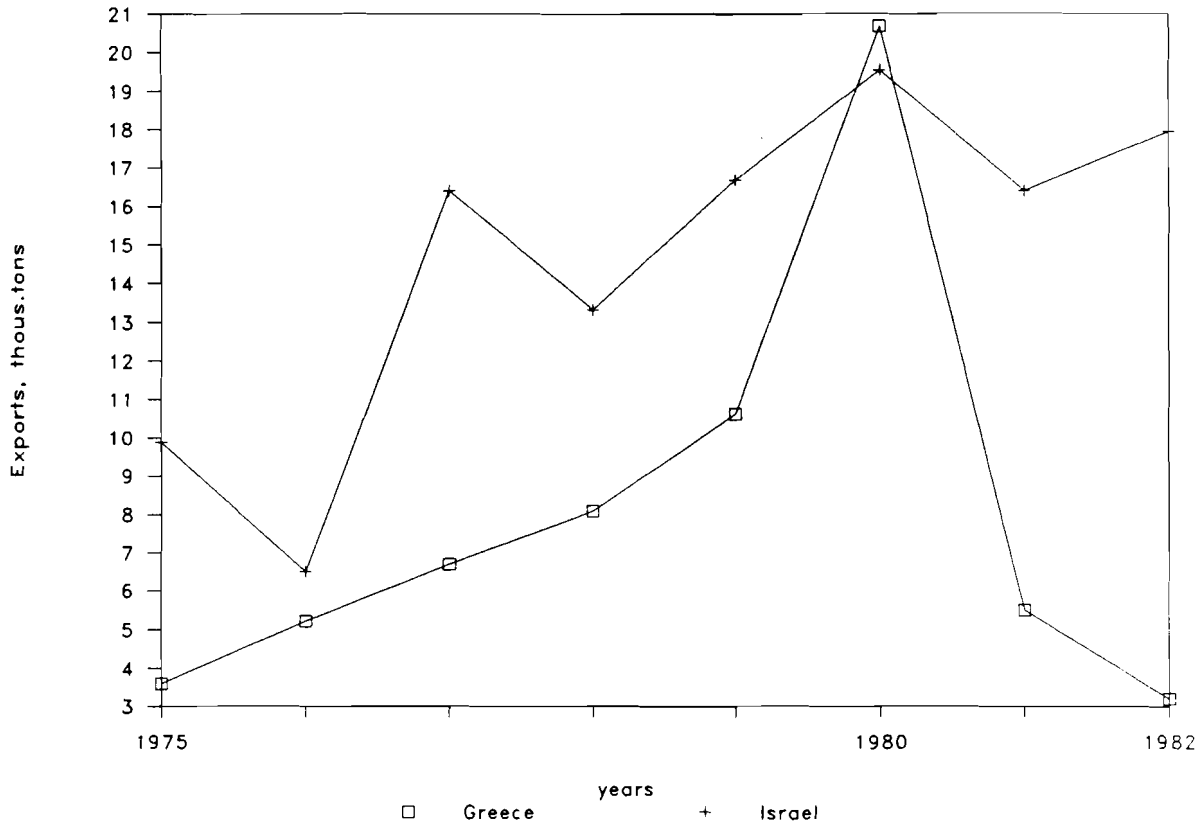

Fig.91 Pesticides Exports Share

in total Exports, %

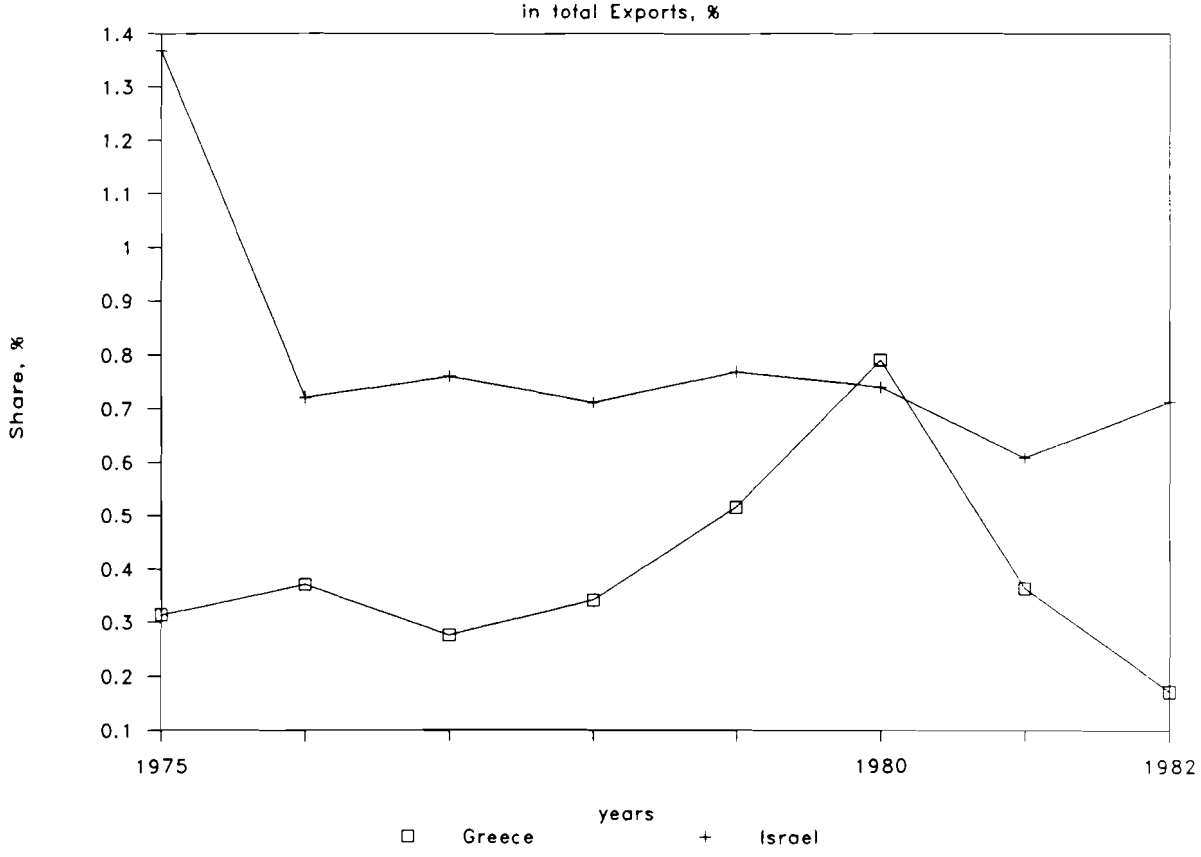

Fig.92 Pesticides Export Price

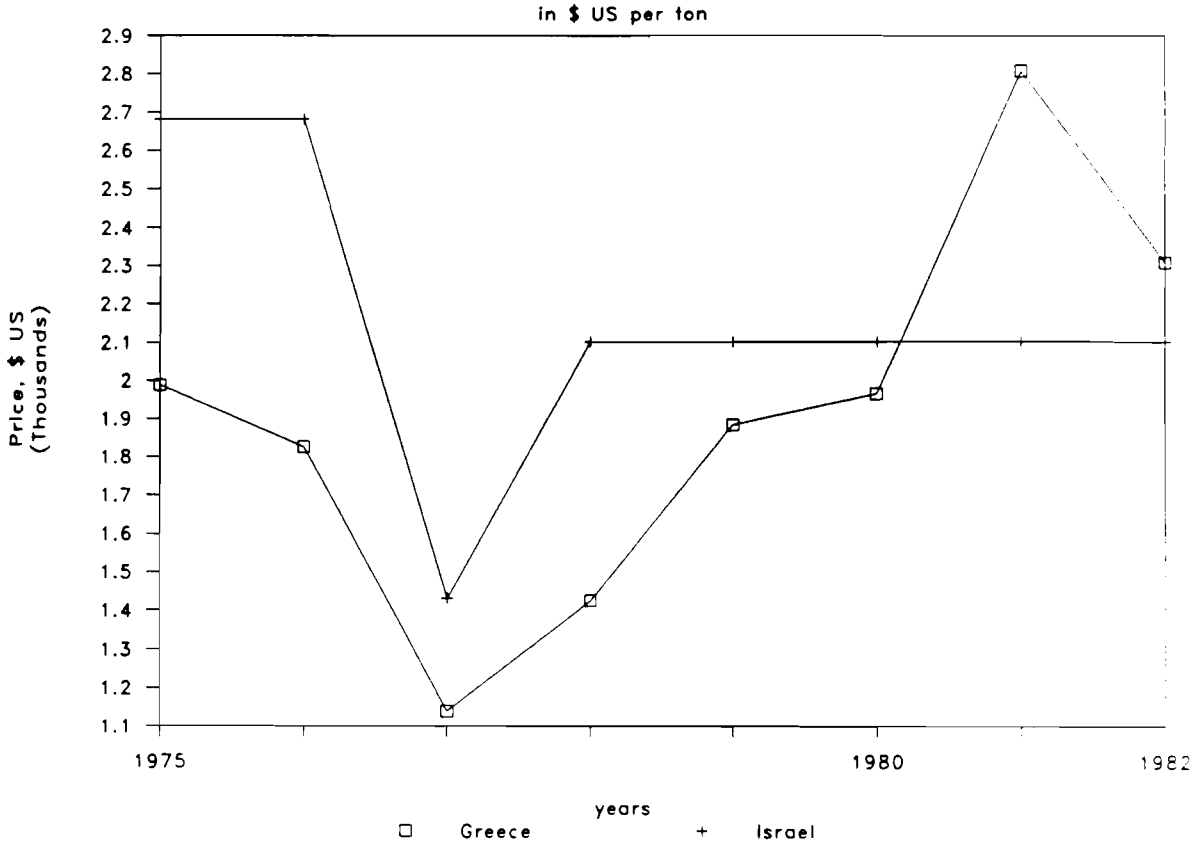

Fig.93 Pesticides Imports,thous.tons

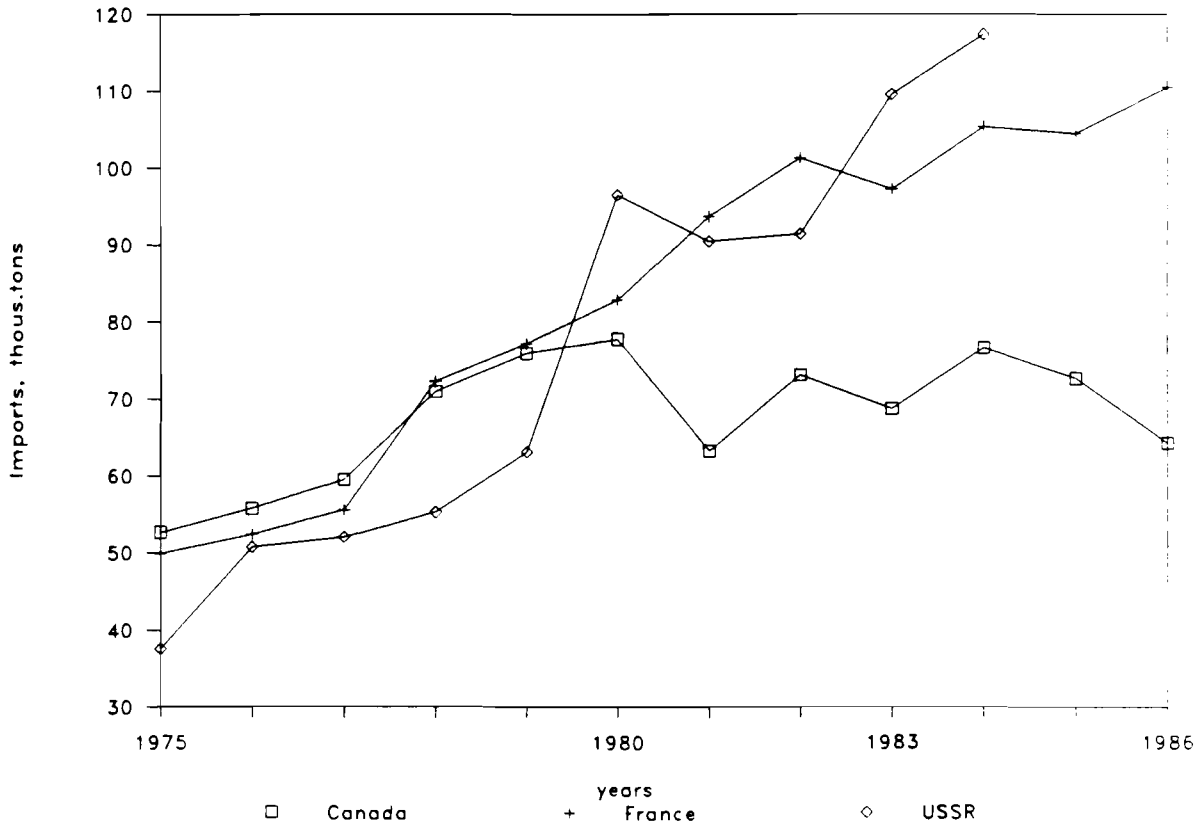

Fig.94 Pesticides Imports Share

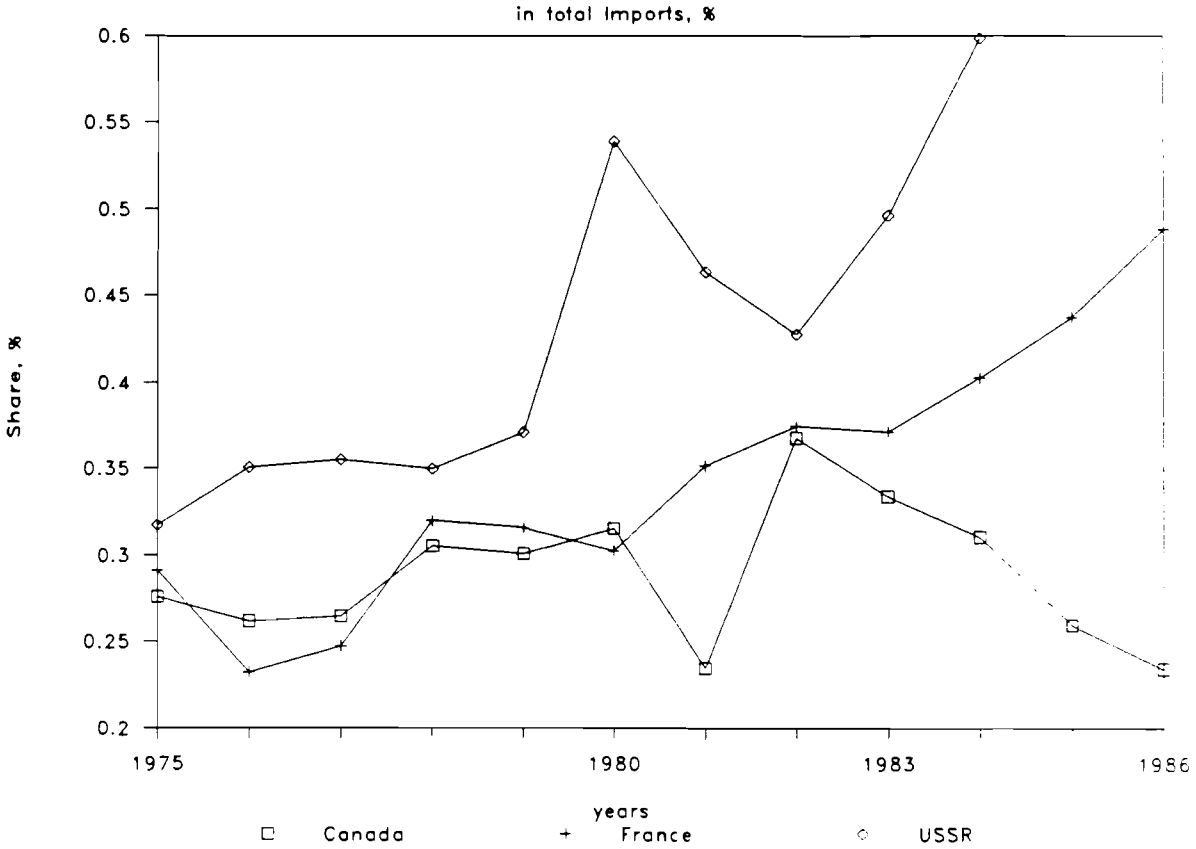

Fig.95 Pesticides Import Price

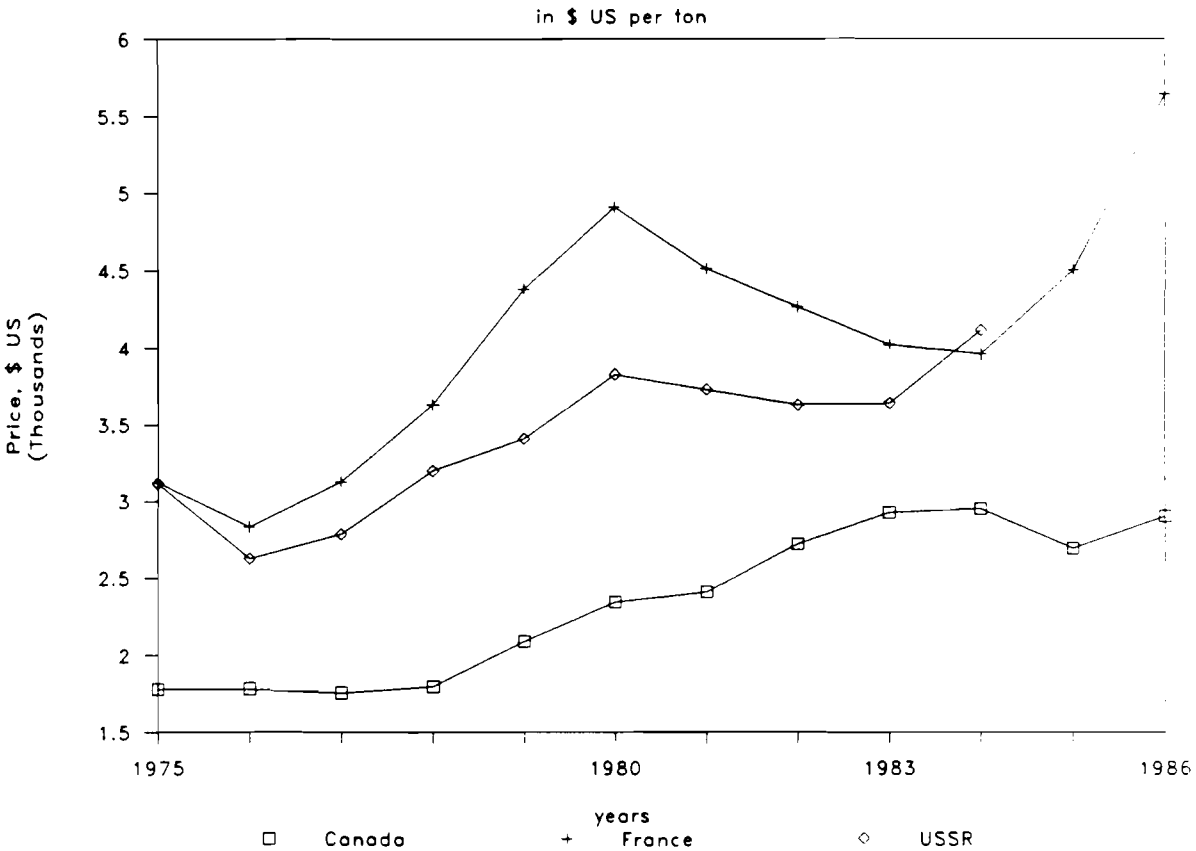

Fig.96 Pesticides Import Price

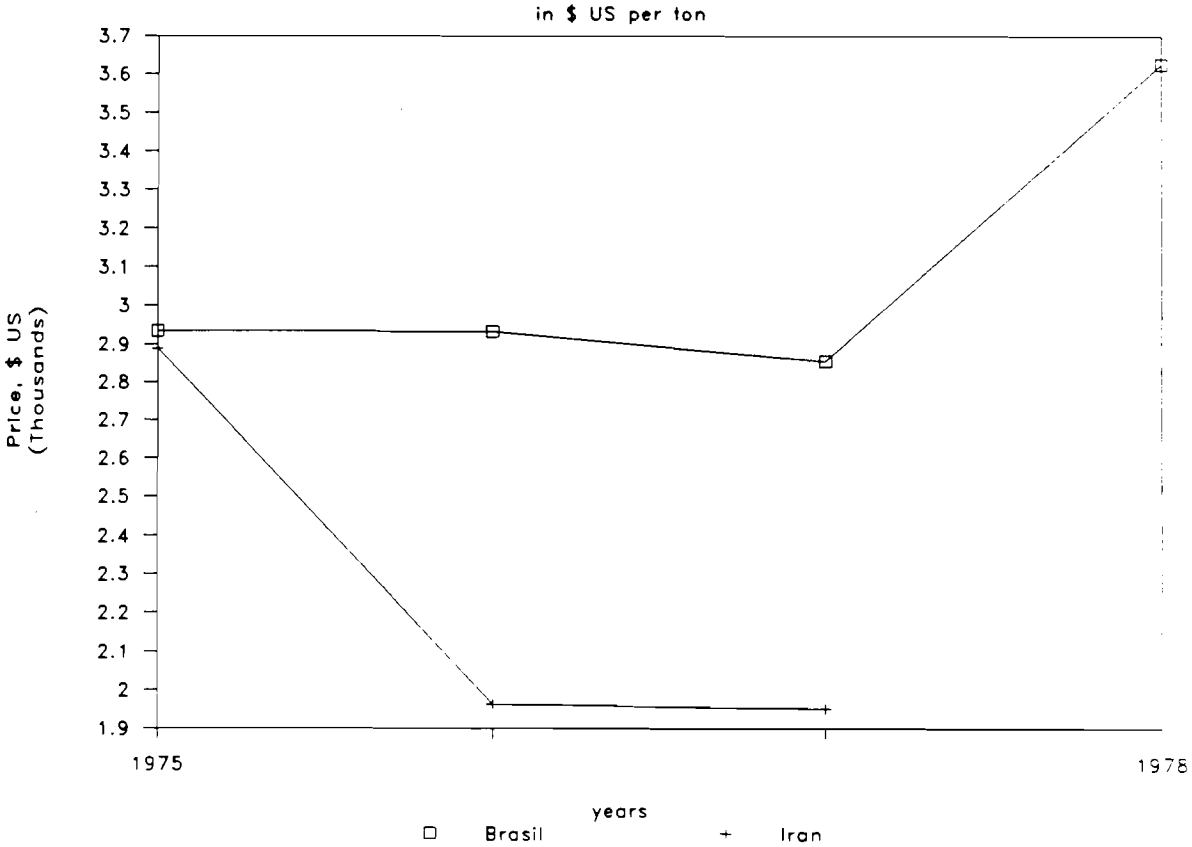

Fig.97 Pesticides Imports,thous.tons

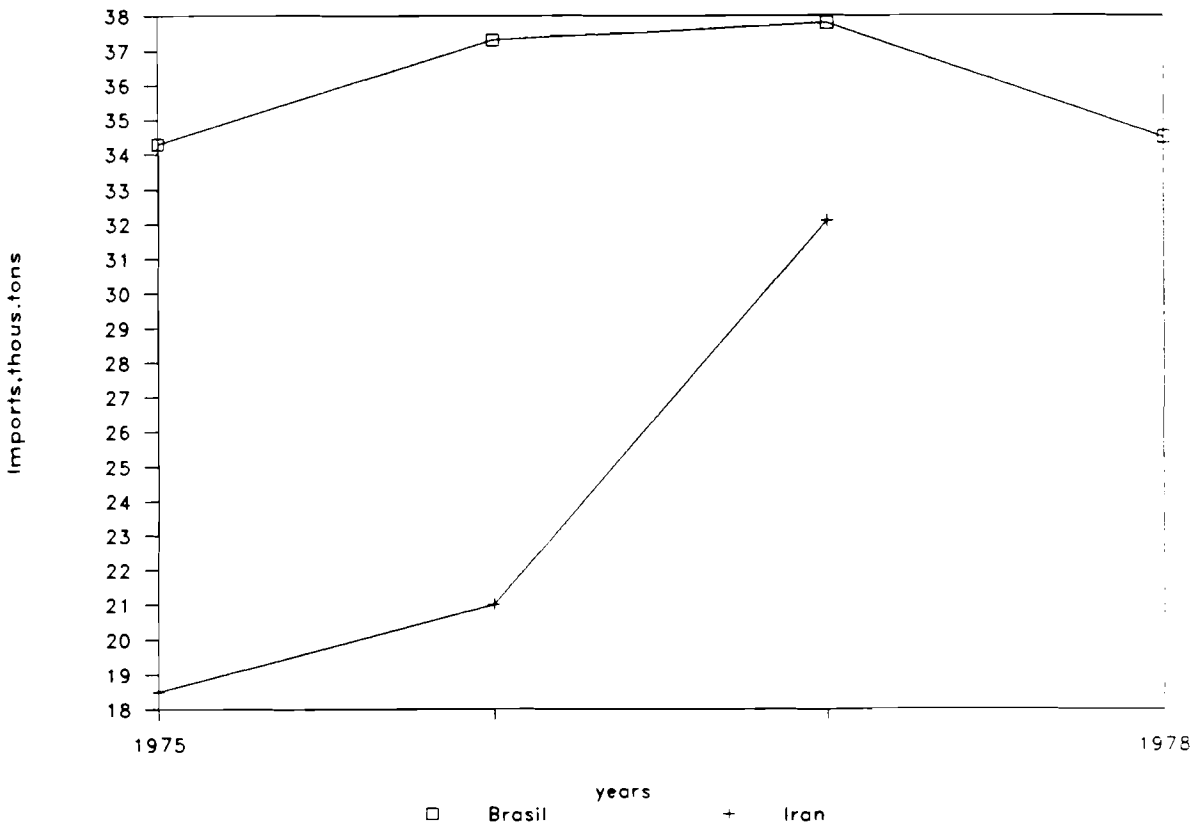

Fig.98 Pesticides Imports Share

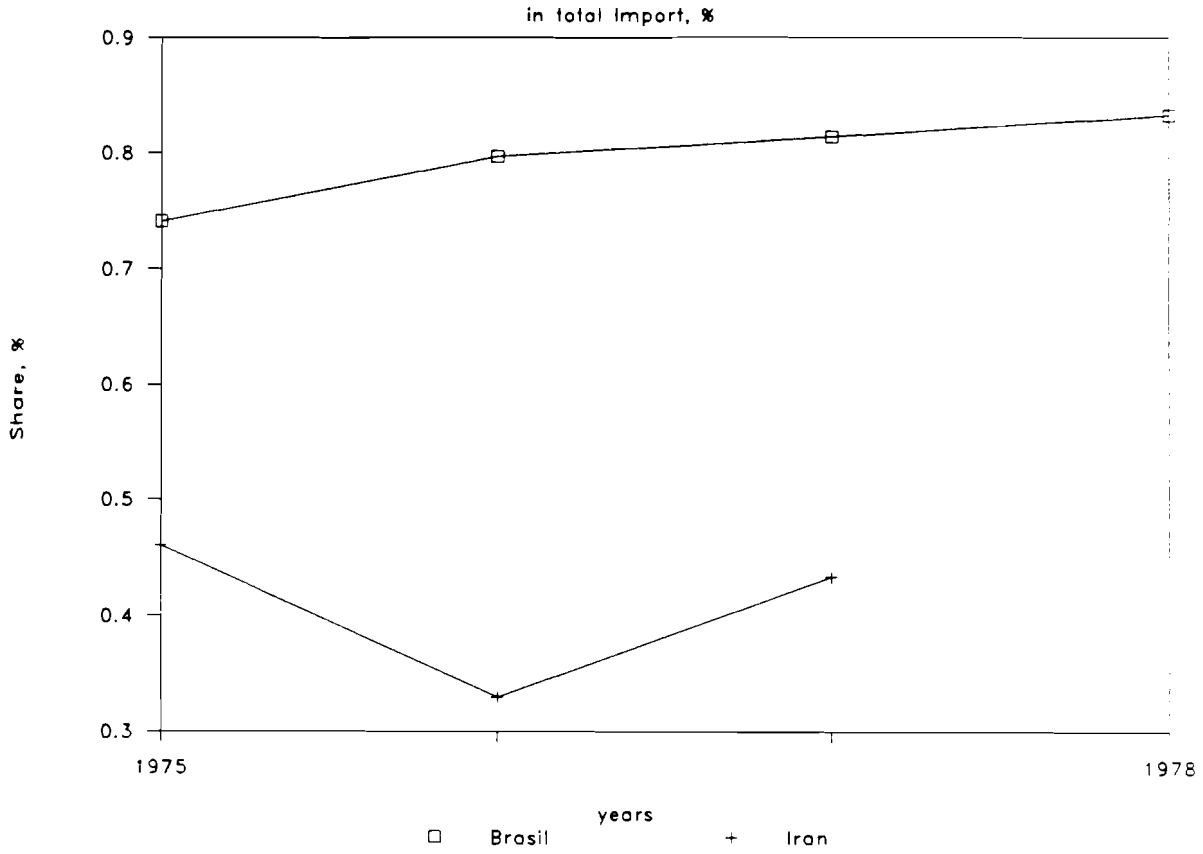

Fig.99 Pesticides Imports, thous.tons

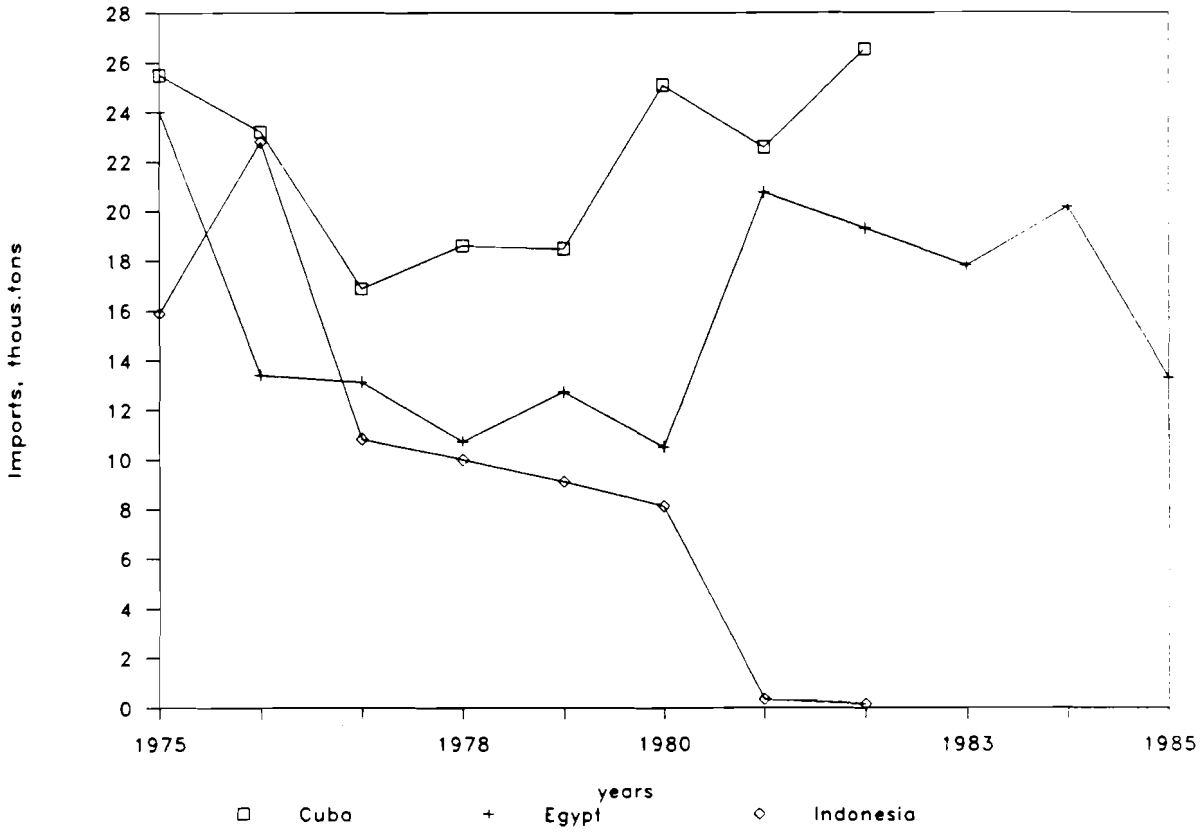

Fig.100 Pesticides Imports Share

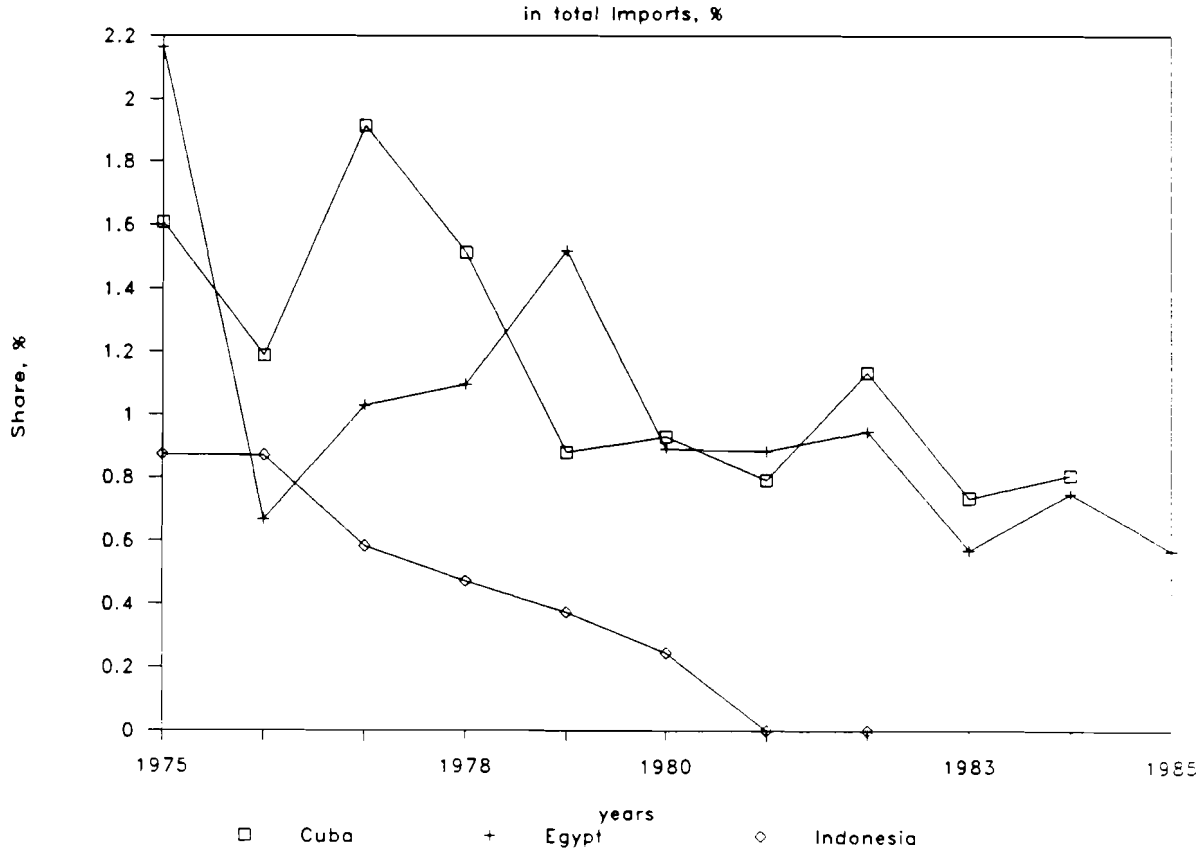

Fig.101 Pesticides Import Price

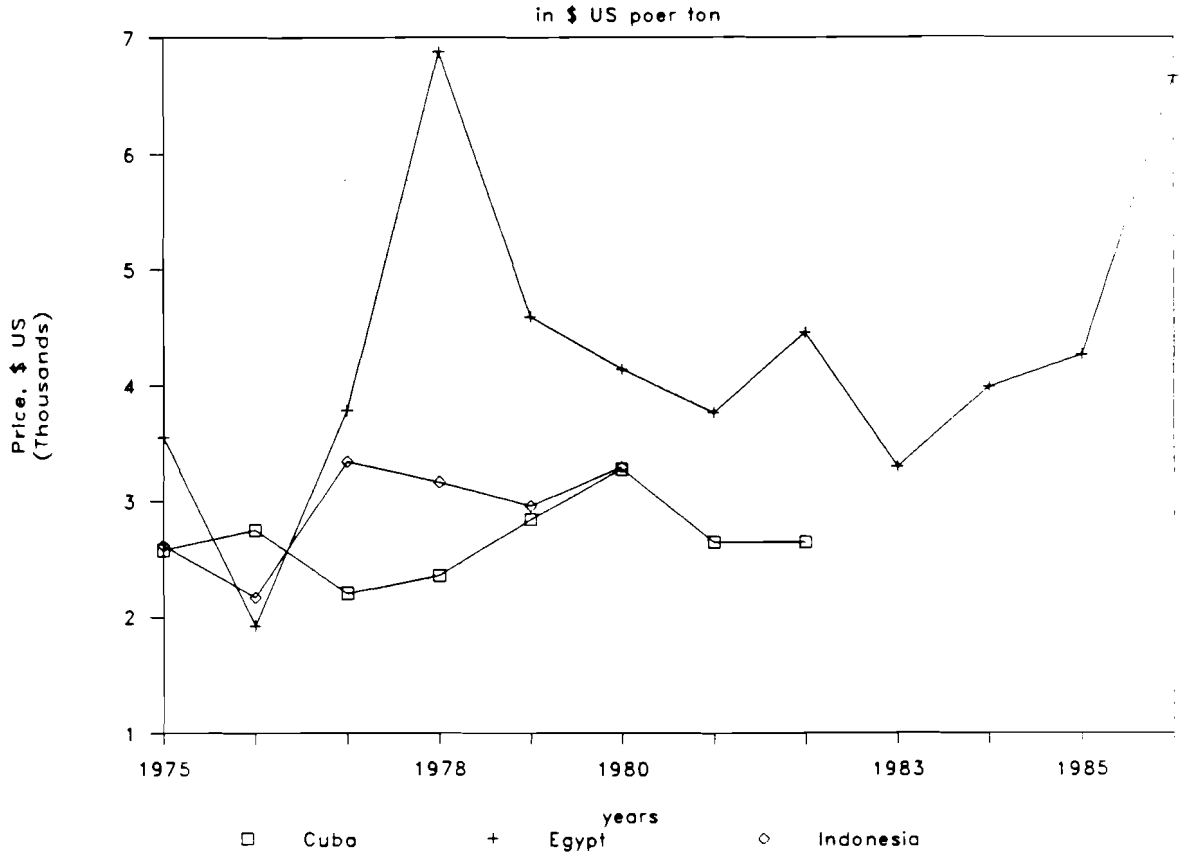

Fig.102 Pesticides Import Price

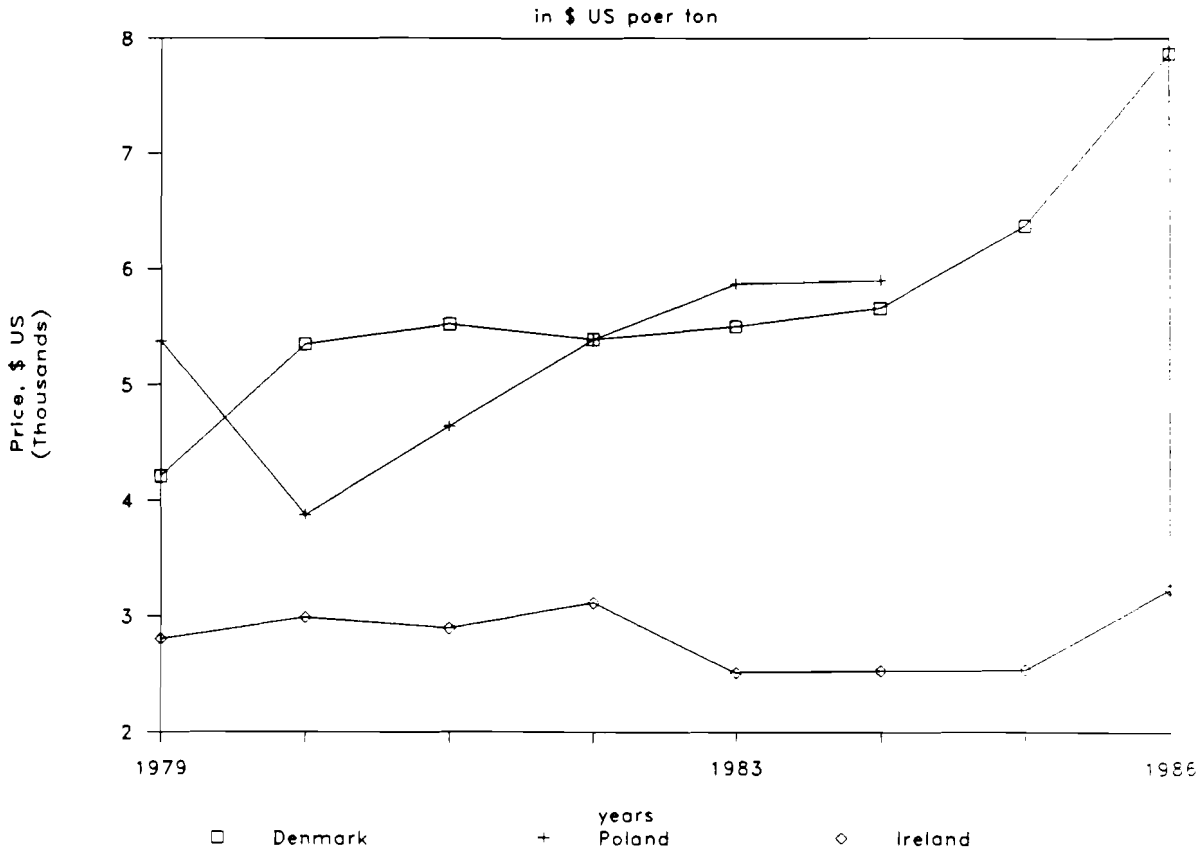

Fig.103 Pesticides Imports,thous.tons

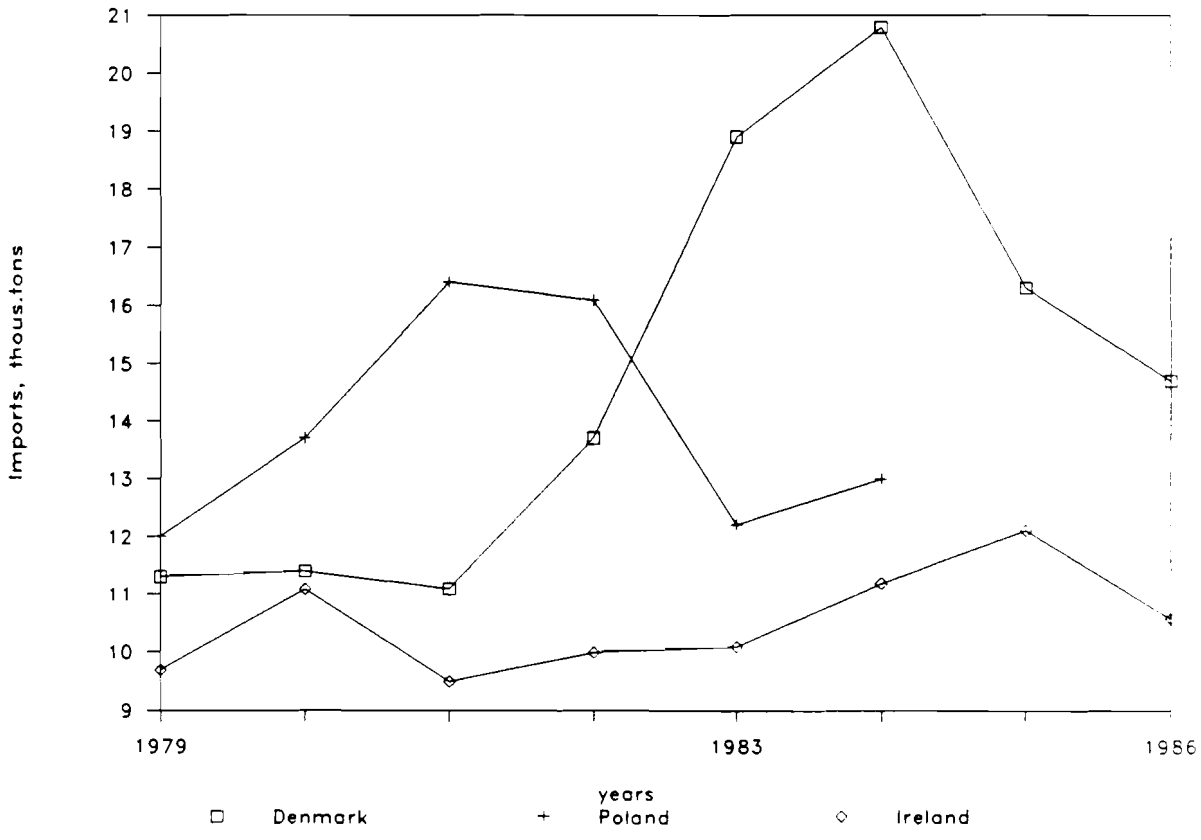

Fig.104 Pesticides Imports Share

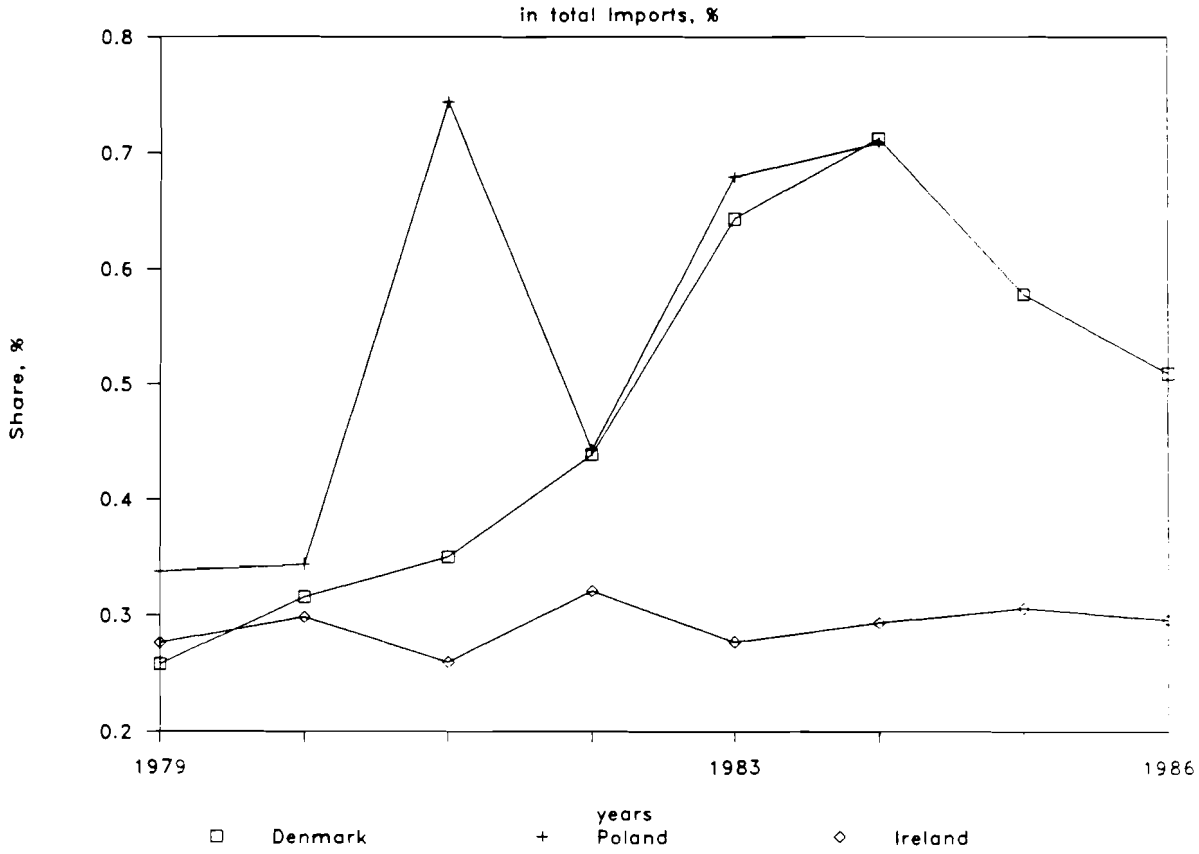

Fig.105 Pesticides Imports, thous.tons

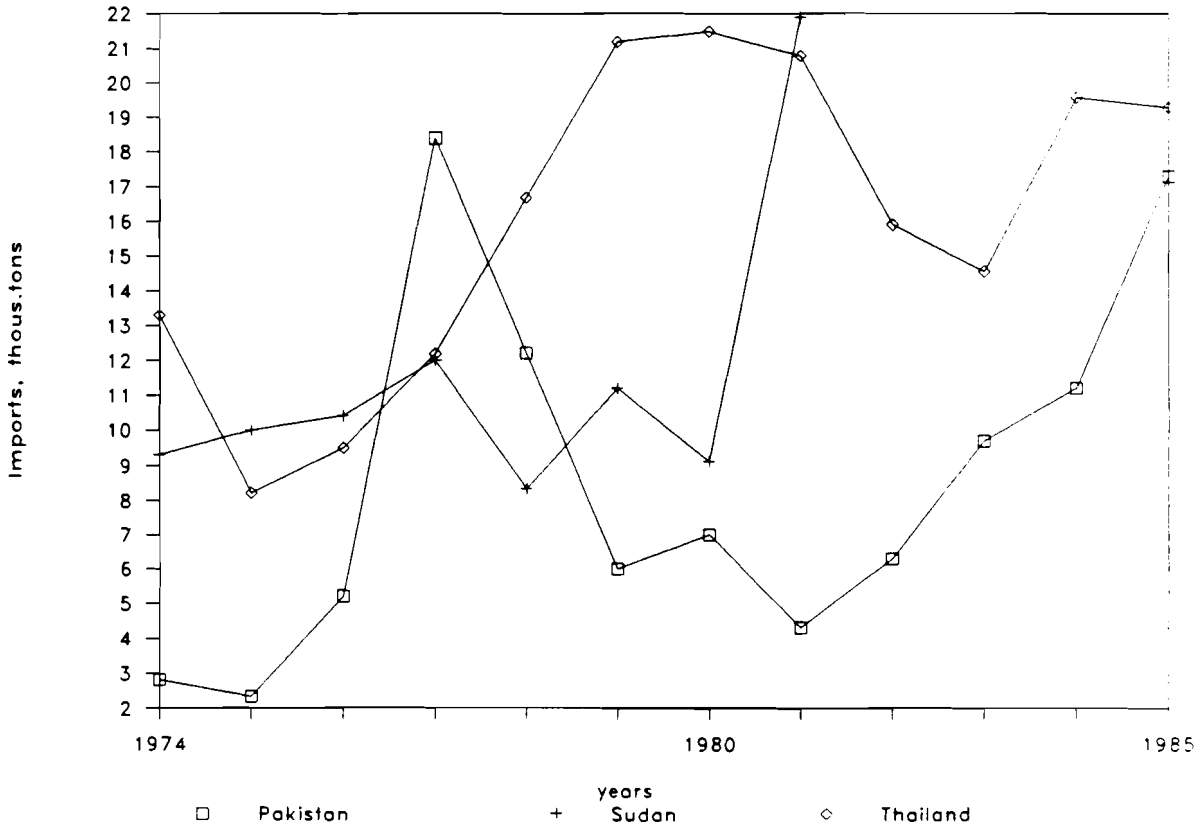

Fig.106 Pesticides Imports Share

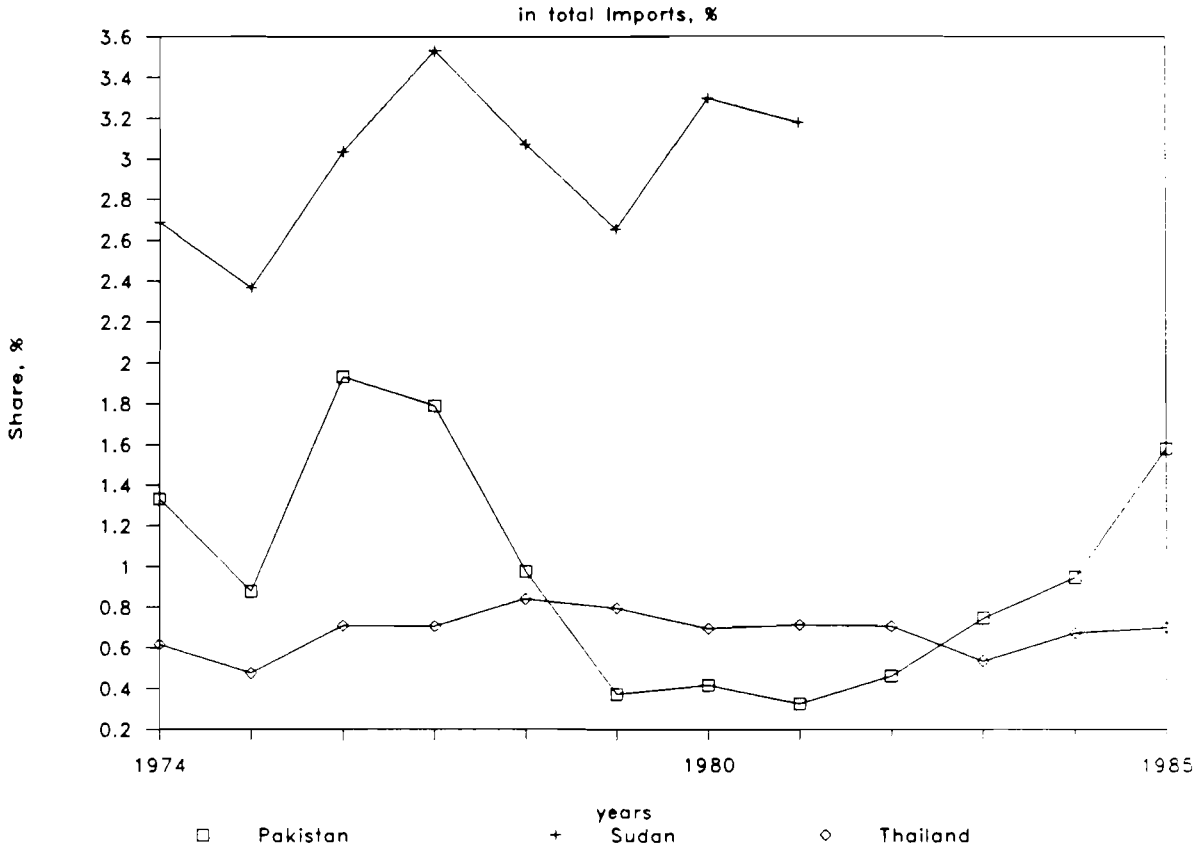

Fig.107 Pesticides Import Price

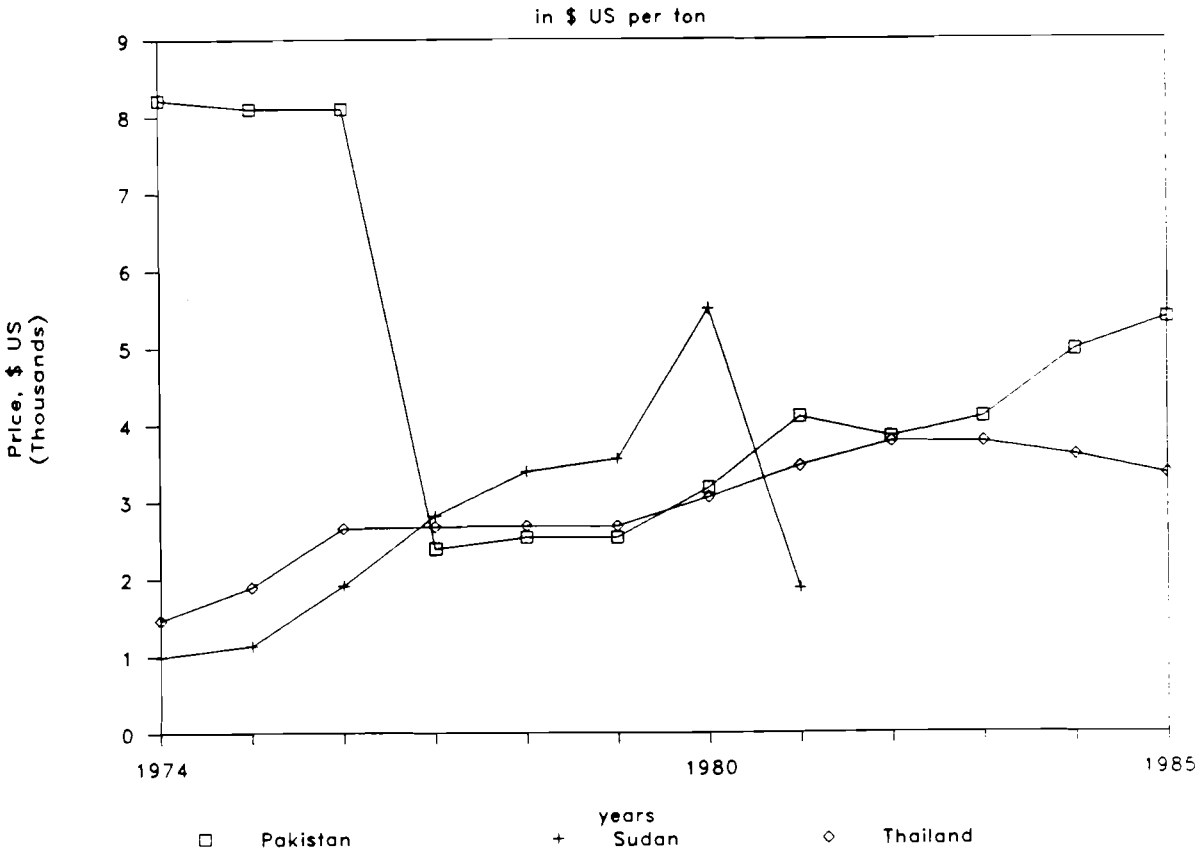

Fig.108 Share of energy inputs for pestic.

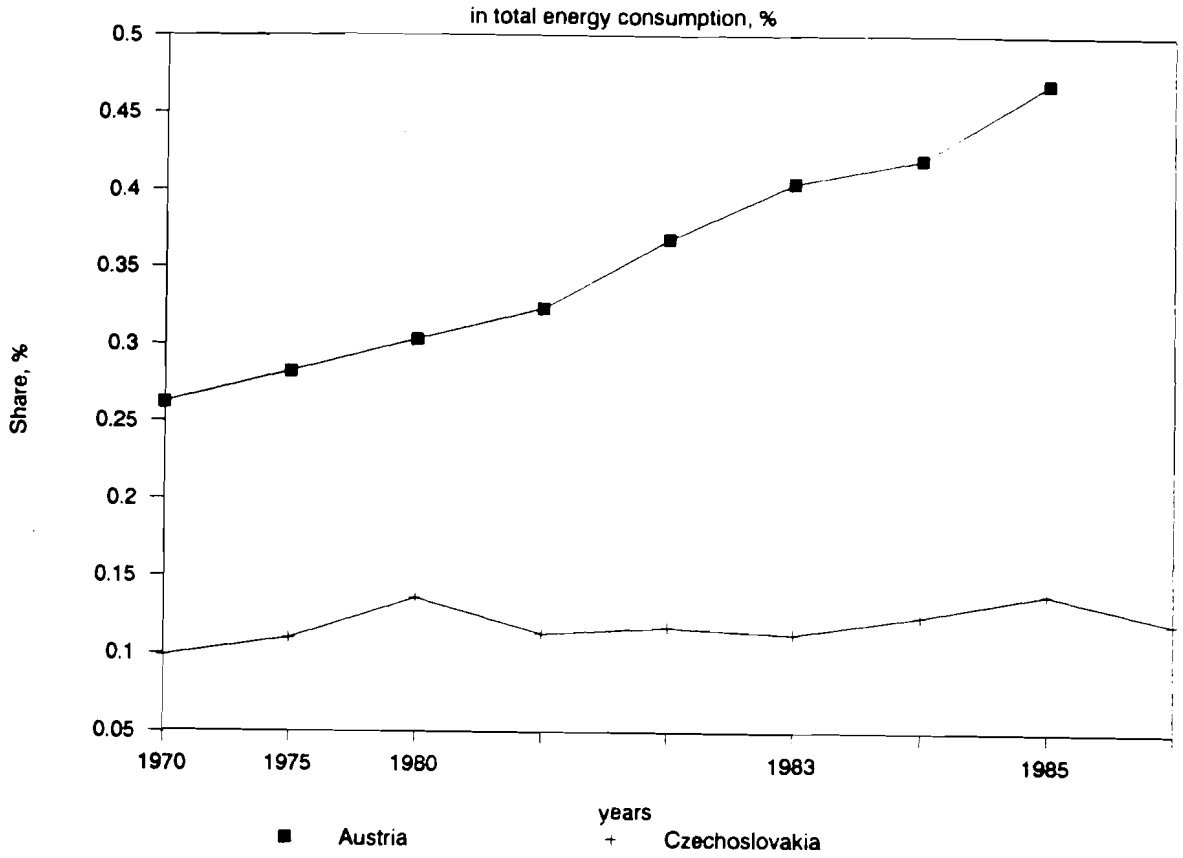

Fig.109 Share of energy inputs for pestic.

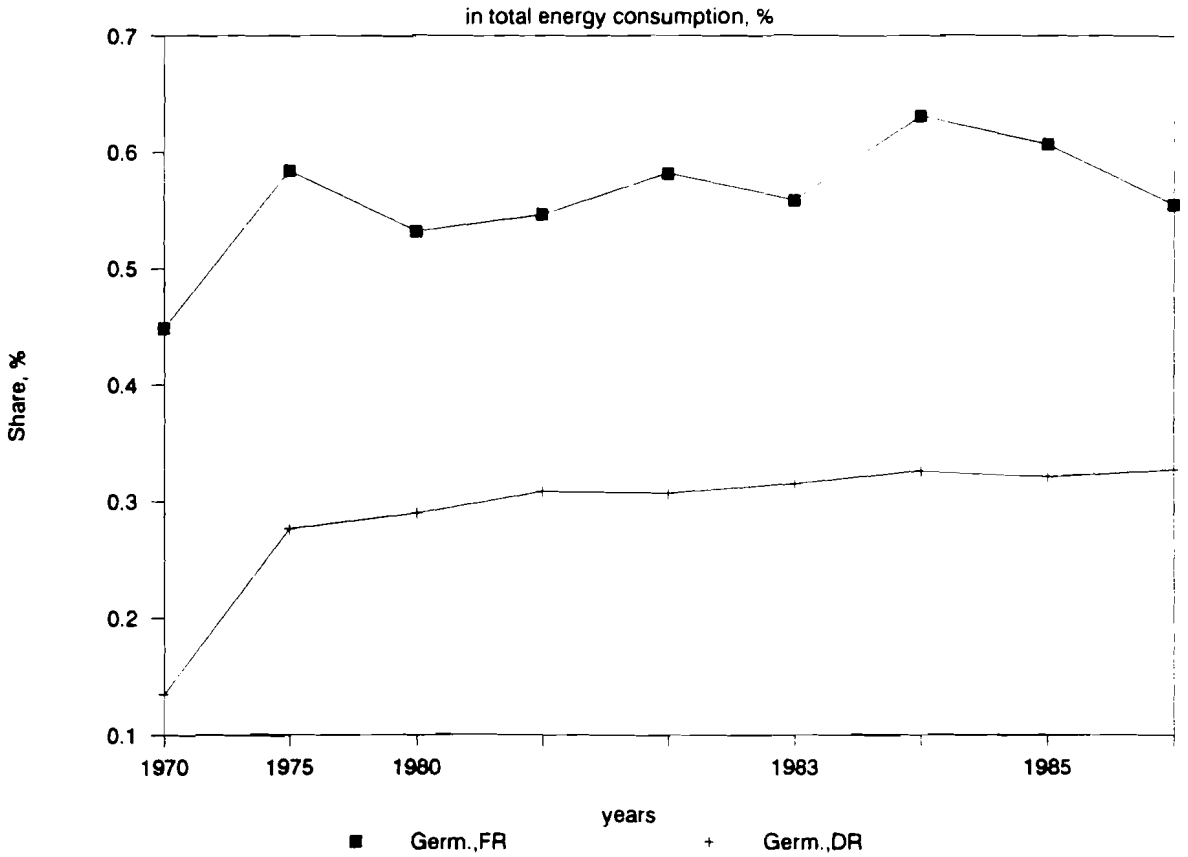

Fig.110 Share of energy inputs for pestic.

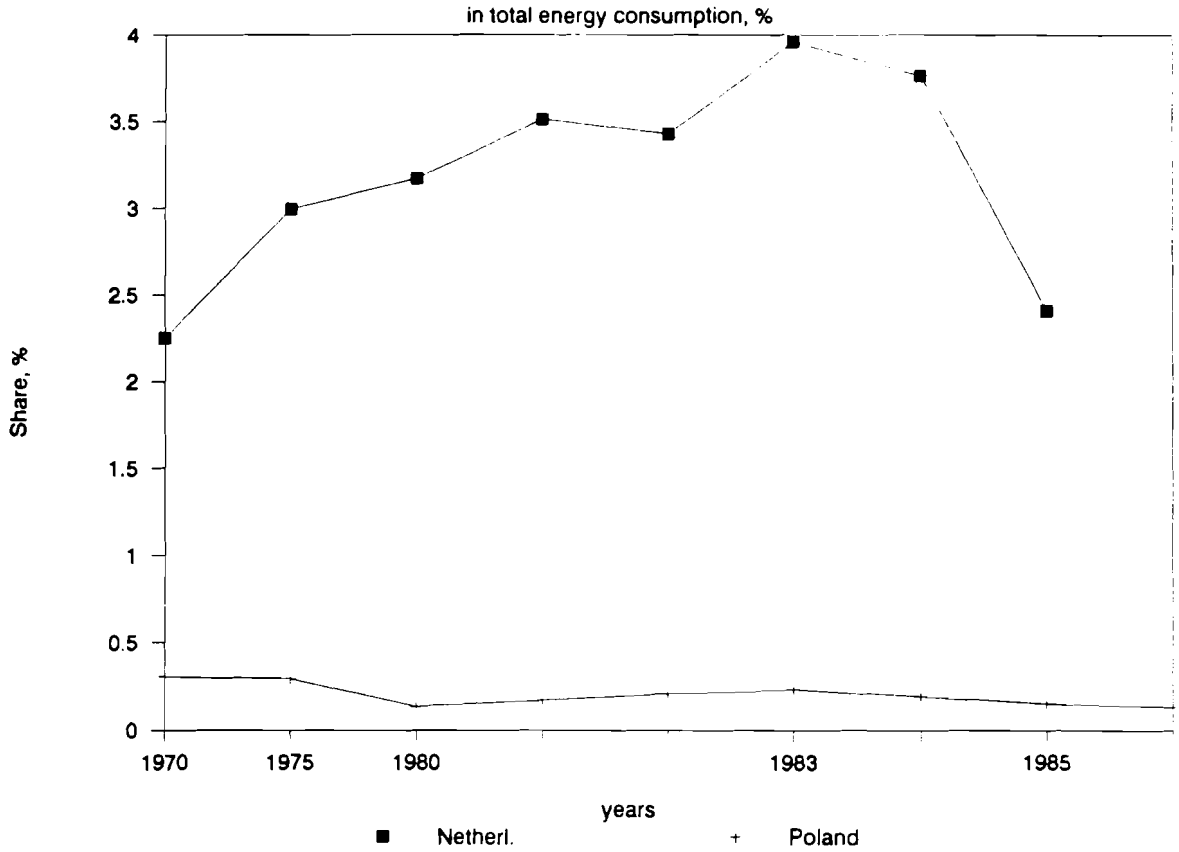

Fig.111 Share of energy inputs for pestic.

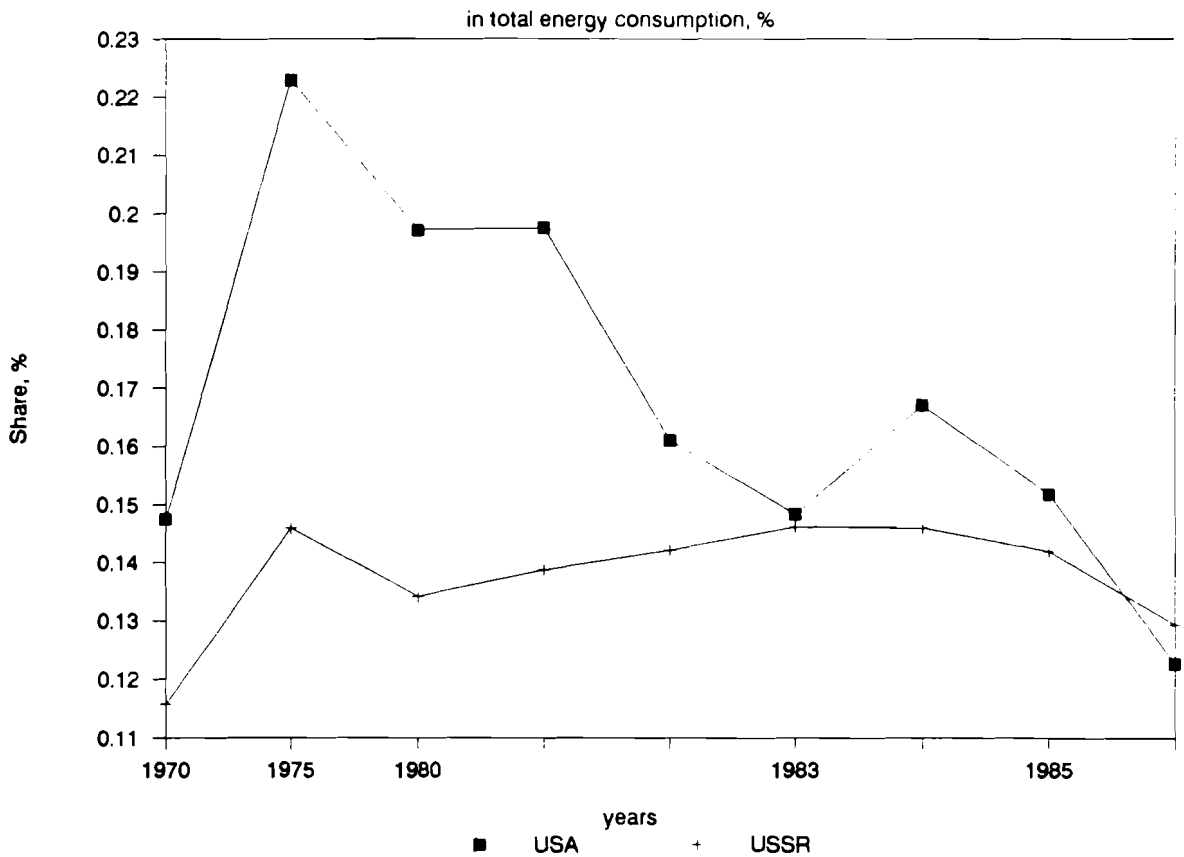

Fig.112 Share of energy inputs for pestic.

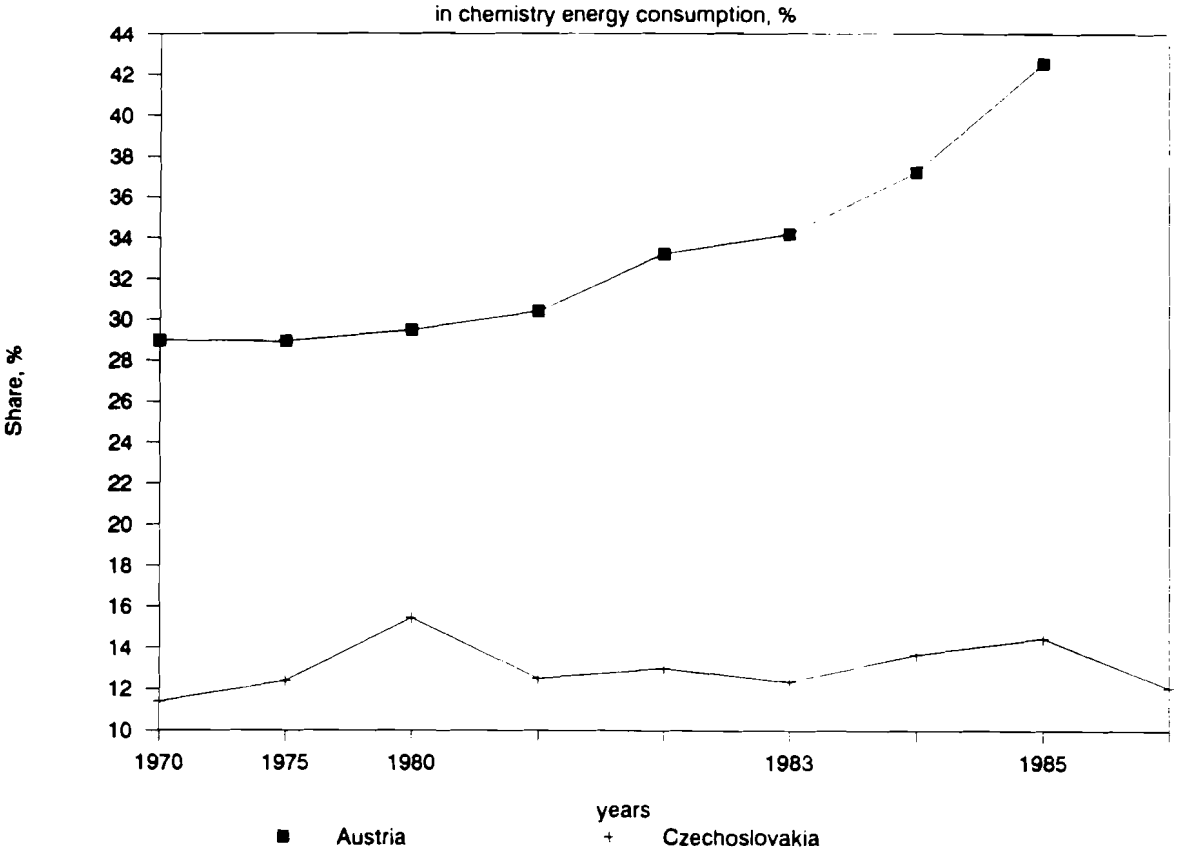

Fig.113 Share of energy inputs for pestic.