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Introducing new Crops and Crop Rotations in the Lower Mondego Valley Irrigation Project, Portugal

Die Einführung neuer Kulturen und Fruchtfolgen im Bewässerungsprojekt des Unteren Mondegotales in Portugal

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1 Introduction

Agricultural policy in Portugal aims to increase productivity and production in order to satisfy demand from a population that has rapidly grown. Within this objective, the creation of new irrigation schemes and the rehabilitation of existing ones has gained priority.

The Lower Rio Mondego Scheme is the largest of the national irrigation rehabilitation projects. The rehabilitation includes modernisation of irrigation and drainage networks and the introduction of intensive and mechanised farming. In this task the Portuguese Ministry of Agriculture is assisted by a German Technical Cooperation project (GTZ). The above mentioned measures are backed-up by appropriate credit facilities, a functioning extension service and an efficient marketing system.

The change from present land use to higher productivity and production levels requires testing of new crops and crop rotations in experimental fields and their introduction at the farm level. How this transition was planned and implemented in the Mondego Valley will be described in this paper.

To show the prevailing problems which had to be overcome the traditional farming systems in the valley are first outlined.

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2 Traditional Agriculture in the Mondego Valley

2.1 Climate and Soils

The lower Rio Mondego Valley lies in the middle of Portugal, near the coast at about 40 N and between 8 and 8.5 E, between the cities of Coimbra in the east and Figueira da Foz in the west, and comprises about 15.000 hectares (see Map).

The main valley has topographic levels of 16 meters near Coimbra, which drop to 0,5 meters above mean sea level in the far western part of the valley. Due to differences in sedimentation, the secondary valleys often have lower topographic levels than the main valley.

According to Koeppen's climatic classification, the climate in the lower Mondego Valley is of the type Csb, i.e. a warm climate with dry summers and a mean temperature in the warmest month below 22° C with at least four months above 10° C.

The mean annual rainfall ranges from 990 mm in Coimbra to 710 mm in Figueira da Foz at the Atlantic Ocean coast. The influence of the Atlantic Ocean is also noticeable in the lower summer temperatures and higher temperatures in the westernmost area.

Near the coast occasional night frosts occur in February. Further inland the risk of night frost is slightly higher during the period November to March but only for an average total of 5 to 10 days per year.

The soils in the lower Mondego Valley are recent alluvial deposits unterlain in the western part by maritime deposits. As the present material of which the Mondego deposits are derived are schistic and quarzitic, the soils in the main valley are not calcareous.

The soils in the middle part of the Mondego Valley show mild to moderate alkaline reactions due to the influence of the calcareous material of the secondary rivers in this area, while the eastern part of the Mondego Valley again consists of soils which are medium acid to neutral.

In the higher eastern part of the project area the soils have silt loam to loam textures in the first 50 cm of the profile, underlain by lighter textured layers.

In this area the soils have high to very high infiltration rates and readily available moisture contents which range from low to medium. Further to the west the clay content increases, resulting in clay loam to sandy clay loam textured soils with medium infiltration rates and high readily available moisture contents.

The organic matter content of the soils is generally high and the nutrient status favourable, except for the phosphate content of the acid soils where phosphate fixation occurs due to low pH values.

An overall phenomenon is the presence of a compact, rather impermeable layer at a depth of about 30 cm. This layer, which is about 25-30 cm thick, is caused partly by the mobilization practices of wet-rice cultivation and partly by differences in deposition. It has to be broken either by subsoiling or by deep plowing to drain the soils and extend the effective rootzone, if crops other than wet-rice are cultivated.

The water quality of the Lower Mondego river imposes no restrictions on crop selection (pH = 7.1; EC mmhos/cm = 0.11; SAR = 0.89).

2.2 Traditional cropping patterns in the valley

Rice, with 54% of the total area, is at present the most important crop in the Mondego Valley.

In general soil preparation for rice starts about April. The majority of farmers use tractors for this work. After the soil has been ploughed the fields are flooded to a depth of 5 to 10 cm. Thereafter the seedbed is prepared by using a kind of harrow with only one line of teeth several times. The desired effect, i.e. puddling, is achieved by the combined influence of the harrow and the cage wheels of the tractor. Following soil preparation the pre-germinated rice seed is sown into the water either by hand, tractor-drawn machines or by aeroplane. The seed rate is about 200 kg per hectare. The rice varieties used in the project area are: Allório, Stirp, Ponta Rubra, Aricombo, Ribe.

As far as the present irrigation system allows, farmers alter the water level according to plant growth. Plant protection is carried out when necessary and a total per hectare amount of 110 kg N and 60 kg P_2O_5, that is, 60 kg N and 60 kg P205 as basic fertilisation and 50 kg N and 50 kg K_2O as top dressing, the latter applied every forth year.

About September/October the fields are drained and the rice is harvested. The usual method of harvesting is with combine harvesters, running on tracks. These are owned either by a single farmer or group of farmers, cooperatives or individuals who carry out the work for payment. The straw is baled and used for the animals either as feed or litter.

Traditionally a maize-bean mixture has been grown mainly by family farmers on about 8.000 ha of the Mondego Valley. However, since about 1979 its area has been decreasing to around 3.600 ha and rice is grown there instead.

The mixture is generally sown in April after the soil has been prepared in the traditional way, which is by plough and disc harrow. It is sown in rows either manually or by seeders which are drawn by animals or men. Maize (seed rate 50 kg/ha) and beans (30 kg seeds/ha) are grown together in the same row and the distance between rows is about 60 to 70 cm. In August or September maize yields about 2.500 kg/ha and beans about

250 kg/ha. Harvesting is done manually. The irrigation system used is furrow irrigation with 2 to 3 applications of water depending on the requirements.

During the winter a limited amount of forage is cultivated i.e. Lolium multiflorum or an oats-vetch mixture. Soil preparation is the same as for the summer crop and all other work is done manually. Seed density is about 35 kg/ha for Lolium and 150 and 40 kg/ha for oats and vetch. The vegetation period is from October/November to March/April.

Farmers only harvest the daily feed for their animals. On average two cuts are harvested but exact information on yields is not available due to the more or less permanent harvesting and re-growth.

As regards vegetables potatoes is the crop produced by almost all farmers. On average 30% of production is for home consumption and 70% for sale.

In other even smaller fields peas, beans, tomatoes and onions are grown for local markets.

2.3 Orchards, vine yards and poplar plantations

Although fruit trees and olive trees exist all over the valley, they only cover about 55 ha each.

Vines are grown on about 380 ha. The wine produced is of inferior quality and is also almost exclusively for home consumption.

At present about 180 ha of poplars are grown in the valley for the production of matches. Every 9 years the trees are cut, involving about 20 ha per year. The average yield is 16 t/ha.

2.4 Animal husbandry

The total number of cattle in the project area is about 21.000, which can be broken down into 4.000 milk cattle, 8.000 meat cattle and 9.000 working cattle (1981).

In the Mondego Valley milk production on a larger scale started in 1976 after the introduction of Friesian cattle. At present these are kept on small farms with up to 5 but as a rule only I or 2 cows. Only very few farmers have more than 20 or 30 cows. Average production is 2.500 lt/year.

For centuries working cattle have been kept in the project area for soil preparation for all crops and for transport. Even today a considerable proportion of the work is carried out by working cattle, although this proportion is decreasing.

The cattle fattened in the Mondego area are crossbreeds of Charolais and only very

rarely pure-bred. Sheep are normally kept in herds of about 70 to 100 head, with one shepherd for 100 sheep. Some herds consists of up to 170 head. Many small farmers have 1 to 2 sheep which eat fodder left by the cattle.

2.5 Farm size distribution

The farm-survey carried out in the Mondego Valley in 1980/81 showed the number of farms in the Valley to be about 7.600 and the number of land owners to be 13.000. The average farm size is about 3.5 ha with an average area of 1.7 ha in the valley. The average number of plots per farm is 3.6.

3 Planning and implementation of the change

The planned increase in agricultural production is intended to be achieved by intensification of cropping and forage production. This requires improving technologies for existing crops such as rice and maize, the introduction of new crops and the adaptation of intensified crop rotations. This process is scheduled to take place in four steps as follows:

1) Organisation of experimentation.

2) Planning and execution of trials.

3) Testing solutions on a larger scale.

4) Advising farmers.

In the following subchapters these steps are described in more detail.

3.1 Organisation of experimentation

The original plan was to establish three research stations in the valley, i.e. one for each of the three soil types (see subchapter 2.1). In addition, the different natural resources and the distance farmers would habe to travel in order to visit these stations were of great importance in the choice of their location.

After a short time the idea of having three stations had to be abandoned, mainly because of the station's investment and maintenance costs and the fact that in a region with the given property structure the area required was difficult to find in one lot. Thus, only one station was installed in 1979 on the heavy soils near the estuary at Quinta do Canal.

However demonstration fields are used in varying locations in the project area.

The experimental station has an area of about 25 ha divided into 10 fields. An office

building and a machine shelter were erected. The equipment, including a combine harvester and a 140 HP tractor, was financed by the government of the Federal Republic of Germany through a technical cooperation project (GTZ). The first trials were carried out in 1980.

Limitations arose from the lack of irrigation water in summer which made research into irrigation rather limited. Final improvement can only be expected when the overall hydraulic structures have been successfully completed.

3.2 Planning and execution of trials

The development of modern, more profitable agriculture under irrigation was not though to be possible without changing traditional production techniques. In order to achieve this alternative crops to rice and maize-beans or adequate production techniques and an efficient mechanisation system were required.

Several problems had to be overcome:

1) The soils in the Mondego Valley especially on the lower part, are very difficult to handle:

   - when they are wet tractors sink in or cause compaction with resulting impediment to plant growth;
   - when the top-soil is dry and the subsoil is still wet the equipment only presses the hard top-soil layer into the soft subsoil without any real tillage;
   - when the soil is completely dry soil preparation is totally impossible.

   Soil preparation is satisfactory during only a very short period of the drying process. One of the tasks of the soil preparation trials at the station therefore had to be to recognize this period and to use it successfully. Three methods of soil preparation were compared to the traditional one (see Table 1).

2) The required drainage on the heavy soils in the valley only works in combination with subsoiling. Extensive research into subsoiling and drainage therefore had to be carried out. A number of different filters were tested. Three methods of subsoiling were investigated: deep ploughing, subsoiling with vibrating tynes and mole-drain (see Table 1).

3) Mono-culture rice had to be replaced in some areas by other more economic crops since rice for climatic reasons cannot yield much more than 5.000 kg/ha in the Mondego valley. Efforts were made to find ways of using the land permanently instead of only during 5 months with rice as at present. Several varieties of wheat, maize and forage were tested (see Table 1).

Table 1: Trials carried out at the experimental station of the Mondego Valley

Trial factors	Treatments
Subsoiling and drainage	Deep ploughing, Subsoiling with vibrating tynes, mole draining
Soil Preparation	Plough and disc-harrow, Rotary cultivator, Multitiller
Distance between drains	9 m, 18 m, 27 m, 36 m
Drain Filters	Cocos, Nylon, Ricestraw, Sand
Drain-Diameter	50 mm, 65 mm
Drain perforation	Standard, No perforation, Small perforation
Drain Decline	1.0%, 2.0%
Forage varieties	Forage beans, Oats/Vetch, Persian clover/rye grass, Egyptian clover/rye grass
Maize varieties	Pivot, Matador, Metro, Rebel, Mirac, Ricca, Helix, Precox, G 4252
Wheat varieties	Arosa, Coconit, Mexicano 1481, Mara, Xecora, Nazareno Strampelli

4) Due to drainage problems some parts were to remain under rice production. The problem was to increase production efficiency in these areas. On the experimental station a system of soil preparation on dry soils was developed. Although results are promising so far (yield increased up to 10%) more work is required. Moreover, it was found that the rice fields could be used continuously when a clover-grass mixture was chosen for winter fodder production.

As a result of the experiments three different cropping patterns have been developed. As soon as the new water control stuctures have been established in the valley, a change towards these pattern is expected:

- On approximately 4.500 ha near the coast on heavy soils in low lying areas, rice and winter forage should be grown. This area is designed to be irrigated through a one-canal rice irrigation system.
- On approximately 5.000 ha in the centre of the valley with somewhat lighter soils, fodder crops such as maize, sunflower and sorghum can be grown in summer, with grass-clover mixtures in winter. This area is designed to be under surface irrigation.
- Approximately 5.000 ha in the western part of the Valley near Coimbra can be

used for fodder production and vegetables (tomatoes, beans, strawberries etc.). The major part of this area is designed to be under sprinkler irrigation.

3.3 Testing experimental results on a large scale

The farmers of the Mondego valley are not accustomed to permanent exploitation of natural resources with all the resultant consequences. Although in adjoining higher-lying areas, the so-called "montes", permanent but extensive agriculture is common, it is beyond the present capabilities of most farmers to use the "montes" and the valley more intensively. To overcome farmer's reluctance regarding permanent use of the land the recommended crops were grown in cooperation with some farmers whose land was already suitable before the new structures were completed.

Starting in 1986, following the development of the agricultural land, 22 demonstration fields will be established covering all areas of the valley. In these fields the new crops and cropping techniques will be demonstrated in cooperation with the regional extension service.

3.4 Advising farmers and implementing supplementary measures

To improve the extension service for the lower Mondego valley the following developments were required:

- Establishment of a Rural Training Center on the border of the project area. Courses on various subjects are given in this school for farmers.
- The creation of "Farm Management Groups" (Grupos de Gestao Agricola). In 1984 there were four in the valley area. These groups consist mainly of farmers who act as village level advisors (contact farmers) at regular meetings where groups receive talks on subjects of special interest. The officials in charge of the groups receive monthly instruction from specialists (e.g. animal husbandry, plant protection, accounting, economics).
- The local advisors of the extension service of the Regional Directorate for Agriculture (DRABL) are informed regularly on the results of experiments carried out in the area by various institutions (INIA, Projecto Mondego and the DRABL).

Supplementary measures to enable farmers to adopt the new cropping techniques are mainly:

- Land consolidation. This will result in 3-4 ha plots in which crop production can be fully mechanised and a new road system established (transport time savings);
- Special credit lines to facilitate farm level investment required.

– Market studies to indicate future production prospects for the main products and to improve their existing marketing system.

4 Economic effects on farm level of the new cropping patterns

4.1 The present farm types

Basically four different farm types are observed in the valley. These are:

1) Part time farmers. The valley area of these farms is 0.3 to 1 ha. They grow at present mainly vegetables, maize/beans and vines. Some have small areas of poplars and rice.

2) Subsistence farmers. The valley area of these farms is 1 to 3 ha. Subsistence farmers mainly grow a maize/beans mixture and vegetables.

3) The family farm. The valley area of these farms is 1 to 20 ha. The small family farm grows the same crops as part-time farmers, with more emphasis on vines. Family farms with a size between 3 and 10 ha grow rice on about 50% of their area, and on the rest maize/beans, vines and vegetables are grown. Large family farms almost exclusively grow rice.

4) The "company" farms with more than 20 ha follow either the medium sized family farm system or grow exclusively rice, fruit trees or poplars.

The Table 2 shows incomes of the different farm types:

Table 2: Farm incomes for present average farms of the Mondego Valley

Farm income	Farm type (average size)			
(Esc.)	0.6 ha	1.5 ha	6.4 ha	>20 ha
Total	70360	91780	176770	499540
Per ha of valley area	117266	61186	27620	24977

*) 50 Esc. = 1 DM
Source: (2)

4.2 Planned farm types

The new farming pattern is basically a shift from only one crop per year to two crops.

This shift includes the introduction of innovations such as:

- Substitution of the traditional maize-bean mixture grown in summer through a cash crop, e.g. maize.
- Replacement of rice on 2/3 of the scheme area by another cash crop.
- Introducing forage or a cash crop to replace the current winter fallow.
- Intensification of the production through adequate fertiliser application, plant protection and improved varieties.
- Mechanisation of land preparation.

Introducing the new crops and crop rotations implies changing the farming pattern in the valley. To support the extention service, new farm types were elaborated:

- Small farms (0.6 to 1.5 ha valley area) are recommended to grow mainly maize as grain or forage (if fat-stock is kept) and vegetables (cauliflower, tomatoes, potatoes, green pepper, beans, etc.);
- The family and "company" farms are recommended to grow mainly maize (grain and forage) and wheat or winter forage. The forage is to be used for milk or beef production.

According to calculations made, the new cropping pattern can be expected to more than double the income from farming. These increases should be enough to motivate farmers to accept the technical risk of the proposed change in farming.

The farmer will be charged for the costs of maintaining the new irrigation, drainage and road infrastructure and probably for part of the investment (a cost-based water price whose level has not been determined yet). The costs for the irrigation equipment (91.000 Esc./ha) are to be paid by the farmer.

To implement the new cropping patterns farmers are expected to need the following credits:

- as long term credit 80% of investment in buildings, equipment and machines and cows;
- as short term credit 100% of production inputs;
- a fixed sum of 39.500 Esc. for each head of fatstock.

Interest rates are about 18% and the inflation rate is approximately at 10% (1988).

5 Summary

This paper deals with planning and implementation of the transition from traditional cropping to new crops and crop rotations in the Lower Mondego Valley of Portugal.

First the prevailing conditions of the valley are described, i.e. climate, soils and the traditional cropping pattern, in which rice and a maize-bean mixture predominate.

Then the organisation of experimentation, planning and execution of trials and testing the experimental results on a large scale are outlined. The measures to improve the regions agricultural extension service are described. Finally some economic effects of the transition are briefly analysed.

Zusammenfassung

Die Arbeit behandelt die Planung und Implementierung des Überganges von traditioneller Landwirtschaft zu neuen Kulturen und Fruchtfolgen im Unteren Mondegotal in Portugal.

Zuerst werden die bestehenden Rahmenbedingungen beschrieben, d.h. das Klima, der Boden und die traditionelle Bodennutzung, in welcher der Anbau von Reis und eines Mais-Bohnengemisches dominiert.

Im weiteren werden der Aufbau des Versuchswesens, die Planung und Durchführung der Versuche und die großflächige Erprobung von Versuchsergebnissen dargestellt. Maßnahmen zur Verbesserung des landwirtschaftlichen Beratungsdienstes der Region werden beschrieben. Zum Schluß werden einige ökonomische Auswirkungen des Übergangs auf die neue Bodennutzung kurz analysiert.

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