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The perils of technology transfer: the Australian wheat/medic system in the Near East/North Africa region.

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Summary

Yields and production of rainfed areas in the Near East and North Africa are stagnating. The Australian wheat-medic system has been tried out in several countries of the region. Increases in soil fertility and yields were expected as well as better crop-livestock integration. Difficulties were more serious than foreseen. The farmer of the region differs from his Australian counterpart by the much smaller size of his farm and by his preference for keeping his land-use options open to match climatic variability.

Résumé

Les rendements et la production des zones de culture en sec stagnent dans la région du Proche-Orient et de l'Afrique du Nord. Le système australien de rotation blé-Médicago annuel a été essayé dans plusieurs pays de la région. On espérait une amélioration de la fertilité des sols et des rendements, et une meilleure intégration agriculture-élevage. Les difficultés rencontrées ont été plus sérieuses que prévues. Le paysan de la région diffère de son collègue australien par la taille de son exploitation, beaucoup plus faible, et par sa préférence pour des systèmes de culture qui le laissent libre de s'adapter à des conditions climatiques plus ou moins favorables».

In the Near East/North Africa region, both cereal and livestock production cannot keep pace with the demand resulting from population increase and improved standards of living.

The population of ten important countries of the region (Algeria, Egypt, Iraq, Jordan, Kuwait, Libya, Morocco, Syria, Tunisia, United Arab Emirates, the two Yemen) has increased from 100.7 million inhabitants in 1969/71 to 164.2 million in 1987 (2). During the eighties, the cost of annual wheat imports oscillated — according to climatic conditions and market prices — around the three billion $ mark. The bill for the yearly imports of the main categories of animal products (meat and milk) averaged about 4 billion $ (3). Perhaps of even greater importance than dependency on food imports, the above figures highlight a stagnation of the land productivity which seems rebel to ordinary remedies.

The region relies on a mix of irrigated and rainfed agriculture. In 1971, irrigated areas represented 7.1 % of arable land, or 4.3% if Egypt (where agriculture has been identified with irrigation for millenia) is excluded. In 1987 irrigation covered 8.1% of arable land, or 5.5% without Egypt (2). Some increase in the extent of irrigated areas has thus taken place — notably in Tunisia, Saudi Arabia, Syria and Morocco — but on the whole, the opportunities for large scale irrigation schemes seem to have come to an end. In the future, it seems probable that major irrigated areas will have to concern themselves with improving the efficiency of present irrigation schemes and preventing a too rapid siltation of water reservoirs.

It is now generally agreed that improvement of agricultural production in Near East/North Africa (NENA) agriculture will depend on the intensification of the region's rainfed agriculture.

Wheat and barley are the dominant crops, occupying about 40% of total arable land or 70% of the land devoted to annual food crops (5). The above feature results i.a. from the climatic conditions, characterized by long, hot and dry summers, rain being concentrated during the cold period of the year, from October/November to April/May. This pattern is well suited to cereal growing. Grain legumes such as chickpeas and lentils, and forage crops, are also grown in rainfed conditions in the region. In North Africa, the most common forage crop is a mixture of oat and vetch which is generally made into hay. In the Near East barley is sown extensively, even in arid conditions, with the purpose of grazing it lightly during winter; if the rains fail and there is little prospect of a reasonable harvest, barley is grazed down.

The dominant cropping pattern in the rainfed areas of the region is the cereal-fallow system i.e. one year of cereal cropping followed by a year of rest.

The introduction of a fallow aims at avoiding the decline in cereal yields which results from continuous cereal cultivation despite use of increasing quantities of fertilizer. This observation has recently been upheld by the discovery, in soils growing continuous wheat, of a bacteria capable of suppressing root growth of weed seedlings (6).

Another reason for the use of fallow is that it is supposed to improve nitrogen mineralisation and water storage in the soil, making both elements more freely available to the subsequent cereal crop. This theory has led to several variants. The rest period could be accompanied by several workings of the land (as in the N.W. United States) so as to keep the fallow clean: the elimination of vegetative cover and the creation of a fine soil mulch would prevent the evaporation of surface water. Others recommend working the fallow in the spring

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only («le préparé de printemps») so as to facilitate the ploughing of the land prior to cereal cultivation. A spring tilling of the fallow also serves to eliminate part of the weed population, particularly if tilling takes place before most of the weeds can set seeds.
A different view of the fallow is to use its vegetative cover to enable a simple system of crop/livestock integration. Indeed, plants growing on the fallow are generally edible by livestock and a cereal grower can thus integrate a flock of sheep into his farm without too much investment. Should the prevailing climatic conditions be particularly adverse to graziers using more marginal lands, the cereal grower who does not have much livestock can profitably rent out some of his fallows.

Other scientists have challenged the above theories. They argue that the quantity of water stored in the soil and made available to the cereal at the time of maximum growth is the same whether the cereal is preceded by a fallow or a crop, even under low rainfall conditions (7). Others state that, instead of a fallow, wheat can profitably be alternated with a forage mixture such as barley/vetch or oat/vetch, without problem for the major cereal crop, provided the field is ploughed up soon after the hay is harvested (4).

A general disadvantage of the cereal/fallow system is the low productivity it entails per surface unit. This in turn militates against the use of inputs (fertilizers, herbicides...), the cost of which can only be offset every other year. The basic compensation is the flexibility the system offers to the land owner by placing part of his assets in reserve.
However, during the sixties, while countries in the region were trying hard to develop their irrigation capabilities, predictive data regarding population increase and food demand clearly indicated the need to devote attention to rainfed agriculture.

At the beginning of the seventies, a number of authoritative voices pointed to the Australian example as a possible way to intensify rainfed agriculture in the region. Australia is a continent remarkable for its climatic variety which ranges from desertic to temperate conditions. A climate similar to that of the NENA region can be found in some parts of Southern Australia.
As from the second third of the 19th century, settlers started to move north of Adelaide to till the land. They specialized in extensive cereal and livestock operations. The initial yields of 860 kg per ha fell to 490 kg at the end of the century after continuing cereal cultivation had been applied. Fallow and superphosphates then came into play. While this system suited a low labour availability, it created soil losses and erosion as the fallows were tilled to keep the soil bare to prevent water losses.
By 1930, the system has created a dust bowl over the area and was near collapse.
Several factors encouraged the introduction of new cultivation methods: mechanization made tillage quicker, forage seeds appeared on the market, and export possibilities made livestock production particularly attractive (10). For several decades, Australian scientists had been collecting seeds of potentially interesting forage plants, particularly legumes, around the Mediterranean basin.
This collection, and changes taking place in South Australia, led to a cropping system based on a rotation of temporary pastures (or leys), and cereal cropping.

These temporary pastures are legume-based, and the originality of the system rests on the use of annual, hardseeded species. After a year of cereal, the legume is sown and the ley thus created can be grazed as from the second part of the growing season. However, part of the seeds only have served for the initial establishment, because of widespread hardseededness. The next season, when a new cereal crop follows, part of the legume stock seed will have had its coat cracked by summer heat and will germinate, thereby regenerating a legume sward in the cereal without further sowing; the medic ley will thus regenerate itself naturally, provided there is a good set of seeds in the ground. This will take place if: a) the seeds are not buried too deeply in the soil; tyne implements are used to this effect during the cereal/ley rotation for the tilling of the land; b) phosphate fertilizers are generously applied, in order to favour legumes at the expense of grasses and grassy weeds; c) the stocking rate is not too heavy and does not prevent seed set. In return, the nodules which are present on the roots of the legumes can fix the nitrogen available in the air. It has been estimated that the amount of N fixed by a ley in the soil commonly amounts to 60-70 kg N/ha, corresponding to about 300 kg of ammonium sulphate (10).
The above system, introduced in the thirties, was fully established in the sixties in South Australia. It is claimed that it restored soil fertility and increased cereal and livestock production severalfold. The legumes used in the alkaline soils of Australia are a range of medics (annual *Medicago*, close cousins of the better known perennial *Medicago*, the lucerne).
Over the years, the most favoured rotation has been a wheat crop and a medic pasture alternating each year, although two years of pastures followed by one or two years of crop are also used.

Since the soils of Near East and North Africa are in general alkaline, it was assumed that an alternation of wheat and medic-based pasture was the key to the intensification of rainfed agriculture in the region. As of the beginning of the seventies, several such projects were established in the region, starting with Algeria, Tunisia and Libya: later on, Syria, Jordan and Morocco followed.
Several disappointing results were in evidence, some years after project inception. The following factors hampered the easy transfer of Australian technology:
— mechanical factors: as previously mentioned, the small seeds of medics should not be placed too deeply in the soil, hence the preference given to tyne implements. In the NENA region the disk plough is, by far, the most common plough. This was the cause of some disappointing medic germination rate in a number of trials (1).
— a range of biological factors:
  - **adapted strains and varieties:** the medics used in the projects in the region had been bred in Australia. Quite a few cultivars were not adapted to the region because of cold winter days which are less pronounced in Australia than in the region. To fix biological nitrogen the root nodules of the medic need interaction with a *Rhizobium* bacteria. Some medic species have specific rhizobium requirements, others are more promiscuous.

Some imported rhizobium did not perform. The lack of knowledge on and scant use of local medics and rhizobium was also responsible for some poor performances.

- **biological nitrogen fixation:** the amount of N fixed by the medic did not live up to expectations. Even under favourable experimental conditions now applied, a wheat after year of medic may produce less than the same crop of wheat after fallow but receiving 60 kg of N/ha (6).
- **weed infestation:** the extension of the wheat/medic system in the region has also abutted against a severe weed problem in the wheat crop. Cereals have been cultivated in the region since time immemorial and some of the land must have been cultivated more or less continuously for more than two millenia. This means that the local weed population has developed adaptations to climate and cultural practices and are very difficult to eradicate. Even in South Australia, where the situation used to be less severe, recent information seems to point to the difficulty in controlling broad leaf weeds in the wheat crop in spite of a generous use of herbicides (9).

— livestock factors: livestock management is important in maintaining the wheat/medic system. In this case, livestock means sheep, the largest category of livestock in the region, well adapted to grazing a short-size sward like a medic and its pods. A stocking rate which is too high will deplete the seed stock on the ground and compromise self-regeneration. Too low a stocking rate will compromise the return on the investment made by creating the ley and favour infestation of the medic by weeds. A number of projects have failed on the above account. This leads us to

— socio-economics and crop/livestock integration factors: the first of these relates to farm size; in South Australia, this ranges from several hundreds to several thousands ha; in the NENA region, the farms are of a much smaller size and generally fragmented.

In Australia farms generally started on a crop/ livestock integration basis and they are better protected against risk when testing new methods. Furthermore there are summer rains in Australia, a fact which decreases the drought effect. In the NENA region the farmer is up against a storng climatic variability and tends to favour risk-evading strategies. For instance, if a cereal farmer has livestock it is for the capitalization of his cereal sales and the constitution of a cash reserve on the hoof. If his flocks are too small to use the grazing available on the farm, he may rent out part of his land to a grazier for a period of the year, but the rent value will be the same in the case of a fallow or a ley, with the former needing no investment and bearing no risk.

Similarly, the farmer in the region will be reluctant to commit his land for several years to a wheat/medic system, which may give an incremental grazing value only after the third year of the start of the system (8).

Conclusions

The efforts to introduce the Australian wheat/medic system have been valuable in taking a farming system approach and focusing attention on soil fertility. They have also enabled the region (often through international research centres such as ICARDA) to gain a better knowledge of its forage legume and companion rhizobium populations. This effort should continue with, perhaps, greater flexibility in the choice of the cereal (barley v.wheat), the legume (a mix of vetch and medic rather than a medic alone) and the farming system (grazing and/or hay v.a cereal/ley rotation). Some of the constraints mentioned above could be migliorated, but some appear difficult to handle: the size of the farms; the weed problem; the reaction to climatic variability (the tendency for the farmer of the region to double-gamble climate and give a speculative slant to his landuse).

The above illustrates the fact that component research is more easily transferable than a farming system which is supposed to replace age-old adaptations to a wide range of socio-economic and biological factors not easy to perceive. Another lessen is the need to develop a strong national research capability required to gain the knowledge of the local farming systems, work out the new technology needed for further progress or collaborate in the adaptation of imported technology.

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