CLIMATIC CHANGE AND DROUGHT MITIGATION: CASE OF MOROCCO

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1. Situation of Moroccan climate

Morocco is located in the northern margin of the northern hemisphere desert belt. Consequently, most of its land is arid or semi-arid.

Precipitation, in Morocco, is low and highly variable from one season to another and within the cropping year. Although drought can occur at any time during the growing season, two main periods of drought are more likely; the early one that coincides with seed germination and seedling emergence and the terminal drought that is more frequent and affects grains set and growth (Watts and El Mourid, 1988).

During this last decade, drought in Morocco has become more frequent.

Prediction of climatic change and global warming studies demonstrated that Morocco is among the countries that are more likely threatened by climatic change. In fact, global circulation models showed that the consequence of the increase of CO_2 and other greenhouse gases in the atmosphere is, for Morocco, the elevation of yearly average temperature by 1.5 to 2.5 °C above the current concentration for the period 2021-2050. For 2071-2100, the increase will be higher and might reach 2.5-4 °C. The increase of temperature due to the increase of the concentration of greenhouse gases in the atmosphere will be accompanied by the reduction of annual average rainfall which will reach 10 % for the period 2021-2050 and 20 % for 2071-2100. For the coming 20 years, the reduction of the precipitation might be 4 % (INRA, 2002).

2. Main impacts of climatic change

The most important impact of climate change as mentioned above may be the increase of drought frequency and the reduction of the length of the growth period of crops. We already noticed these phenomena during these last 20-40 years. According to MADRPM (1999a), drought frequency occurrence before 1990 was only 20 % (1 year drought in 5 years period). However, during the last decade, Morocco experienced, in average, 1year drought for each 2 years period. Moreover, a study conducted in one region of semi-arid areas of Morocco showed that the length of the growing period was reduced from around 180 days in 1960-65 to 110-130 days for the period 1995-2000 (Benaouda, 2001).

Drought that Morocco has experienced during the last two decades has affected negatively crops and animal productions. These effects vary with the intensity and period of drought. Cereal yield production for example (INRA, 2002) can be reduced by 25 %, 60 %, 70 % or even 85 % if drought occurs early, during the middle, early and late and early and during the middle of the growing cycle, respectively. For the forage production, we notice pasture degradation and cereal straw yield reduction. This cereals by-product plays an important role in animal feeding especially in semi-arid and arid areas of Morocco. For livestock production, drought, in addition to its direct effect on animal health, affects negatively feed availability. Consequently, animal growth and birth rates and meat and milk production are reduced.

To cope with climatic change and drought phenomena, Morocco has lunched different development and research programs (MADRPM, 1999b). I will describe here briefly the studies that have been conducted on agro-ecological characterization and focus my presentation on drought mitigation strategies developed by researchers. But it is important to mention that among the main development programs undertaken by the Ministry of Agriculture of Morocco to reduce the effects of drought are the distribution of animal feed to the farmers to safeguard livestock and the encouragement of farmers to use the improved and adapted management packages and to acquire subsidized inputs and agricultural equipment in order to secure 60 Millions of quintals of cereals under moderately dry cropping seasons.

3. Agro-ecological characterization

To develop sound drought mitigation strategies, it is necessary to characterize the climate and drought at regional and national levels and to develop tools that can help in management and decision making at political and technical levels in the agricultural sector (El Mourid el al., 1996). To do so, data bases on long term series of meteorological parameters have been constituted for the main agricultural zones. These data sets have been completed using weather generators (models) for the sites where weather information is not available. Trends of climatic change in time and space have been determined and frequencies of drought at the national, regional and local levels have been mapped using modelling and GIS and drought indices such as SPI (standardized precipitation index) and the length of the growing period have been calculated. The linkage of the weather generator with crop models (SIMTAG for cereals for example) has helped in the development of yield potential maps for certain crops (especially wheat), the prediction of crop production and the estimation of the length of the growth periods of plant species. The variables concerning yield potential and growth periods required information on soil characteristics and land cover.

In summary, the expected outputs of the ongoing studies on climate description and on soil and land cover characterization are the assessment of climatic change in time and in space with regard to frequencies of weather types, precipitation, temperature and length of growing periods, the prediction of crop production and crop management, the development of land suitability and variety adaptation maps, the description of crop ideotypes for different regions and the adaptation of management practices to climatic change in time and in space.

4. Drought mitigation strategy

The complexity of climatic change and drought phenomena in agriculture imposes the development of an integrated approach of drought mitigation (Karrou, 2000) based on the choice of species, (land suitability), genotypes and agronomic packages adapted to these situations. Genetic and agronomic approaches of drought mitigation are described below.

4.1. Genetic approach

The input “variety” is the most economical production factor since the seed transmits the genetic yield gain. Research methodologies adopted to develop new genetic material are based on land races exploitation and selection of varieties in typical environments. To improve the efficiency of breeding programs and reduce the period required for variety development, analytical approaches and biotechnological methods have been recently used. In general, the recently released varieties are characterized by large adaptation. This characteristic is due to their optimal earliness, their tolerance to drought and their fair resistance to certain parasites.

In the case of cereals, more than 75 varieties have been released by INRA with 80 % of them after 1983. The adoption of the new varieties by the farmers allowed 35 % and 50 % increase of grain yield of bread wheat and barley, respectively. For this last 20 years, the yield improvement of cereals corresponds to an increase of 2 to 4 quintals per hectare at the national level, although this period was characterized by many dry years. The shift from the old varieties to the newest ones increased also water use efficiency that jumped from 8 to 17 Kg of grains/mm of water used.

Among the cultivars that are proven to be adapted to the arid and semi-arid zones are Aglou, Taffa, Acsad 60, Annoceur and Tamellalt, for barley, Sarif, Yasmine, Amjad, Tomouh, Oum Rabia and Marzak for durum wheat and Arrihane, Aguilal, Achtar, Kenz, Merchouch for bread wheat.

For food legume crops, the most important research achievement is the shift of the period of sowing chick pea from spring to fall by developing adapted varieties (Rizki, Douyet, Farihane). The advantage of this type of crop (called winter chick pea) is that it takes advantage from fall and winter rains. For faba bean and lentil, two adapted varieties per species to drought prone areas were recently released.

In the case of forages, in addition to the development of nine varieties of Medics and three of trifolium subterraneum, Acacia and more importantly Atriplex and the alley-cropping system (annual forage grown between strips or bands of Atriplex) were appreciated by farmers in the arid and semi-arid areas.

4.2. Agronomic approach

In addition to the use of adapted species and varieties, the adoption of dry land agriculture techniques by farmers in rainfed agriculture areas of Morocco can also substantially improve and stabilise crop yields and protect the environment. In fact, researchers showed in on-station and on-farm trials the importance of the use of the minimum tillage (Kacemi, 1992), no-till (Bouzza, 1990) and mulching technologies. In fact, these conservation techniques reduce evaporation, increase the interception of rain and its infiltration and insure the saving of water, energy and time, guaranty a long term productivity increase and increase the sequestration of carbon (reduction of greenhouse gases emission). Moreover, chemical fallow (weeds are controlled chemically by herbicides) allow the conservation of an amount of 75 to 100 mm of water in the soil (Bouzza, 1990) which is available to the following crop (usually wheat). When limited quantities of irrigation water are available, the application of 60 to 70 mm at critical growth stages as supplemental irrigation (tillering, heading and during grain filling in the case of wheat) can increase yields by 70 to more than 100 % (Boutfirass, Karrou et El Mourid, 1994).

To take advantage from water saved due to conservation techniques and supplemental irrigation and from the rains received during the growing season and hence increase yield and water use efficiency, crops have to be well managed. In fact, early planting can help the plant to use more water (rains received early in Fall) and to avoid terminal drought stress and high temperatures. If this technique is used, cereals can produce 40 % more than when the late sowing is practiced (Bouchoutroch, 1993). Moreover, early weed control (at 3 to 4 leaf-stage) reduces the competition between the crop and weeds for water and hence this water is better used to produce the crop yield (Tanji and Karrou, 1992).

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