

Kingdom of Morocco

Activity report INRA 2008



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Institut National de la Recherche Agronomique



His Majesty King Mohammed VI, May God Assist Him



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A WORD FROM THE DIRECTOR

The main event of the year 2008 was the initiation of **the Green Morocco Plan** by His Majesty King Mohammed VI during the first Agriculture Conference of the 3rd International Agriculture Exhibition of Morocco (SIAM 2008). This plan was designed to reflect the new strategy of the Ministry of Agriculture and Maritime Fisheries in agricultural development.

Today, the National Institute of Agronomic Research (INRA) is solicited by the public authorities in order to support the implementation of **the Green Morocco Plan**, through the supply of technology and the mobilization of its expertise. This is an opportunity and a challenge for our researchers. It is also an ideal framework for improving the performance of communication, establishing a synergy between research and its environment, and setting up the mechanisms for targeted technology transfer.

Furthermore, this year witnessed two major events : the first concerned the evaluation of the Mid-Term Research Program (PRMT) 2005-2008, and the second concerned the development of the 2008-2012 PRMT, according to a systemic and participatory approach within the regional agricultural development plans.




The scientific and technological achievements for the past 12 months were of great importance to the development of our agriculture. Breeding new varieties, which is one of our strong aspects, was enriched by the registration in the national catalogue of a colza variety, the selection of new clones of fig tree for drying, and the initiation of six lines of durum wheat and three lines of common wheat into the protection process.

The development of tools to help producers take suitable decisions according to the production areas and to envisage climate change, was also a positive achievement for optimizing investment in agriculture.

We are decided to work in consultation with the profession, with the national agricultural research system and with all development partners in order to reach the objectives of the two Green Morocco Plan pillars. All this will be done with the aim of allowing to our country a sustainable agricultural development.

Prof. Mohamed BADRAOUI,
Director of INRA-Morocco





The Minister of Agriculture and Maritime Fisheries visiting INRA stand (SIAM 2008).

HIGHLIGHTS

Appointment of the new INRA Director

Mr. Aziz Akhannouch, Minister of Agriculture and Maritime Fisheries, presided on Thursday 6th, March 2008, the ceremony of investing Professor. Mohamed Badraoui with the post of INRA Director, in fulfilment of His Majesty King Mohammed VI decision.

In his speech, the Minister reminded the audience of the confidence His Majesty placed in Prof. Badraoui whose professional career had been full of great successes and achievements, things that make him the suitable person to take the destiny of this prestigious research institution which is INRA. He also paid a great tribute to Professor Hamid Narjisse, the outgoing Director, for his contribution to the reputation of INRA through the major projects initiated and the prestigious achievements on the institutional scientific and technical levels.



The Minister Of Agriculture And Maritime Fisheries Beside The New Inra Director, Prof. Badraoui, And The Former Director, Prof. Narjisse.

The Minister also paid a great tribute to Mr. Mohammed Abdelmajid El Idrisi Ammari, INRA Secretary General, who succeeded in managing the affairs of the Institute during the interim period.

Concerted consultation with the profession

Meetings were held with COMADER as the representative of the profession to discuss partnership opportunities and make research-development programmes more relevant to the needs of professionals.



INRA and the Profession : together for the implementation of the **Green Morocco Plan**.

FAO Prize

Parallel with the celebrations commemorating the World Food Day (WFD), the FAO awarded Dr. Riad Balaghi one of its Merit Awards for 2008 to for his research on climate changes and their impact on agricultural yields. The prize-award ceremony took place at the Haras of Bouznika and was presided over by the Minister of Agriculture and Maritime Fisheries.



INRA Director receiving the FAO Merit Award from the Minister of Youth and Sports.



INRA Director handing over the FAO Award to Dr. Riad Balaghi.

International Agriculture Exhibition of Morocco (SIAM) 2008 : an opportunity to better present research results

At the third International Agriculture Exhibition of Morocco (SIAM), INRA focused on biotechnology and the upgrading of agricultural products. Two laboratories were designed showing the processes of developing the proposed technologies.

Presentation of INRA Offer to the Minister of Agriculture and Maritime Fisheries in support of the Green Morocco Plan

Since the official announcement of **the Green Morocco Plan** in the presence of His Majesty King Mohammed VI in April 2008, during the first Agriculture Conference in Meknes, INRA started preparing its contribution to the achievement of this Plan. The Offer was presented to the Minister of Agriculture and Maritime Fisheries in July 2008 at Ain Dick by Prof. Badraoui.

INRA offer is based on research results dealing with fields related to the two pillars of **the Green Morocco Plan**. It is also an investment opportunity for the promotion of small and medium enterprises through food products agro-processing.

Evaluation of the Mid-Term Research Programme (PRMT) 2005-2008 : major achievements

- **Mapping 4.5 million hectares for crop suitability** : decision-making tools for investors and policy-makers ;
- **Design of 29 agroclimatic maps** : for more visibility on the duration, the period of vegetation and the potential yields of cereals in the various agro-ecological zones ;
- **Enrichment of INRA gene bank** with more than 22000 accessions of various inventoried species, in addition to 8000 accessions of durum wheat mutants (genetic stock) ;
- **Registration in the national catalogue** of 7 varieties of durum wheat, triticale, forage peas, oats, colza, and submission of 12 varieties to registration, in addition to the selection of several varieties and clones of citrus, olive trees and date palm ;
- **Development of environment** protecting pest control methods : bio fungicides and bio pesticides ;
- **Development of economy inputs and of water-saving techniques** ;
- **Technical innovation in agricultural machinery** : self-propelled field sprayer ;



Testing the prototype of the self-propelled sprayer on a wheat field.

- **Simple agro-industrial processes** suitable to agricultural production conditions, and processing/development of farming products ;
- **Genetic improvement and performance of local sheep and caprine breeds.**

Development of the 2008-2012 MidTerm Research Program (PRMT)

The 2008-2012 PRMT is the outcome of the evaluation results of the 2005-2008 PRMT, and of **the Green Morocco Plan** needs. The guidelines of this PRMT deal with the following topics :

- Characterization and conservation of natural resources : Water, Soil and Agrobiodiversity; Breeding of new varieties and improvement of animal breeds ;
- Development of technological packages for better yields and a better quality of products ;
- Development of agricultural products ;
- Socioeconomic and impact studies ;
- Research-development and technology transfer.

The results of the 2005-2008 and 2008-2012 PRMTs were submitted to the Technical Committee for validation.

Openness and diversified cooperation in harmony with the research strategy

To be open to its scientific, technical and socio-economic environments both nationally and at the international level is the basis of INRA's strategy. This strategic collaboration was materialized by the 37 agreements and research projects made and worth 33 million dirhams.

Tableau 1 : Orientations selon les Régions du PRMT 2008-2012

CRRA	Research orientations by regions in the PRMT 2008-2012
Agadir	• Water management and development of new production ways.
	• Development and valorization of Terroir products.
Oujda	• Conservation and sustainable management of rangelands.
	• Sustainable intensification of irrigated production systems.
Kénitra	• Improvement of the productivity and competitiveness of citrus.
	• Intensification and diversification of production systems.
Errachidia	• Improvement of sustainable production systems, management of oasis and semi-desert rangelands.
	• Development of palm tree sector.
Tadla	• Water management and valorization.
	• Intensification and diversification of agricultural production systems and valorization of Terroir products.
Tanger	• Improvement of goat production systems for meat and milk.
	• Optimal diversification and intensification of agricultural production systems in irrigated lands.
	• Development of production chains in and support of mountain terroir products.
Settat	• Impact of climate change in arid and semi arid areas.
	• Development of adaptation strategies to draught.
	• Diversification of production systems and integrated crop management.
	• Improvement and conservation of genetic resources.
Rabat	• Organization and strengthening of local community capacity.
	• Sustainable management of natural resources: water, soil and biodiversity.
	• Improvement of productivity and competitiveness of some strategic agricultural chains.
Meknès	• Development of new niches responding to new climate and economic contexts.
	• Integrated crop management of fruit trees.
	• Sustainable intensification and diversification of cropping systems.
Marrakech	• Management of natural resources and dynamic in mountainous zones.
	• Development of olive sector.
	• Contribution to the rehabilitation of palm tree and valorization of product.
	• Development of production systems in marginal lands.

CRRA : Regional Agricultural Research Center.



ENVIRONMENTAL CONSERVATION AND PRESERVATION OF NATURAL RESOURCES : A PRIORITY FOR AGRICULTURAL RESEARCH

Two major objectives have governed the development of decision-making tools : the identification of production areas and the orientation of supporting public policies for better investment in agriculture through the elaboration of database, the agro climatic atlas, the crop suitability maps, and the assessment of the climate change impacts on agriculture and crop production forecasting.

Impact of climate changes on Moroccan agriculture

All the climate change scenarios that were elaborated for the Mediterranean region converge towards the advent of a more arid climate. For the first time in Morocco, studies were conducted to reduce spatial scales of planetary climatic scenarios to a low one (scale) in order to translate them

into impacts on our agriculture until the end of the 21st century.

The results of these two studies show that aridity will be gradually increasing in Morocco due to rainfall decrease and temperature rising, although some years might be sporadically very rainy (**Figure 1**). Consequently, the yields of rain-fed crops will be reduced over the long term (**Figure 2**) and the most vulnerable lands will lose their agricultural suitability (**Figures 3 and 4**).

The results presented can be used in immediate practical applications in agricultural decision-making processes, and a prospective component of the agricultural development and food security policies in Morocco. The methods and tools developed thanks to these two studies made agriculture forecasts possible until the year 2030.

Irrigation and technological progress are prerequisites to attenuating or reversing climate changes impact (**Figure 5**). As a consequence, in order to attenuate the

negative effects in the long term, it is necessary to start from now by investing in agricultural development.

Aridity increase in Settat due to climate change under scenarios A2 (optimistic) and B2 (pessimistic)

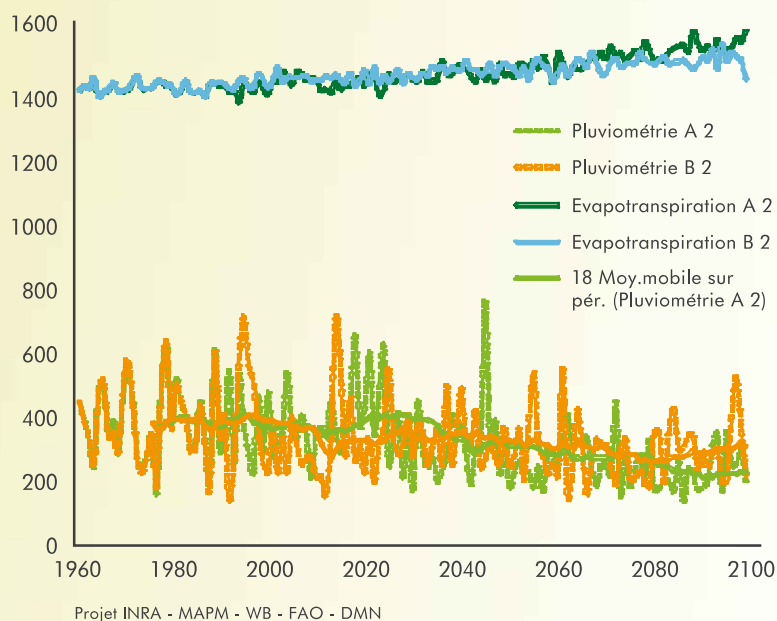
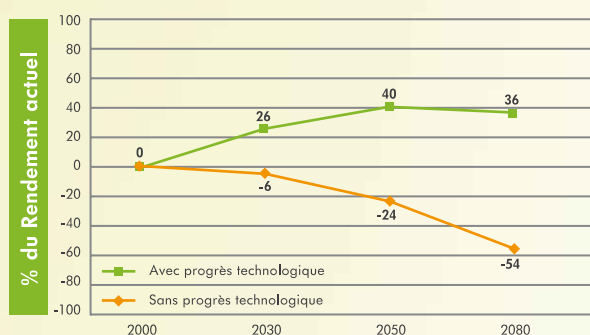


Figure 1 : Potential rainfall and evapotranspiration forecast according to a model of statistical scale reduction.

Moderate impacts until 2030, and severe beyond (optimistic scenario A2)



Moderate impacts until 2030, mastered beyond (Optimistic scenario B2)

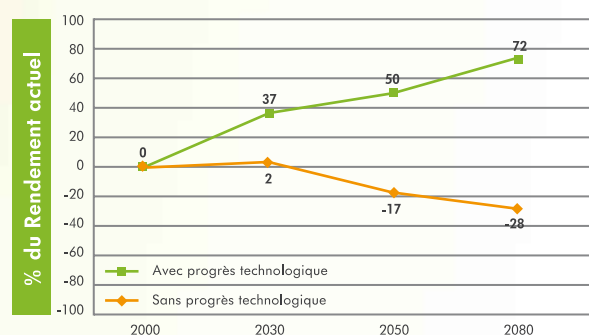


Figure 2 : Impact of climate change on rain wheat yields in Morocco.

Land crop suitability maps

The «Land crop suitability maps» project is carried on at INRA by the study of other regions of Morocco : Zaer (Wilaya of Rabat-Skhirat Temara and neighbouring areas)

and Bhira (Province of Kalaat Sraghna). The combination of the different soil, climatic and ecological data of crops using the FAO methodology (1976) made it possible to identify the agricultural suitability classes for lands in these regions.

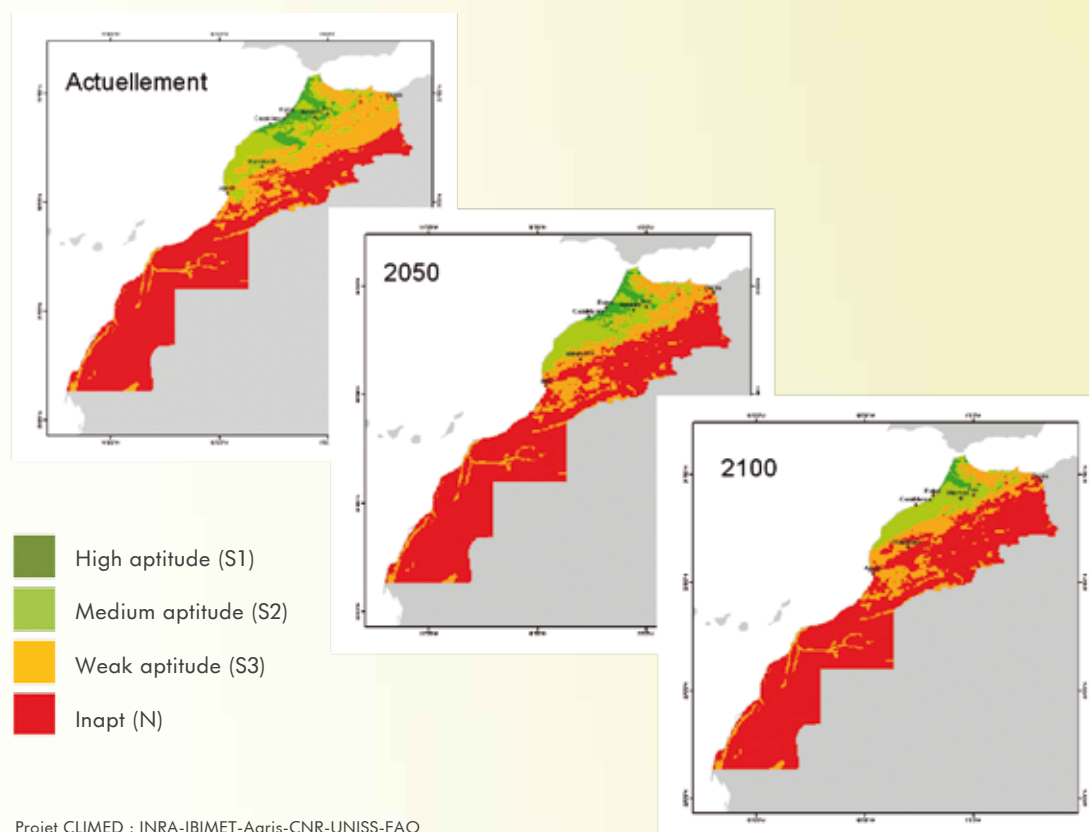


Figure 3 : Impact of climate change on land agriculture suitability Rain agriculture, Scenario A1B (C02 emission mastered).

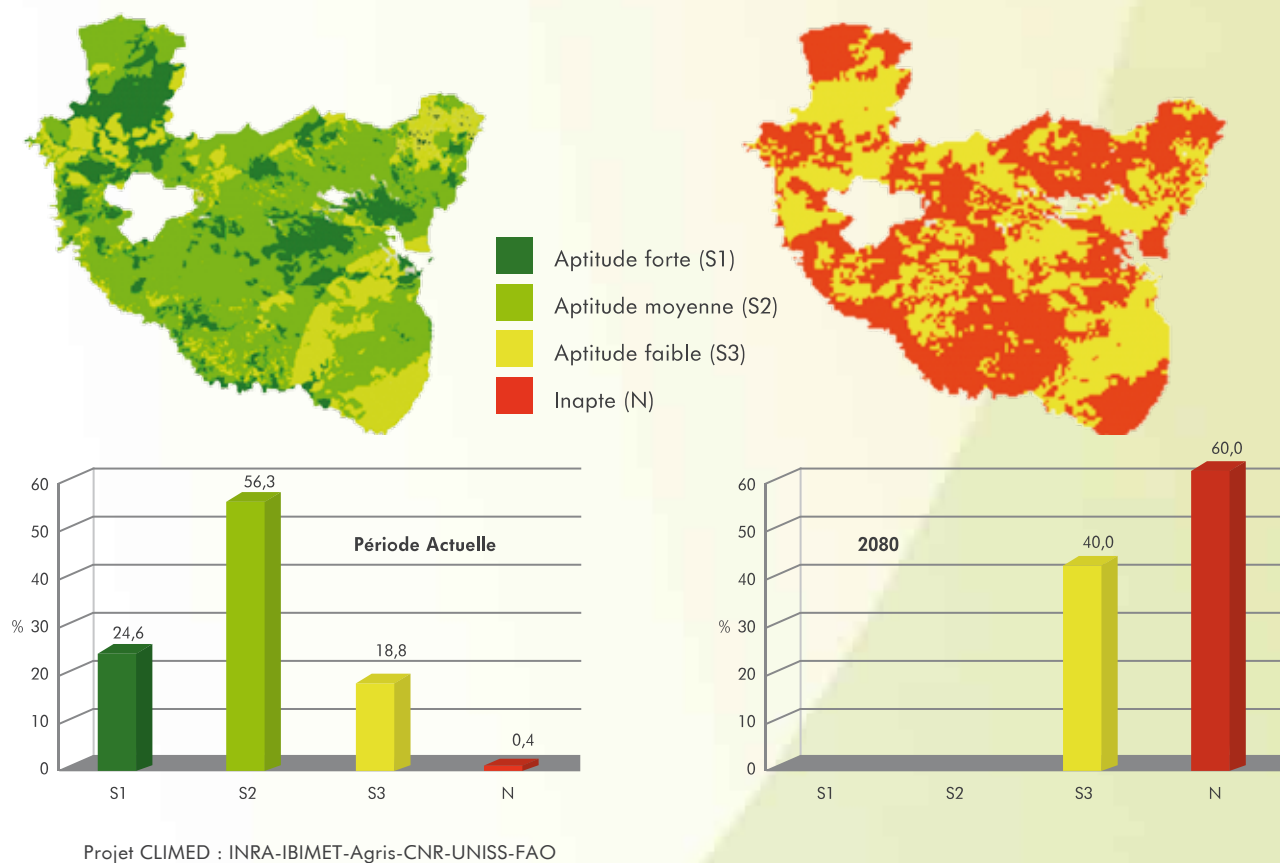


Figure 4 : Impact of climate change on land agriculture suitability in Settat Province. Rain wheat, Scenario A2 (pessimistic).

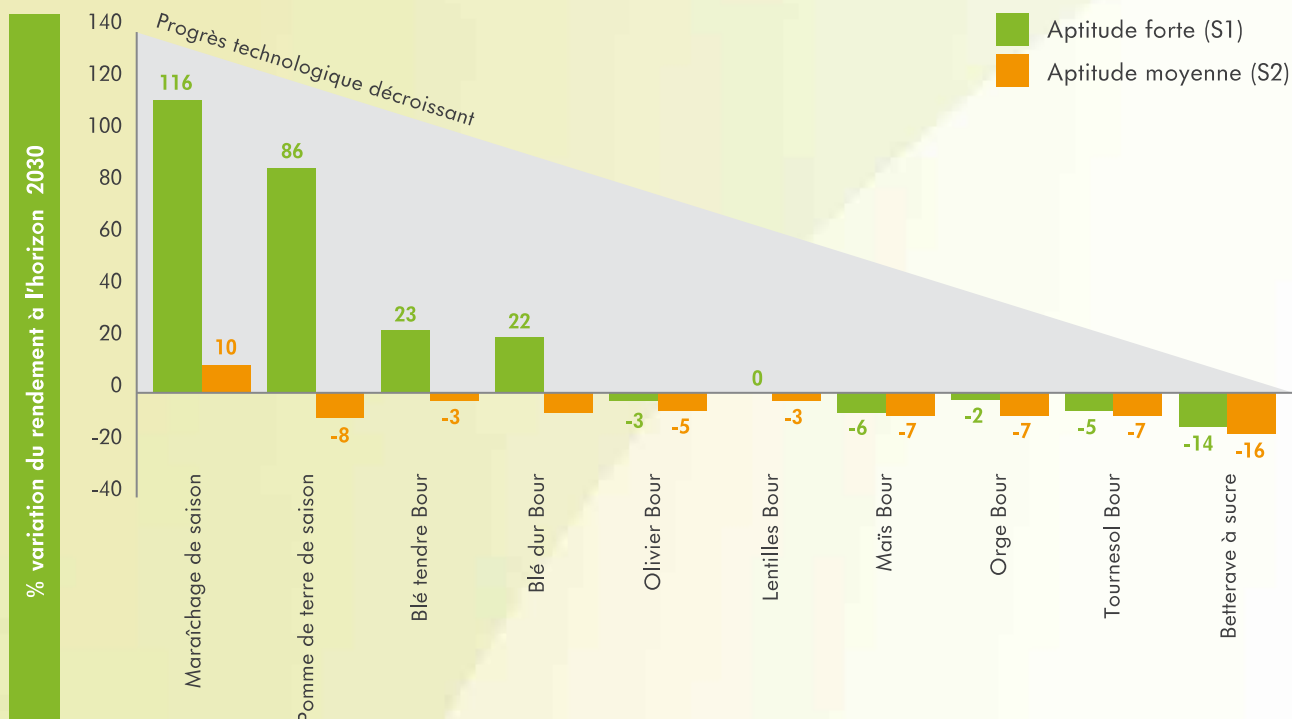


Figure 5 : Impact of climate change on agriculture production according to technological progress achieved.
Favourable agro-ecological areas, Scenario A2 (pessimistic).

The land crop suitability map of the Zaer region designed at the scale of 1/100000 (**Figure 6**) deals with a total surface area of 330000 ha of which the pedology comprises 84 series and 28 complex units of soils.

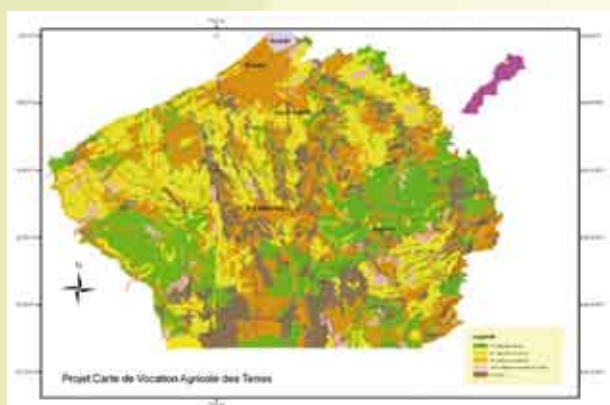


Figure 6 : Land crop suitability map.
Case of aptitude classes to wheat in RabatZemmour-Zaer Region.

Wheat, barley, maize, chickpeas, green peas, sunflower, olive trees, vine and vetch-oats were among the crops studied.

In the Zaer region, the high aptitude class (class S1, which includes deep and moderately deep fersiallitic soils and fersiallitic soils), and those of average aptitude (class S2 which includes moderately deep calcimagnesian soils and

deep fersiallitic soils which are slightly sandy on the surface) were predominant for wheat in rain-fed agriculture, except for zones showing rough topography or depressions that were flooded in rainy years.

Evaluation of intensive agriculture impact on underground waters

The intensification of agriculture led generally to an excessive and irrational use of nitrogen fertilizers that affect irrigation waters (**Figure 7**).

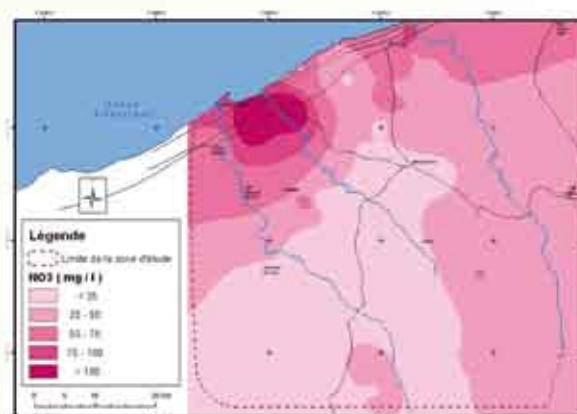


Figure 7 : Geographical distribution of nitrate concentration in groundwaters in Benslimane-Bouznika Region.

Analysis results of water from a sample of 45 wells in Bouznika and Benslimane zones show that 53.3% and 20% respectively suffer an excessive nitrates (higher than 50mg/l) pollution. This pollution is mainly due to the excessive use of nitrogen fertilizers in market gardening and to the abusive use of groundwater.

Improvement of grazing lands and biodiversity conservation

Rehabilitation of the grazing lands in the Eastern Region through the use of indigenous species

The tests conducted sought to study the germinative capacity and the persistence of the native pastoral seeds species "*Salsola Vermiculata* L.". The preliminary results showed that the seeds of this species were characterized by a short persistence and had an optimal germinative capacity after 72 hours at a variable temperature of 8 to 20°C for freshly collected seeds. While collected seeds that were stored in ambient conditions registered a very low germinative capacity.

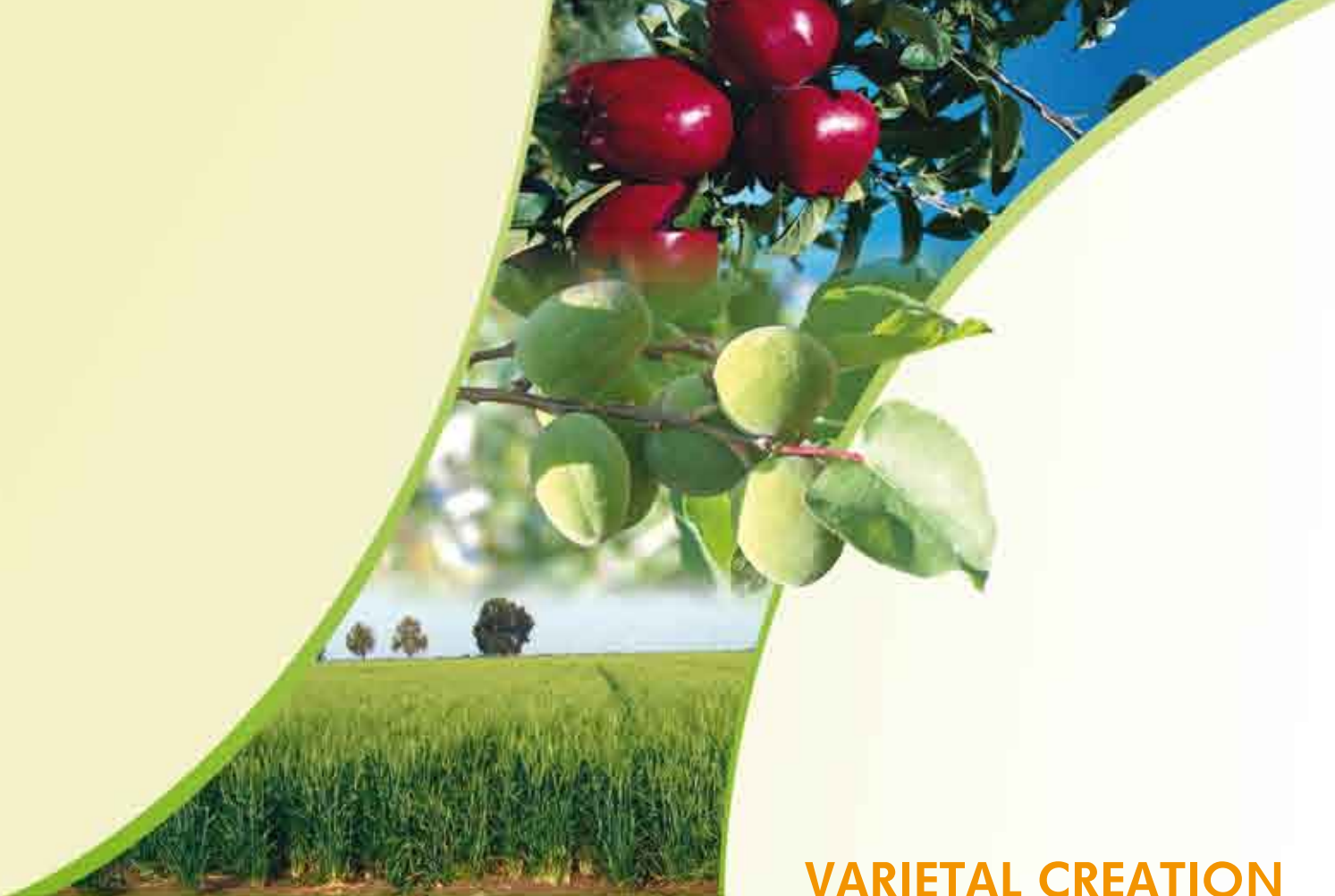
A pastoretum gathering a collection of living pastoral species was set up at El Ayoun CT (Oujda) using seedling stands and mainly by transplanting young plants and seedlings. Transplantation success rates exceeded 50% for the majority of species. *Artemisia herba-alba* (100%), *Salsola vermiculata* (90%), *Anthyllis cytisoides* (30%), *Medicago arborea* (80%), *Rosmarinus officinalis* (70%), *Lavandula dentata* (50%), *Thymus algeriensis* (50%) et *Prosopis juliflora* (100%).

Rangeland rehabilitation through indigenous species in the pre-Saharan areas

The test conducted on the improvement of the vegetative propagation of jojoba using rooting hormone, indole-acetic acid (IAA), acid beta-indolebutyrique (AIB) and acid alpha-naphthalène acetic acid (NAA) showed that the use of the AIA can

improve jojoba rooting by 85% against 45% of intact (boutures) cuttings. In addition to hormones, cutting type (normal, Crossette and heel) plays an important role in rooting improvement, hence heel cuttings gave the best rooting rate compared to the other types. As a consequence, the combined use of the AIA with the heel cuttings reached a very high rooting rate (92.5%), indicating that jojoba is able to propagate through cuttings. Similarly, cactus can play an important role in the rehabilitation of pre-Saharan rangeland, due to its photosynthesis mechanism which enables it to resist to hydric stress. The impact of three irrigation rates (2, 6 and 12 times/year) combined with the number of rackets on the growth of varieties of spineless cactus and amycleae was evaluated. In fact, recovery rate of 98% was maintained until the end of the test. Height growth is slow (92 cm in 22 months) while the lateral growth is relatively fast (151 cm in 22 months). As for growth, it is accelerated by the increase in the number of snowshoes at planting and irrigation rate increase.

Similar results for rates 6 and 12 times/year were recorded. At 22 months, the spineless cactus produced more rackets (35 units) than the armed cactus (29 units). However, the aerial phytomass of armed cactus was higher. Finally, fruit production was better for irrigated spineless cactus with the rate 6 times/year. Similarly, the results obtained from experiments on optimal conditions of seeds germination and seedlings establishment in *Artemisia herba-alba* showed that soaking in water for 48 hours is the best pre-treatment to consider with a 70% germination rate followed by water soaking pre-treatment for 24 hours.



VARIETAL CREATION AND CONSERVATION OF GENETIC RESOURCES : MAIN FEATURE OF AGRONOMIC RESEARCH

Narjisse : a new variety of colza recorded in the official catalogue

It is a very productive variety for our favourable areas (Gharb, Loukkos) with an average yield of grain recorded in six environments about 25 q/ha. It has a cycle time of 160 to 170 days and an oil content ranging from 44 to 50% depending on environmental conditions, and a weight of 1000 seeds superior to 3.50 g. It is a variety of canola quality or "double zero" '00", ie, its oil is without erucic acid and its oil-cake contain very glucosinolates. This variety is recommended for areas of Gharb, Loukkos and Sais.

Lines in course of registration in the official catalogue :

Species	Lineages	Test Year
Durum	D32M78	1 st year
	D25M78	1 st year
	BFI 16	1 st year
	D22M67	1 st year
	5DW028	1 st year
	5DW030	1 st year
Wheat	D65M78	1 st year
	D76M78	1 st year
	D22M67	1 st year

Crop improvement programme

Durum wheat

As part of the strategy of improving resistance to drought, HVA1 gene was introduced into the variety Isly. The integration of this gene was confirmed by molecular testing.

On the other hand, and in order to identify new sources of resistance to brown rust, to drought and to technological quality of grains, 737 lines from national and international nurseries were evaluated. Results led to the selection of 200 strains resistant to brown rust and are superior or equal to the witness, the variety Tomouh for the yellow colour, and the variety Marzak for gluten strength.

In order to broaden the genetic variability and improve yield stability of durum wheat, a population was created by chemical radiation of the CHAM1 variety. A DNA mirror bank of about 3000 lines was set up in search of genes of economic interest.

Bread wheat

The breeding and improvement programme of Wheat combines productivity and quality.

Three powerful lines, NS732, L222/3, and L254/3 with a multiple resistance combining tolerance to drought, resistance to septoria, to rusts and to cecidomyie, were identified and will be introduced into the official catalogue after purification and multiplication.



Wheat

The STS markers and Stb2 associated respectively to the gene Lr21 with resistance to brown rust and to the Stb2 gene with

resistance to septoria were confirmed and used as selection markers on an international collection of wheat. Twenty genotypes of this collection with these resistance genes were identified and will be introduced into the breeding programme of wheat.

Barley

Screening results in the field for tolerance to cecidomyia through the collection of local barley from Abda showed that a significant number of lines, 28 in total, has a high tolerance, and no infestation by hessian fly. This result explains the adaptation of local populations of barley to biotic and abiotic stress.



Barley

Chickpea

The evaluation of 468 lines in six production areas allowed the selection of 49 lines adapted to arid and semi arid areas. Similarly 18 lines confirmed their high performance in different sites.



Chickpea

Oat

Despite the difficult conditions of the crop season 2007-2008, some lines showed good performance, such as A7-017/01-02 with 18.4

quintals of grains in the experimental field of Marchouch, and line 32 with 17.4 TMS/ha in Larache. Among these materials, five lines were selected for the production of forage dry matter, four lines for grains production and other lines for mixed use. The lines VR1, VR4, 90SA40 and 92SA129/4m gave grain yields of 27.5, 29.1, 25.8, 21.9 quintals/ha, respectively. They will be tested according to verification tests to detect elites for the official catalogue.

As regards the tetraploid programme, analysis of protein in grains of genotypes derived from interspecific crosses (*A. sativa* x *A. magna*) x *A. sativa* (*A. sativa* x *A. murphyi*) x *A. sativa* was made. Six lines from (*A. sativa* x *A. magna*) x *A. sativa* and one line derived from (*A. sativa* x *A. murphyi*) x *A. sativa* have a protein content exceeding by 1 to 6% that of the hexaploid parents.

Lupine

Lupin breeding programme aims the selection of sweet varieties adapted to conditions in production areas. Three lines (L22PS2, L13PS4, 11 2M-1, L7PS1, D31) were retained. These lines are differentiated from witness Multilupa by :

- Their earliness, exceeding by 10 days Multilupa ;
- Their yield, 30 quintals per hectare against 25 quintals/ha for the witness and, mainly with a bitterness rate significantly lower to that of the witness ;
- Their good level of resistance to powdery mildew and rust.



Lupine test

Sugar beet

The evaluation of germplasm for the identification of a genetic material rich in saccharine and adapted to environmental conditions led to the selection of eleven families exceeding 1.3% to more than 4% the witness derived from varieties used in grande culture.

Results of seed production at Annaceur showed a high genetic variability of family heads. From the 1520 genotypes observed, 65% showed early drafts of bolting 240 days after sowing, in conditions of extreme vernalisation ($T < 0^{\circ}\text{C}$). Grains yield varied from 30 to 650 g/plant. Seed production remains delicate due to particular vernalisation requirements, according to genotypes.

Aromatic and medicinal plants

Research on wild plants focused on inventory and, biomass and quality assessment studies. These studies dealt with two Central High Atlas regions, Ijoukak Valley and Azilal region. Results revealed a specific richness. On the other hand, evaluation studies of productivity in the massif of Agoundis showed a worrying degree of degradation of these plants. Quality assessment is underway, it will further characterize the chemical benefit of major species used namely thyme, sage and lavender.

Saffron

Results concerning the genetic variability of the saffron showed a great variability of flowering date, length and weight of the stigma and weight of corms produced. The percentage of flowering plants in pots did not exceed 10% all sizes coincluded. An significant percentage of corms did not develop and remained at the vegetative stage.

Studies on in vitro production of selected corms (quality, size, number of flowers/

corm, length of stigma, weight of stigma) showed that the nature and concentration of hormones are important factors in the bud corms. Combinations of auxin and cytokinin, led to promising results.

Introduction of saffron in other regions was measured by agronomic criteria and quality parameters of the production. Saffron quality is measured by crocin percentage, coloring pigment, and saffranol content. It is greatly influenced by the drying process and picrocrocin content which determines taste. Tests conducted confirmed a strong interaction «genotype x environment. At sites at more than 1000 m in altitude, saffron quality is higher.



Left : Saffron flower at full opening (time of stigma gathering). Right : clearing of buds on fragments of ripened CORMES in culture environment.

Citrus

Variants (36) stemming from orange variety seedling (Sanguinelli, Navel, Moro Blood Grosse, Pineapple, Salustiana, Cadena, Hamlin, Pearson Brown) and an Ortanique mandarin were identified in the Afourer collection. The evaluation of these clones grafted onto the rootstock Troyer citrange, conducted in Agadir region, focused on performance and criteria related to internal and external quality of fruit. Results showed that production per tree ranges from 7.6 kg to 140 kg, while the average fruit weight varies from 88.3 g to 344.2 g. A predominance of medium-sized fruits with an equatorial diameter greater than 65 mm was recorded.

Study of variants within and between groups of different maturities showed that harvesting can take place over a period of

four months (January to April). Five orange productive clones, with good quality and good storage capacity were selected. These clones are described according to the Union for the Protection of New Varieties of Plants descriptors and will be proposed for inclusion in the official catalogue.

Olive

Results obtained after a ten-year assessment of progeny derived from crosses between many parents of different origins, led to the selection of many genotypes. Some (L3A4, L2A3 and L11A26) are characterized by a high productivity (80 to 100 kg), high content in oil (21%), fruit of medium size and a better growth speed. Others (L2A3, L15A50, L13A50) are productive (55 to 84 kg), with a light overhead and medium sized fruits and an average oil content (18%). The analysis of oil quality will lead to a better characterization of these genotypes and to identify the best ones (Figure 8).

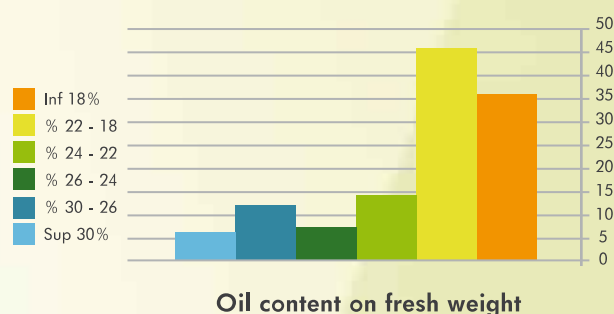


Figure 8 : Genotypes grouping according to their richness of oil.

Date palm

The multiplication of buds has been successful with different varieties and clones initiated. The multiplication rate is variable depending on genotypes. The Mejhoul variety is among those most difficult to multiply, due to buds regeneration capacity decline manifested by a greening and early lengthening. Besides, during the year 2008, 6500 budding strains were produced from different clones and varieties requested by farmers. They were delivered for multiplication at a great

scale. The use of bio reactors based on the liquid aspect led to promising results of buds multiplication and automation of this operation.

Moreover, the search for molecular markers associated with resistance to bayoud is part of the varietal creation programme of date palm. The DNA of the progeny derived from susceptible and resistant parents was compared to that of parent. The 8 RAPD primers (10-nuclear bases) used allowed the selection of 17 candidate RAPD markers for resistance to bayoud. Among the 30 primers tested, 22 were found compatible, but only two (MIC 15 and 19.) could reveal MIC candidate markers that could be associated to resistance.



Date palm multiplication

Almond

The evaluation of the genetic material performances of the almond tree revealed broodstock for their productivity characters, fruit quality and lateness of flowering. The phenological study of this material showed biological evidence of climate change facing Morocco (**Figure 9**).

The vegetative propagation of interspecific hybrids peach X almond (PXA) that might serve as a rootstock for Rosaceae stone (almond, peach) was initiated. Using *in vitro* culture is essential to overcome the constraints related to the nature of the genetic material. This method led to the identification of five local hybrids with a good capacity to multiply *in vitro* by the technique of axillary bud. The disinfection protocol, the beneficial

environment for the initiation of culture (axillary bud) and maintenance medium were developed. The study of the roots showed that the rooting of this material is delicate and depends on the age of the explant and probably also of the culture medium (in particular, the type and concentration of auxin : IBA or NAA). The genetic potential of the almond collection ACSAD was assessed for the selection of broodstock adapted to rainfed conditions. The genotypes studied showed different levels of adaptation and a great genetic variability observed for the main traits of economic interest. Moreover, comparison with the cultivated varieties allowed the selection of five genotypes with yields of almond that exceed the variety "Marcona".

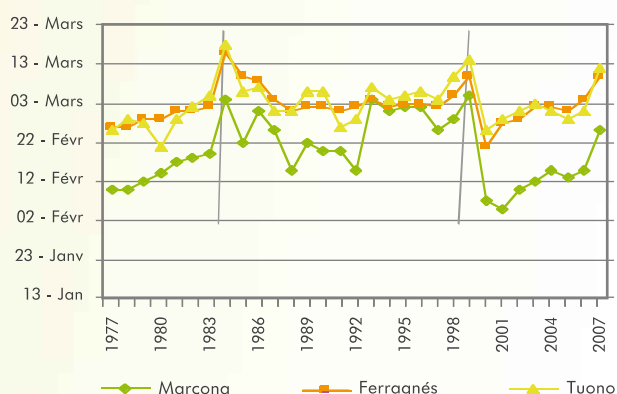


Figure 9 : Dates evolution at full flowering of almond varieties : a tendency towards precocity

Carob

The surveys conducted on the carob in the Middle Atlas have enriched the collection of the carob tree. The characterization of this material led to the identification of competitive genotypes namely in regard to production (about 10 quintals per tree, and cloves 10 g), grain yield and adaptation to adverse conditions. These genotypes will be set in collections. Multiplication tests showed that the germination of seeds can reach 100% thanks to seeds soaking in water at room temperature for 5 to 15 days. The success of grafting is obtained from plants of 3 years of age associated with the cleft grafting technique from May.



Cleft grafting on 3 year carob seedlings

Cactus

A collection of 31 cactus genotypes *Opuntia ficus indica* (L.) Mill originating from coastal areas from El Jadida to Tangier, Tetouan and Chefchaouen, was planted and studied at the Melk Zhar experimental field. The results obtained showed the existence of a wide phenotypic and genotypic variability for most traits measured. The characters most variable are young snowshoe per plant and the number of fruits per plant. Regarding the characteristics measured at the bat, there is a wide variability in the width of the racket, the shape index, the number of areolae, the number and length of the longest spine. The analysis of fruit characters showed that seed weight, the number of seeds per fruit and the sugar content have a significant variability. The genetic improvement of these characters seems promising in order to develop more productive varieties.

Caper

The improvement of caper multiplication techniques is of a great interest for the domestication of this species. The cuttings

is a vegetative propagation technique that allows obtaining a large number of plants of each mother plant while maintaining its quality. The objective of this activity is to study the effect of hormonal treatment by IBA (Indole Butyric Acid) on the rooting of wild populations of caper and the effect of the original cuttings. The success rate of propagation of caper has varied significantly depending on the origin of the populations collected from 22 to 35%, and the use of indole butyric acid to 3% has significantly improved the rooting of cuttings. The application of treatments with Indole Butyric acid significantly improved the success rate of cuttings in the caper. The origin of the clones affected this rate with a good rooting ability of Taounate ecotypes versus those of Sidi Kacem.

Ex situ conservation of plant genetic resources

INRA genebank currently maintains over 22,000 accessions belonging to 256 species. Eight kinds of strategic importance in food security represent more than 77% of total accessions preserved. These include *Hordeum*, *Medicago*, *Avena*, *Triticum*, *Helianthus*, *Zea*, *Vicia* and *Oryza* (**Figure 10**). Thanks to the gene bank, researchers multiply germplasm for regeneration and/or evaluation purposes. In 2007-2008, 931 accessions were characterized and multiplied.

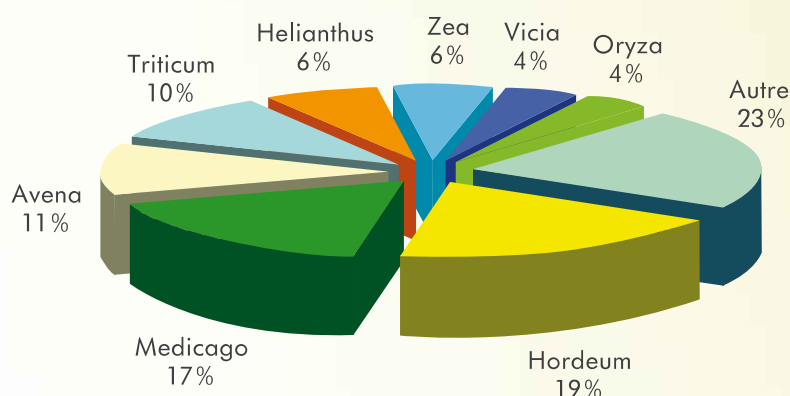


Figure 10 : Graph : Main genre kept at INRA gene bank.



RATIONAL FARMING TECHNIQUES FOR A QUALITY SUSTAINABLE PRODUCTION

Integrated Crop Management

Improvement of irrigation water management for wheat in Tadla region

Tests on several consecutive years (2004 to 2008) for the assessment of technological packages were conducted among farmers in rural communes of Ouled Zemame and Bradia (irrigated perimeter of Tadla). The objective is the adoption by farmers of strategies and technologies for optimal use of rainwater and irrigation. These tests covered three main topics : varieties, planting dates and wheat supplementary irrigation. The results of this evaluation showed that the choice of varieties (productive and resistant to drought), the adoption of early planting (late October-early November), and the use of supplemental irrigation significantly improve wheat production and productivity of rainwater and irrigation. Results show that grain yields of Ashtar, Salama and

Radia varieties exceeded 10 tons per hectare. The choice of varieties allowed a water productivity of 2.4 kg/m^3 against 0.8 kg/m^3 among some farmers. The average yield obtained by farmers through early planting is 7.7 T/ha against 6.2 T/ha in late planting. Early planting also improves water production that increased from 0.8 to 1.2 kg/m^3 . Supplemental irrigation allowed yields of 8.3 tons per hectare for some farmers, with a water productivity of 2.3 kg/m^3 .



Different phonological stages of wheat linked to sowing date

Management of irrigation and fertilization of citrus in the region of Kenitra

Studies on irrigation water saving in citrus orchard «*Washintong Navel/Troyer citrange*» aged and planted in sandy soils in the experimental field of El Menzeh (Kenitra) showed that conversion of irrigation systems to sprinkler irrigation system is located very encouraging. Transition to the localized irrigation system saves 40% of water used, or 2800 m³/ha of water compared to current practices in the Gharb.

The potash fertilizing applied to leaves of the clementine 'Cadoux', grafted on *Carrizo citrange* in the Experimental field of Sidi Allal Tazi allowed a rapid absorption of potassium compared to the application of potassium in the soil. All foliar treatments, whatever their sources of potassium. The number of applications and planting density improved fruit color compared to the witness. Treatment with 4% K₂SO₄ had a maximum gain of yield of about 28 kg of fruit per kilogram of fertilizer.

Management and saving of irrigation water for alfalfa

The restriction of irrigation doses of 2/3 and 1/3 compared to 100% of potential evapotranspiration (ETP) from three oases populations (Rich 1, 2 and 3), three Demnate populations (Dem 1, 2 and 3) and a control, induced a significant reduction in the production of biomass in green and dry in all populations studied with a reduction in the number of cuts at the most stressed water regime. In such conditions, populations from the oases gave the best forage yields than Moapa. Genetic analysis of these populations was used to select the best populations for their inclusion in the official catalogue.

Adaptation of perennial grasses to drought

The aim of the study is to identify the major eco-physiological adaptations to survive drought for 18 varieties of perennial pasture grasses belonging to *Phalaris*, orchardgrass and fescue. The yield potential of three perennial grass species tested is higher in the case of *Phalaris* and cocksfoot compared to fescues. The analysis of plants survival showed that varieties with adaptive responses contribute to the delay of dehydration by regulating leaf growth and progression of senescence. Other responses contribute to drought tolerance. Four groups of varieties were identified according to their drought resistance and durability. One group, represented by the Flecha variety, with a level of resistance to drought and high durability, another group of varieties with a level of drought resistance and intermediary durability, which is the case of Fraydo, Centurion and Kasbah varieties. A third group, with a level of resistance to drought and limited durability, includes the varieties Atlas, Australian, and Sirolan Tanith. One last group having resistance to drought and low durability, consists of varieties Curie, Delta, Jana, Medly, Ottawa, Porto, Sisa and Lutine.

Modeling the behavior of durum wheat under different management models in semi-arid areas

Crop management involves a large number of physiological and environmental parameters and techniques to master in order to use agricultural inputs and natural resources optimally. The GECROS and CERES models for interaction between cultures and their environment were calibrated in the semi-arid conditions of Sidi El Aydi (Settat). With these models, it is possible to predict the yield of durum wheat at the plot with a high degree of accuracy under different growing conditions (variety, nitrogen fertilization and irrigation) in semi-arid environments (Figure 11).

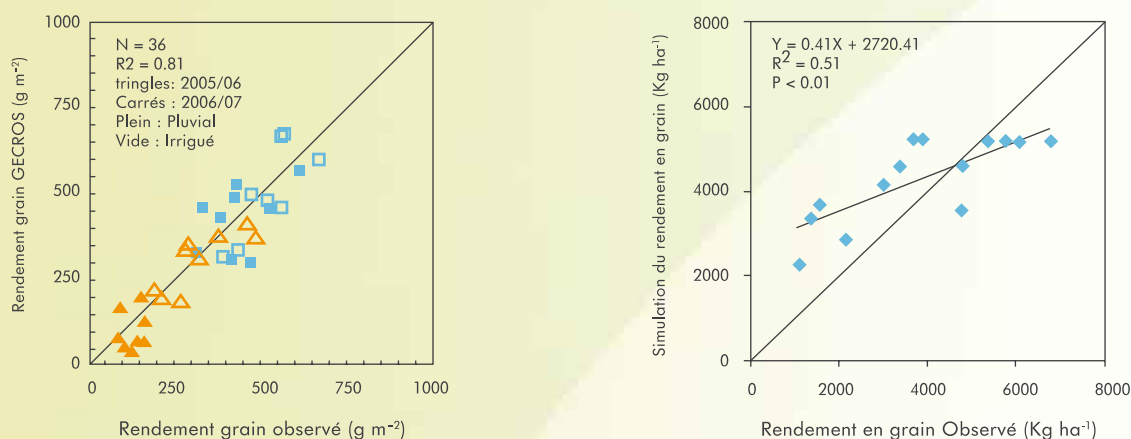


Figure 11 : Comparison of seed yield observed and simulated by the model.

Promotion of conservation agriculture (no-tillage) in semi-arid

Tests of direct sowing were conducted with farmers in the rural area of Jemâa Shaim, under rainy conditions in 2007/2008. Combination of rainfall during this campaign was about 200 mm, indicating a deficit of around 30% compared to

normal. Despite the unfavorable weather conditions, the yields in Jemâa Shaim were averaging 3.7 Qx/ha for direct sowing against 3.2 Qx/ha for conventional sowing. Modified Stability Analysis, which allows the measurement of technology behavior according to environments, showed that the direct sowing gives better yields than conventional sowing when environmental conditions are unfavorable (**Figure 12**).

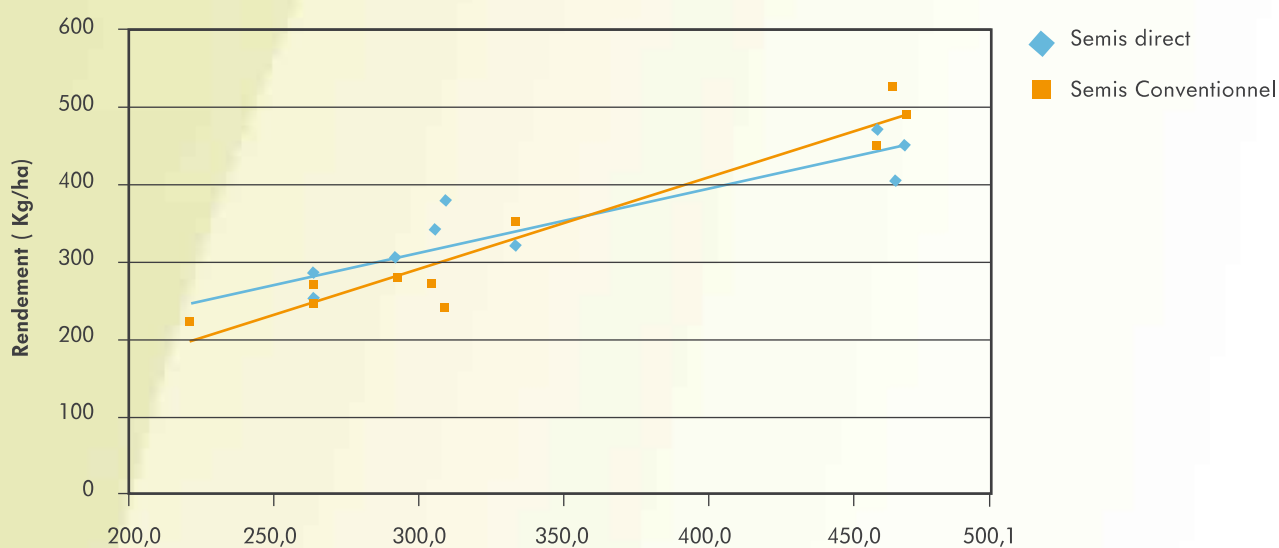


Figure 12 : Analysis of modified stability of durum wheat yields in Jemâa Shaim region (Safi) showing a superiority of no-tillage on conventional sowing in different environments.

Organic vegetable crops in the Souss Massa

In organic farming, compost and particularly the organic amendments are highly recommended in horticulture intensive because of their buffer effects and capacity to improve soil structure. Tests in «tunnels»

glass houses, conducted in the Experimental Area of Melk Zhar (Agadir), showed that the incorporation in soil of organic compost for growing zucchini «Natura» led to the production of about 65T/ha. In the long run, use of compost can improve the rate of soil organic matter and organic crops.



NEW ECONOMIC TECHNIQUES

RESPECTFUL OF ENVIRONMENT FOR PLANT PROTECTION

Integrated protection of cereals and food legumes pests

Initiated within project MGCP (**Integrated Pest Management in the cereal/food vegetable cropping system : research and human capacity building**) research was conducted in partnership with ICARDA to develop a package of technologies for integrated pest management associated to the production system cereals/legumes.

Distribution and importance cereals and food legumes enemies

Surveys were conducted in main cereals and food legumes regions in the aim of mapping the distribution and impact of different enemies associated to these crops and developing an expert system of pests control. A total of 259 fields were visited

including 80 of barley, 81 of wheat, 39 of durum wheat, 31 of beans, 13 of chickpea, 11 of peas and 4 of lentils.

Diseases associated with grain

The diseases most prevalent in the fields of wheat, in order of importance, are brown rust (*Puccinia triticina* Erikss), septoria (*Mycosphaerella graminicola* (Fuckel) Schoter, anamorph *Septoria tritici* Desm) and to a lesser extent yellow rust (*Puccinia striiformis* Westendorp f. sp. *tritici*). Other minor diseases were also observed such as stem rust (*Puccinia graminis* Pers. : Pers. f. sp. *tritici* Eriks. E. Henn), powdery mildew (*Blumeria* (*Erysiphe*) *graminis* f. sp. *tritici*) and common bunt (*Tilletia tritici* (syn. *T. caries*) and/or *T. laevis* (syn. *T. foetida*).

At fields of durum wheat, the situation was characterized by the predominance

of brown rust (*Puccinia triticina* Eriks.), Tan spot (*Pyrenophora tritici-repentis* (Died.) Drechs. (Anamorph *Drechslera tritici-repentis* (Died.) Shoemaker), and septoria caused by *Septoria tritici* (Desm.) Rob. (teleomorph *Mycosphaerella graminicola* (Fuckel)

Schroeter) and *Stagonospora nodorum* (Berk.) Castell. & Germano (teleomorph *Phaeosphaeria nodorum* (E. Müll.) Hedjar). Yellow rust caused by *Puccinia striiformis* Westendorp f. sp. tritici was only observed in Tadla (**Figure 13**).

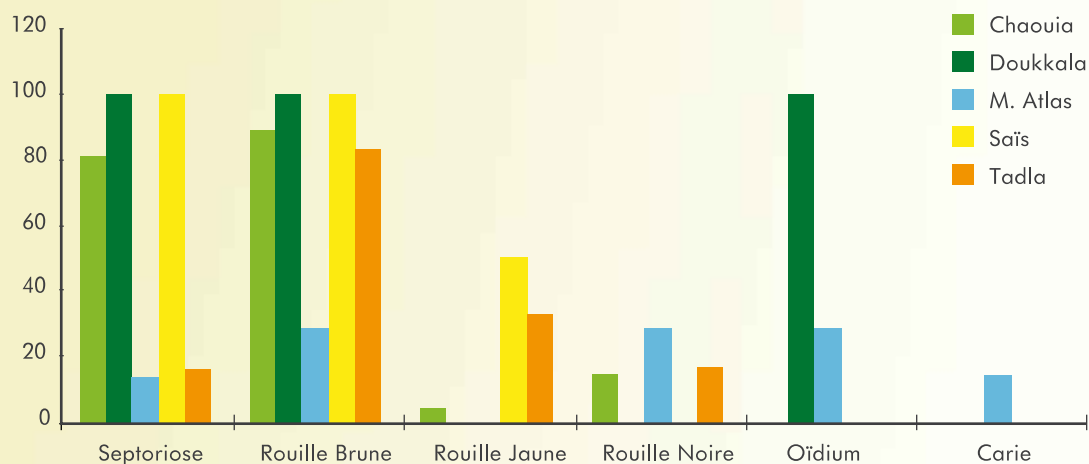


Figure 13 : Prévalence des maladies cryptogamiques sur blé tendre, par région prospectée durant 2007-2008.

However, determination of heterothallic types (mating types) of a series of 24 strains of *S. tritici* by technology "Multi-plexed PCR" revealed the existence of the two types (MAT1-1 and MAT1-2) on wheat. This result indicates that the sexual form *Mycosphaerella graminicola* (Fuckel) Schoter might exist and be a source of primary inoculum.

This form generates an accentuated genetic recombination and threatens varietal resistance.

Concerning *barley diseases*, net blotch caused by *Pyrenophora teres* Drechsler was seen in all regions. The net type caused by *P. teres* Drechs. was confined to regions of Abda, Chaouia, Doukkala, Hmar and Gharb. In opposition, the spot type (*P. teres* f. *maculata* f. Nov.) dominates in the pre-Rif and Zemmour-Zaër. Charcoal Covered (*Ustilago hordei* (Pers.) Lagerh.) was observed in Abda, Doukkala, Chaouia, Sais, Zemmour-Zaër and the Middle Atlas. The smut disease (*Ustilago nuda* (Jens.) Rostr.) and brown rust (*Puccinia hordei* GH Oth.) were encountered respectively in Abda and Gharb. The scald (*Rhynchosporium secalis* (Oudem.) Davis) and

powdery mildew (*Blumeria graminis* (DC.) Speer (*Erysiphe graminis*) f. sp. *Hordei*) were present in the Middle Atlas.

Insect pests of cereals

The midge in wheat and barley, *Mayetiola destructor* Say *Mayetiola hordei* Keiffer, are present, with varying levels of severity, in areas of Abda, Hmar, Doukkala, Chaouia, Tadla, Zemmour-Zaër, Gharb, Sais, Pre-Rif and Middle Atlas. A large infestation of stubble stem sawfly, *Cephus spp* was observed at the maturity stage.

Distribution and importance of bromine associated with cereals

Variability in the distribution of bromine species has been noted in cereals fields in the region of Sais and the Middle Atlas. It depends namely on the type of soil, previous crop and weather conditions. Infestation levels in 200 plots explored ranged between 126 and 844 plants/m². The species *B. rigidus* Roth was noted in more than half of the fields with a recovery rate of 44.6%. *B. rubens* L., *B. madritensis* L. *B. sterilis* L. and *B. mollis* L. were

also encountered with varying degrees of frequency.

Diseases associated with beans

Alternariose diseases (*Alternaria tenuis* Nees), root rot (*Rhizoctonia* spp or *Fusarium* spp.) rust (*Uromyces viciae-fabae* Schroeter) and chocolate spot (*Botrytis fabae* Sardina and *B. cinerea* Pers.) predominated in the bean pathosystem. They were observed respectively in the regions of Hmar, Hmar-pre-Rif-Zemmour-Zaër pre-Rif-Middle Atlas, Chaouia and Doukkala.

Legumes weeds

Floristic surveys have identified 195 weeds species of legumes crops belonging to 41 botanical families containing 132 genre. Five families dominated the weed flora encountered with a percentage of 56.4 of the totality : Asteraceae, Poaceae, Fabaceae, Apiaceae and Brassicaceae.

Control of cereals and legumes enemies

Search for sources of resistance to wheat diseases

A series of 22 varieties of Moroccan wheat and 26 lines introduced from CIMMYT-ICARDA, with good agronomic performance were tested in greenhouse away from septoria. Evaluation of components of partial resistance of this material, expressed by the latency and pycnidial recovery, revealed the resistance of one single moroccan variety (Saada) and five strains introduced. Other works in the fields confirmed the high level of resistance of the germplasm introduced from CIMMYT, both to brown rust and yellow rust.

In the case of caries, evaluation of a nursery consisting of 22 varieties of Moroccan wheat and 50 durum wheat genotypes (26 from Morocco, 12 from Spain and 12 from Italy) showed a higher sensitivity in wheat.

Selection for resistance to net blotch in barley

The evaluation of a Moroccan germplasm of 600 barley lines from the genebank at-CRRA Settat to net blotch in greenhouse conditions led to the identification of 97 genotypes resistant to this disease that are to be developed in the national programme of genetic improvement of barley.

Selection for resistance to midge and to stem sawfly stubble

A total of 3247 lines, generated by ICARDA, were tested for resistance to midge in Sidi Allal Tazi field. The selected resistant material consists of 373, 85, 2 and 61 lines respectively at stages F7, F6, F5 and F4. Some lines F7, also proved resistant to stem sawfly stubble will be tested on the cob online to select those with the double resistance both to midge and to stem sawfly.

Chemical control of the rigid brome in wheat in Sais

Estimation of bromine competition to wheat culture in Sais revealed a highly significant effect of bromine density on the reduction of yield. To control bromine, the new molecule Propoxycarbazone sodium + NH₄SO₄ proved very effective. The product was applied at a dose of 2.8/+2.8 g ma/ha at early tillering stage, 10 days after the first application, in combination with ammonium sulfate at a dose of 150+150 g/ha. Further to this treatment, the levels of yield reached were very satisfactory.



Field infested with bromine



Treated field

Reducing the volume of the bouillie mixture slurry for the application of glyphosate

The study of the effect of the spray volume on the efficacy of treatments with glyphosate against the bean broomrape (*Orobancha crenata* Forsk) in Tadla showed a very good efficacy of treatments using volumes ranging from 120 to 400 l/ha. Hence, a spray volume of about 200l/ha may be recommended instead of 500l/ha generally recommended. This can result in substantial savings of two thirds of the water volume of the slurry.

Combining genomics, genetic resources and breeding for wheat and barley production development Morocco

Works conducted under the project «Generation Challenge Program : Bridging genomics, genetic resources and breeding to Improve wheat and barley production in Morocco» aims to use genetic resources namely reference series (reference sets), genomics tools developed by the members of the PAG, C-Gcenters, ARIs and the National Agricultural Research Systems (NARS) for the genetic improvement of wheat and barley. In 2008, evaluation of germplasm of wheat allowed the identification of 7 strains resistant to midge, *M. destructor*. In the case of durum, 11 lines were selected, resistant to brown and yellow rust (*P. striiformis* and *P. tritica*) and 16 lines resistant to root rot. The evaluation barley germplasm led to 28 strains resistant to barley midge *M. Hordei*, and 9 others resistant to net blotch of barley, *P. teres*. The genotypes of wheat identified resistant to leaf rust in 2007 were used as parents in a breeding program with the objective of incorporating resistance, broadening the genetic base and developing varieties with multiple resistance.

Furthermore, a series of germplasm within the regional programs of improvement with

target known markers was used in breeding programs assisted by molecular markers (MAS). This material includes resistance to the 3 types of rust : *P. tritica*, *P. graminis* f.sp. *tritici* and *P. striiformis*, characteristics of quality such as high levels of seed protein, gluten and resistance to cyst nematode. Breeding programs for the MAS are at different stages of progress pyramiding of genes.

Development of Integrated Protection of Citrus

Biological control of conservation diseases of citrus fruits

Research conducted led to the identification of a strain Z1 (*Pichia guilliermondii* Wickerham) with a high level of antagonism vis-à-vis green and blue rot (*Penicillium digitatum* Sacc and *P. italicum* Wehmer). Laboratory tests on the possibilities of incorporating this biopesticide in waxes concluded made evident a high toxicity of formulations of the waxes commonly used in packing stations. Tests of other formulations demonstrated a good activity of the Z1 strain with Shellac wax type, carnauba, carnauba + Shellac, Candellilla Wax, Rosin maleic, Ester Gum, Microcrystalline and Rice Bran Wax. This result opens new perspectives for the development of this biopesticide in citrus packing chains.

Control of citrus pests

In biological control, evaluation of the impact of aphidiphages interaction on the predation of the black aphid *Toxoptera aurantii* Boyer de Fonscolombe in citrus orchards in the Gharb showed the role played by the native auxiliary fauna in controlling citrus pests. These include beetles, *Adalia decempunctata* Linnaeus. and *Coccinella septempunctata* Linnaeus, midge, *Aphidoletes aphidimyza* Rond.; the Neuroptera including *Chrysoperla carnea* Stephens and hoverflies particularly *Episyrphus balteatus* De Geer. At the association level, the pair

A. decempunctata + *C. septempunctata* most affected the black aphid colonies. These results suggest that the natural fauna in the Gharb region must be taken into account as an essential link of the chain in the control programs.

Investigations on bio-ecological parameters for the installation of the fruit fly rearing in laboratory conditions indicated that the optimum temperature for a balanced sex ratio is 25°C with a development maximum of 30°C.

The bioinsecticide H2 based on *Cedrus atlantica* (Manetti ex Endl.) Carriere, which showed during the previous tests a marked effect on the black aphid, also proved effective against fruit fly and olive fly adults, *Bactrocera oleae* Gmelin.

Emerging pests of citrus in Tadla

The study of the dynamics of citrus emerging pests in Tadla was initiated in order to develop an integrated control programme case of outbreak. The results obtained showed an intense activity of thrips populations on three varieties of citrus at flowering stage. (Navel, Late Morocco and Clementine). A large outbreak of leafhoppers was also recorded on the three varieties, but with varying intensities.

Nematodes associated to citrus

Research on citrus nematodes were pursued by new surveys conducted in the Gharb region, Moulouya, Souss Massa, Haouz, Loukkos and Tadla. The results confirmed the contamination of all orchards visited by the slow dieback nematode of citrus *Tylenchulus semipenetrans* Cobb. Differential host plants tests revealed the exclusive presence of the *Mediterranean biotype* of *T. semipenetrans* in orchards in Gharb, Haouz, Loukkos, Souss Massa and Moulouya.

Virus diseases of citrus

Surveys were conducted in citrus orchards in Souss, Gharb, Moulouya, Tadla, Haouz and Loukkos in order to assess the incidence and distribution of major degenerative diseases : tristeza (*Citrus tristeza virus*) psorosis (citrus psorosis virus) and stubborn (*Spiroplasma citri*). Typical symptoms of psorosis were observed in all regions explored, while the symptoms characterizing stubborn were found in Souss, Haouz and Tadla. The presence of these viruses was confirmed by ELISA test (Enzyme Linked Immuno Sorbent Assay).



Psorosis symptoms (bark peeling) on Maroc Late variety grafted on Bigaradier (Ghrab).

Detection of an outbreak of tristeza in the Loukkos region

Surveys revealed the presence of an isolated outbreak of tristeza in the Loukkos region. Indeed, in December 10, 2008, two orchards ten years old were controlled positive for tristeza at Laouamra by the DTBIA (Direct Tissue Blot Immunoassay) technique and confirmed by DAS-ELISA technique. The first orchard contained the the common Clementine variety grafted on sour orange, and the second is composed of the thin skin clementine grafted onto citrange. This was the first confirmed report of tristeza in the region. Isolated outbreaks of tristeza were detected several times in Morocco, but without causing any real damage. These homes were uprooted and incinerated without any evidence of large-scale dissemination. Aphids as the most efficient vector of CTV,

Control of dodder associated with citrus in Tadla

Protection of date palm

Analysis of the genetic diversity of the bayoud agent

The genetic polymorphism of a collection of 60 strains including 39 strains of *Fusarium oxysporum* f.sp. *Schlechtendahl albedinis* (Killian & Maire) WL Gordon (Foa), from Morocco, Algeria and Mauritania, and 14 strains of *F. oxysporum* (For), isolated from soil of palm groves of Morocco, Mauritania, Sudan, Jordan, Oman, Egypt and Qatar, has been studied using molecular markers RAPD and amplified microsatellite sequences by simple primers. A polymorphism was identified in the special form *albedinis*, hitherto considered genetically homogeneous (**Figure 14**). Moreover, the genetic proximity between Foa and Fo strains revealed in this study suggests new hypotheses regarding the saprophytic origin of Foa.

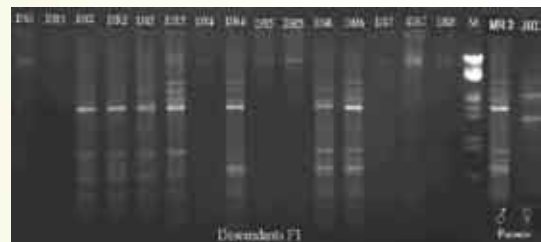


Figure 14 : Electrophoretic profile of DNA male parents (MR3) and females Jihel (JHL, sensible) and some individuals of their descendents DR : Descendent Resistant, DS : Descendent Sensible.

Purification and identification of toxins secreted by the bayoud agent

The study of the structure of toxins from the FII fraction extracted from culture filtrate of *F. oxysporum* f.sp *albedinis* conducted in collaboration with the Faculty of Science and Technology of Marrakech, allowed the determination of the chemical structure of the toxin most virulent H4 by NMR as the tyrosol (**Figure 15**). The biological test showed that some form of «Tyrosol» extract reproduced typical symptoms on young leaves detached from the susceptible variety Jihel.

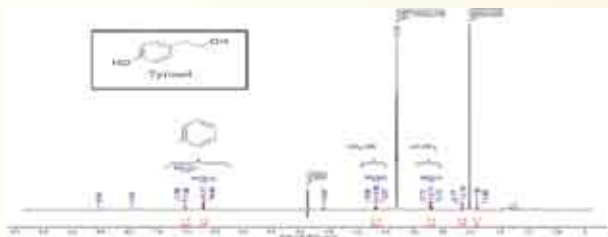


Figure 15 : RMN spectre of peak H4. RMN of protons to the frequency of 500 Mhz, the solvent used is Methanol

Biological control of the bayoud disease

Studies conducted allowed the selection of a chitin based bio-fungicide which completely inhibits the growth of the fungus and activates the growth of two antagonistic actinomycetes a month after its application in soil. This product showed in vitro a fungitoxic effect by inhibiting spores germination and mycelial growth. A significant reduction of spores was obtained during the first week in solutions containing chitin extracts. This effect was confirmed in the third week for all concentrations used. In practical terms, soil amendments containing chitin could enhance disinfection efficiency.

The in vitro study of the effect of three extracts of eucalyptus (*Eucalyptus radiata* Sieber ex DC.), Oleander (*Nerium oleander* L.) and acacia (*Acacia* sp.) on the germination of spores and on mycelial growth of the bayoud agent showed a very marked inhibitory effect of eucalyptus green leaves. The use of this tree leaves as an amendment to soil could reduce infections and saprophytic life of the agent of the bayoud disease.

Antibiosis tests performed on four disease agents of date palm (*F. oxysporum* f.sp. *albedinis*, *Mauginiella* SCAETTA, *Botryodiplodia thomae*, *Stemphylium botryosum*) and an olive disease (*Verticillium dahliae*) allowed the selection, among a collection of 142 microorganisms taken from the rhizoplane of these two cultures, 8 fungi and 4 bacteria with inhibitory action. Moreover, 7 natural substrates of animal, vegetal and organic origins significantly

affected the development in vitro and in soil of these pathogens and their antagonists.

Protection of fruit trees

Research on the fireblight disease

Field research conducted during May 2008 revealed that the fireblight disease, *Erwinia amylovora* (Burrill) Winslow et al., unexpectedly spread to other areas namely El Hajeb, Khenifra, Azrou, Immouzer, Sefrou and Taounate as well as to other sites in the region of Meknes. The species most affected was pear. More than 500 ha of this species (all varieties without exception) were affected with about 30 ha being uprooted and incinerated. Apple was also affected but not in a serious way.



Pear tree at N'zalt Benammar seriously attacked by Fire blight (May 2008).



A young pear tree affected by fire blight (Cross form) (May 2008, Menzeh-Meknès).



Pear fruit totally infested by Fire blight (El Hajeb region, May 2008).

Furthermore, about forty new isolations of the bacteria from samples from Meknes, El Hajeb, Immouzer and Sefrou were constituted and characterized. The behavioral study of 112 new strains vis-à-vis copper and streptomycin showed a strong resistance of a dozen strains to this product at concentrations up to 500 ppm, indicating a greater difficulty in the use of chemical-based control with products incorporating copper.

In the case of treatment with streptomycin, Moroccan strains were classified from very sensitive to highly resistant, indicating that their origin could be one or more countries using antibiotics to control the disease.

Protection of pomegranate

Evolution of the Infestation of shoots and buds of pomegranate by *Aphis punicae* (Passerini) in Tadla led to a study in order to develop a rational approach of pest control. It followed that an aphicide treatment based on pirimicarb at the end of April brought the levels of the aphid population below the threshold of harmfulness. Performance analysis revealed significant yield losses of around 24 tonnes/ha in the absence of a chemical intervention.

Nematodes of Vine/grapevine

Surveys on nematodes associated to vineyards in Morocco were completed by specimens taken from Meknes, Khemisset, Tifelt, Haouz, and Moulouya regions. Results confirmed the presence of two species of the genre *Xiphinema* *X. index* Thorne & Allen and *X. pachtaichum* (Tulaganov) Kirjanov. The species *X. index*, most dreadful for its direct damage and its role as vector of short-leaf viral disease, was identified in Haouz, Moulouya, and Meknes regions. Species of nematodes (*Meloidogyne* spp.) and root lesion nematodes (*Pratylenchus* spp.), not less important, were also encountered in areas explored.

Virus diseases of vine

Surveys were conducted to assess the incidence and distribution of the main virus associated with vine cultivation. Typical symptoms of Fanleaf associated to GFLV (grapevine fanleaf virus) were observed in different regions. Other symptoms were also observed namely leaf roll associated to a complex closterovirus (GLRaV) along with typical symptoms of vine groove wood associated to a minimum of four viruses

among which GVA, Grapevine vitiviruses A. The presence of these viruses was also confirmed by serologic identification using the ELISA test (Enzyme Linked Immuno Sorbent Assay).



Nervure yellowing of the Superior variety graft to Paulsen 1103 (Haouz).



Typical symptoms of foliar winding up.



Inflation above graft line. Symptoms of striated wood Disease.



Symptoms of wood striate disease in wood (Meknès).

Control of apple codling

The reasoning of plant protection against the apple codling moth *Cydia pomonella* L. in the valley of Ait-Bouguemmaz was achieved through monitoring population dynamics of this pest (**Figure 16**). During the study period and at apple flowering, the codling moth shows three distinct flights. Based on observations, chemical interventions were triggered as soon as the level of males capture reached the threshold of 3 males/traps.

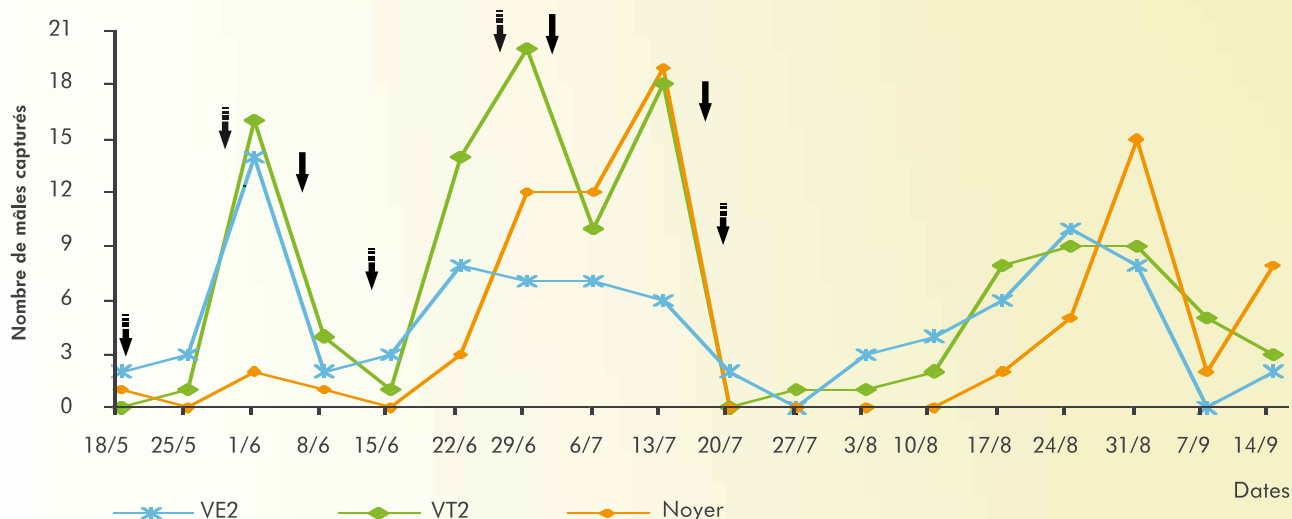


Figure 16 : Trends of males of codling «carepocapse» captured in the valley of Ait Bouguemmaz.

Biological control of post harvest rots of apples

An approach combining the use of semi-selective and specific SCAR marker was developed for plotting two strains of yeast *Aureobasidium pullulans* (de Bary) Arnaud (Ach 1-1 and 1113-5) antagonists diseases post-harvest apples, *B. cinerea* and *P. expansum*. The semi-selective S32 is composed of 0.5 mg/l Euparen, 1 mg/l Sumico, 1 mg/l Cycloheximide, 2.5 mg/l Hygromycin B and 30 mg/l streptomycin sulfate. The two SCAR markers specific to strain Ach 1-1 are 189 and 387 bp, amplified with primer pairs respectively AR13.7/AR13.10 and AR13.7/AR13.11 at hybridization temperature of 62°C. Concerning strain 1113-5, a 431 bp SCAR marker was identified using the primer pair AQ3.1/AQ3.2 at a hybridization temperature of 60°C.

Protection of potato

Biological control of potato soft rot

Research on the antagonists of potato soft rot caused by pectinolytic *Erwinia* (*E. carotovora* var *carotovora* (Jones) Bergey and *Bark atropctica* (Van Hall) Jennison) was pursued by the characterization of a collection of 117 strains of this bacteria isolated from stems

and tubers. Results reflected the phenotypic diversity of these strains in Sais which resulted in 33 strains of a new subspecies *E. c. betavascularum* Thomson et al., 46 strains of *Ec atroseptica* and 38 strains *Ec catrotovora*.

Chemical control of potato weeds

In field tests in Meknes region, the treatment of potato weeds by a post-emergence herbicide containing paraquat applied at 20% at a dose of 300 gai/ha confirmed its effectiveness on twenty species of weeds. This product proved more efficient than metribuzin, generally used in these situations. Paraquat was non residual and allowed the removal of many grass weeds and broadleaves.

Development of integrated control of olive black cochineal

A study on the dynamics of olive black cochineal *Saissetia oleae* was performed on different olive organs in two orchards of different ages in Essaouira region. The observations obtained in these circumstances show the possibility of chemical control of black cochineal aiming essentially stages L1 and L2 with two applications at monthly intervals from July with selective products.



PROMISING RESULTS FOR IMPROVING THE PRODUCTIVITY OF

SMALL RUMINANTS THROUGH THE DEVELOPMENT OF FODDER CROPS

Research activities on sheep and goats focused on improving the productivity of these two species in pure breed and crossing, on determining the parameters of reproduction, evaluation of their performance among farmers, development of goats milk and diversification of food supply. Research dealt also with the characterization of stored forage and agricultural by-products.

D'man and Draa breeds, assets for oasis farming

Research on the D'man race contributed to the development of adapted breeding techniques allowing high prolificacy per ewe at birth (2.33 lambs) and at weaning (1.92 lambs). At station level, productivity weight

is 65 kg/ewe/year which is twice what can be achieved among farmers. Achievements transfer to breeding techniques of the prolific D'man among breeders in Tafilalet and in the oases of the South by the diffusion of selected animals were performed.

The results achieved by the Draa goat breed introduced recently in Errachidia field showed that this race has a prolificacy of 150% and a productivity of 15 kg of bodyweight/goat/year. In terms of milk production, the average amount 0.83 kg/goat/day, or 96 kg in 114 days. In addition, breastfed kids reached average daily gain of 100g/day. The Draa race will play an important role since it is sought in development programmes of income generating activities within the INDH.



Crossbreeding D'man x Timahdite

Crossbreeding, a way to improve small ruminants productivity

Sheep crossbreeding program in the Atlantic bour favorable area

In addition to the multiplication of animals of the new synthetic breed composed of 50% of D'man genes and 50% of Timahdite genes counting today 100 ewes, data of five years of research were analyzed and summarized for 1292 ewes and 1664 lambs belonging to F1 to F4 generations.

The results showed that sheep F1 to F4, all generations considered, achieved a productivity weight at weaning per ewe 4 and 3 kg greater respectively on parental sheep breeds D'man and Timahdite. Similarly, the superiority of the numerical productivity of the sheep at parturition and after 90 days is about 0.5 born lambs and weaned and 0.3 weaned lambs respectively, compared to Timahdite race productivity.

The study of ovulation rate and embryonic mortality obtained by endoscopy in 67 pure breeds sheep and 181 crossbred sheep showed that crossbred ewes of F1 to F4 generations had a high ovulation rate (191%) from 200% in F1 to 194% in F2, much higher than that of Timahdite race (132%) but lower than that of the prolific D'man breed (248%). However, embryonic mortality is significantly higher in the D'man sheep (64%), whereas in the crossbred (F1 to F4) embryonic mortality (26%) is comparable to that recorded for Timahdite sheep (23%).

Impact of disseminating F1 (D'Man X Timahdite) sheep crossbred among farmers

Analysis of data from 331 INRA F1DT sheep during three years at 18 private farms located in the Kenitra-Casablanca and Khemisset axis, and socio-economic assessment revealed the importance of reproductive potential of F1DT ewe. In fact, these sheep allowed the improvement, in comparison with local sheep, of prolificacy at birth from 60 to 77%, a productivity gain of 40 to 60% according to livestock, which is for the best breeder an average productivity of 38.13 ± 3.31 kg of live weight per ewe. Moreover, in a normal year and for the same producing cost, the financial return due to the introduction of F1DT was 1.63 compared to Sardi race. The survey, attitudes of farmers vis-à-vis F1DT sheep, showed that 100% of farmers were favourable to this technology and 60% declared that F1DT is prolific and well suited. In fact, the average mortality rate of adult ewes registered at private farms is small (2.56%).

Sheep crossbreeding programme in irrigated farming system

Within the crossbreeding for D'man x Boujaad (DB) synthetic race creation, research in the field of Deroua this year dealt with the analysis of data recorded for parental breeds and crossbred animals of F1 and F2 generations for the reproductive performances of ewes and F1 to F3 for the production performance of lambs.

Results showed that the highest prolificacy registered was achieved by the D'man sheep and the lowest was recorded in ewes Boujaâd, respectively 2.03 and 1.29 lambs/ewe. Crossbred sheep F1 and F2 made important and intermediate prolificacy between those of the parental breeds, respectively 1.91 and 1.67 lambs/ewe. The superiority of F1 ewes is 11 and 20% respectively for the size and weight

at weaning compared to the values of the D'man race. Similarly, generations F1 and F3 lambs showed superiority respectively at 13 and 1 % in comparison with the weight at weaning of the Boujaâd race.

Improvement of goats dairy production of the North by crossing

In order to improve milk production of local goats in the North, a test of intersection with the Alpine breed was conducted with the objective of assessing milk performance of crossed goats in two production systems. Results showed that in semi-intensive conditions at Bellota station, total milk production in 210 days of Alpine goats (480 kg) is higher ($p < 0.005$) than that of cross goats (Alpine x local) 435 kg. However, under breeder conditions (extensive), milk production of cross goats (Alpine x local) is low 208 kg and comparable to that of local goats of the North (203 kg).

Control of reproduction in small ruminants

In order to improve the productivity of the Sardi and Boujaâd races through the control of the sexual cycle of sheep, synchronization of heat and the use of different doses of PMSG (0, 300 IU and 400 IU) associated to the use of the fluorogestone acetate (40 mg) were tested under conditions of intensive farming at station and extensive at breeders. The results showed that the synchronization of heat oestrus enabled the repackaging of lambing for three days. In absence of synchronization, lambing is spread, 50% occurred in October/November and 50% were spread from December to March.

Administering PMSG to 300 and 400 IU reduced fertility by 2 and 6% for Sardi ewes and 12 to 17% compared with sheep without PMSG. However, doses 300 and 400 IU led to an improvement of prolificacy, respectively 24 and 56% for Sardi and 17 and 71 % for Boujaâd.

Towards the establishment of a technical reference of the proteins associated to sheep pregnancy

Doses of proteins associated to pregnancy (PAGS) can be used as a means of pregnancy diagnosis and reproduction monitoring. This year, four RIA systems (RIA1 to RIA4) were used to monitor the concentrations of PAGS for Boujaâd ewes and 12 D'man X Boujaâd ewes during pregnancy and postpartum. Analysis results of 24 plasma samples per sheep showed that non-pregnant ewes had PAGS concentrations below 1 ng/ml. Average profiles show that concentrations measured in D'man X Boujaâd crossed ewes are higher than those of Boujaâd. Furthermore, the RIA1 system gives higher values than those obtained in the RIA4 system, indicating that the RIA1 system detects different forms of PAGS.

Diversification and improvement of supply and small ruminants feeding time

Diversification, adaptation and production of fodder

Yields and comparison tests of 55 oats strains and 2 control varieties adapted and productive (Allal and Amellal) were conducted in northern Morocco. The results of 9 lines confirmed their production potential and the superiority of 95R124 and 283 varieties due to their strength and resistance to rust. Mag2, MAG3 and mag4 Varieties have good vigour, but their level of resistance to rust is medium, which might expose them to serious attacks in favourable years to disease development.

Characterization of forage corn silage

37 samples of corn silage were collected from different farms in the Gharb and tested to characterize their qualities (fermentation, microbiological profile, chemical composition and nutritional value).

The results showed that the fermentation characteristics are good with a pH<5 in silos, an ammonia nitrogen content below 10% of total nitrogen, normal richness in lactic bacteria and the presence of undesirable microflora (clostridia and enterococci) below the critical threshold. However, deficiencies were identified in the operation of elevators. Indeed, temperatures exceeding 35°C in 48% of the silos and yeasts are present in 85% of bins. The composition of the rations of dairy breeding in the region shows that in 70% of farms, rations containing silage are unbalanced.

Lupine, a promising nitrogen source for sheep feeding

Lupine (grain, silage) are an interesting protein alternative in animal feed. Tests showed that the effect of mechanical treatment of lupine seeds (crushed, ground or whole) on the in vivo digestibility and on nitrogen balance did not affect the digestive use of lupine in sheep. Moreover, the study of energetic supplementation of lupine silage showed that lupine forage harvester Lupine (pH <5) and is rich in crude protein (18% DM for the species and *Multolupa* 14% of MS for species *Luteus*). The addition of barley grain in the diet based on silage Lupine lambs improved digestibility from 73.8 to 78.9% for *Multolupa* and 77.5 to 83% for *Luteus* and nitrogen retention was 49.2 vs 30%.

Using agriculture by-products in the diet of goats in the North



Photo. Cactus rackets used with other products in food nutrition

In order to diversify food supply for goats breeders in the North, tests were conducted in order to study the effect on the quantity and the quality of milk and its fatty acid composition, the incorporation of dried or ensiled olive pomace with or without additives in the diet of local goats.

Results showed that crude olive pomace ensiled with 15% DM molasses can be used in feeding the local milking goats with an incorporation rate of 25% in concentrated ration, and that replacing part of food concentrate by silage of pitted olive grignons in the diet of milking goats, is advantageous because it improved the nutritional quality of milk by increasing the proportion mono-unsaturated fatty acids, without affecting the level of goats milk production.

Characterization of cactus and of new straw in arid areas

In arid areas, food availability for livestock is insufficient both in quality and quantity. The use of new food resources is needed to improve food timing of livestock in these areas. Research aims to study the effect of fertilization on cactus rackets and chemical composition of four straws of PAM. Results obtained show that :

- Quality of rackets poor in nitrogen was improved by 8.1 and 3.23 points compared with the witness, in the year of application, by simply providing fertilizers. Similarly, fertilizers improved the content of phosphorus in rackets respectively by 1.88, 1.58, 0.62 and 1.51 points compared to the control ;
- Straw of fenugreek (8.75), of nigella (8.31), of cumin (9.14) and of cilantro (4.90) have a nitrogen content greater than that of barley straw (4.5). The four PAM straws tested are palatable and their index classification of palatability, used in descending order is : Coriander straw, Fenugreek straw, cumin straw and Nigella straw.



SIMPLE FOOD PROCESSING ADAPTED TO THE

ENVIRONMENT ACCORDING TO A QUALITY APPROACH FOR THE IMPROVEMENT OF AGRICULTURAL PRODUCTS

Chemical profile of essential oils of some MAP

Study on Medicinal and Aromatic Plants (MAP) concerned two localities in the Massif Tazekka namely the communes of Smia and Tazarine where the floristic richness deserves to be saved for genetic diversity and erosion control. The essential oils of four species most used in the two sites were analyzed. For thyme (*Thymus riatarum*), the analysis identified 22 compounds divided into several chemical groups, the major compounds such as carvacrol (22.3%), important rates of p-cymene (21.8%) and of the γ -terpinene (14.7%). Regarding

oregano (*Origanum Compactum*), analysis revealed the presence of 16 compounds including carvacrol is 49.26%, high rates of p-cymene 15.9% and γ -terpinène 14.3%. Pennyroyal (*Mentha pulegium*) was characterized by 15 different compounds among which pulegone represents the majority with 72.5%. As for calamint (*Calamintha NEPT*), 22 compounds were identified, in which the majority is of pulegone with 36.9%, and high rates of limonene (9.9%), of menthol (9.3%) and menthone (7.4%). The content in essential oils measured in these species is 0.8% for pennyroyal, 1.7% for thyme, 1.7% for Acinos and 4.7% for Oregano. The continuation of this study will add value to these species.

Development of goat milk into cheese

A survey was conducted in the localities of Chefchaouen, Ksar El Kebir and Larache to characterize the process of homemade fresh cheese "Jben" and know the expertise of local farmers. This survey was supplemented by laboratory tests to evaluate the physico-chemical, technological, hygienic and nutritional quality of cheese. The results obtained showed the existence of four processes in making goat cheese differing in coagulation type and the nature of rennet used. Fresh cheese makers tend to use the industrial and traditional rennet to reduce manufacturing time and increase yield. Efforts should then be made to make farmers improve the hygienic quality of farm goat cheese.

Moreover, and in order to diversify of cheese products in the North, researchers were interested in developing physico-chemical and microbiological characterization of semi-refined goat cheese to which 10% of thyme was incorporated at the time of moulding. Initial results showed that the flavour changes the physico-chemical and microbiological characteristics of flavoured cheese, which directly influences its sensory quality.



Goat cheese

Improving the microbiological quality of food

In food security, recent research focused on the microbiological quality through the assessment of contaminants in the food chain, the development of milk seeds and of food-processing. Hence, 24 isolates were selected from the laboratory bank for molecular identification. The selected isolates are of a rounded shape (cocci), small, grouped in pairs or in a short chain. Their classification was made and the identification method of *Enterococcus* species was developed using specific primers. The species *Enterococcus durans* was identified and all isolates were Gram positive and catalase negative.

Moreover, the test of lactofermentation application to carrots helped to keep them longer with a higher quality compared to fresh carrots. From these results, the lactic fermentation technology can be applied for the treatment of food destined to people not tolerating lactose. Indeed, lactic bacteria have interesting technological assets thanks to their ability to lower the pH, their tolerance to extreme conditions (temperature, pH and salinity) and their ability to produce aromas. These technological features give the lactic microflora fermentation ability.

Contribution to the identification of dried figs mycoflora in trade

After mycological analysis, 44 strains were isolated from samples of analyzed dried figs. Six genres were identified : *Aspergillus* (22 strains), *Penicillium* (8 strains), *Mucor* (5 strains), *Rhizopus* (4 strains), *Trichoderma* (3 strains), *Alternaria* (2 strains). All these genres were already reported as natural contaminants of food (Le Bars, 1984).

Mildew of the genre *Aspergillus* are the most frequent followed by the genre *Penicillium*. They represent respectively 50% and 18% of isolates obtained. Some of their species are involved in the production of dangerous mycotoxins.

Developing new products for the enhancement of agricultural production

Spreadable paste made from dates and sesame

It is a paste consisting essentially of dates syrup and sesame. This preparation enables one to enjoy the nutritional qualities of sesame mainly its high fatty acid omega-3. The product was prepared and stored without adding preservatives. It was stabilized by a physical process. It also has organoleptic characteristics which were well appreciated by a tasting panel.

Lupine mayonnaise

This mayonnaise was prepared by replacing eggs with lupine. It is a mayonnaise containing no components of animal origin in which fat is rich in cholesterol. Two variants of the mayonnaise were developed. One from of a vegetable oil rich in omega-3, and the other is of olive oil. These two variants of lupine mayonnaise have special dietary characteristics and can be consumed by people with high cholesterol level.

Vegetal lupine cheese

This cheese is made from lupine. Its content in fat is around 40%. It is a fat of plant origin rich in unsaturated fatty acids, and manufactured product is suitable for diets that do not allow the consumption of animal fats.

Oats couscous

This couscous was prepared taking care to keep all constituents of the oat grain. Among the constituents that give oats international nutritional and dietary qualities contains in this new couscous are :

- Avenin, thanks to its composition in amino acids, it is good for growth ;

- Beta glucans as agents helping to reduce cholesterol and blood sugar and also as immuno stimulants ;
- Derivatives of flavonoids partially oxygenated, of polyphenols, which enhance the antioxidant effects ;
- Some minerals in biologically meaningful quantities such as silica, which is the dominant mineral found in oats, and also zinc, copper and manganese. Silica contributes to softer artery and skin. Zinc is highly versatile of enzymes biologically vital and is essential for vision, for insulin action, for the sexual organs and the entire immune system.

Study of the drying ability new apricot varieties

The varieties tested gave fruits with good appearance and good quality that can commercially rival with imported dried apricots. After drying, they preserved the main characteristics sought which are : colour, odour, flavour, and shape. Absence of browning is to be noted.

Study of the possibilities of food paste enrichment by cactus rackets-flour

Pastes have a colour that tends towards the green. It has a similar appearance as paste containing spinach that exist in the market. Colour intensity increases with the rate of incorporation of the cactus flour. The behavioural test of this pasta at cooking showed that up to 10% of cactus flour added, pasta behave well when cooked. Preliminary results of chemical analysis of pasta showed their gradual enrichment in minerals as the content of cactus flour incorporated increases. This work will be completed during 2008-2009 agricultural campaign by studying the chemical composition of pasta of fibre, minerals (calcium, potassium, iron and magnesium) and proteins.



THE SOCIO-ECONOMIC DIMENSION, CENTRAL TO THE ANALYSIS OF

RESEARCH RESULTS FOR A BETTER INTEGRATION IN AGRICULTURAL PRODUCTION SYSTEMS

Economics and Water Efficiency

Introduction of farming techniques for the recovery of irrigation water in Tadla : advancing sowing date, choice of variety, irrigation and nitrogen fertilization led to record yields of 10 tonnes/ha among farmers, with a positive impact on economic productivity of water which rose from 2.25 to 2.92 Dh/m³, a variation of more than 30%.

Community management of irrigation water

Study of the conditions of sustainable management of irrigation systems in the Middle Atlas showed that management practices are to be improved through :

- Development of institutional dynamics observed at other perimeters ;
- Strengthening the capacity and knowledge developed by communities of irrigators.



Seguia fitted out in Middle Atlas

New production niche : carob and pomegranate

Analysis of the carob channel in the Middle Atlas (Khenifra) showed that marketing and distribution channels are dominated by intermediaries. It also showed that yields depend on environmental conditions, on rainfall and on crop care. They vary between 60 and 200 kg per tree for a normal year. The selling prices of carob vary according to months and years between 3 and 7 DH/Kg. The seeds are however sold between 22 and 32 Dhs/Kg.



Carob



Pomegranate

Similarly, the study of the pomegranate channel in the Tadla showed the place of intermediaries in the marketing channels. In fact, these intermediaries and the wholesalers make an average significant benefit margin in fruits trade of 500 Dh/ton, or 0.5 Dh/kg. Furthermore, the important quantity sold by these agents (143 T/year) offers them a net benefit of 77 000 DH/year, equivalent to the margin generated from the production of an average of 6 ha of pomegranate.

Management of production risks

Studies on the use of stubble for livestock and its impact on the adoption of conservation

technologies showed that stubble grazing by cattle has a high economic value in small farms and in vulnerable ones vis-à-vis drought risks. These results imply that the conservation technology transfer programme must take into account the importance of stubble in animal feed, and the priority to give to large farms and to those with a low vulnerability against drought risk.

Evaluation of the profitability of technologies introduced for breeding

The socio-economic assessment of F1 (DT) ewes among farmers in the regions of the Casablanca-Kenitra axis proved that for the same cost of driving animals in a normal year, the gross return is 607,7 DH/head against 372.15 for Sardi.

The financial gain in the introduction of F1DT is of 1.63 compared to Sardi. The introduction of a new way of cattle conducting in Ait Bouguemmaz showed that the conduct of 100 Rahalya sheep, with the fattening of their males products leads to a profit estimated to 77.340 dh/100 ewes calculated on the basis of the estimated selling value of product and charges related to feeding and veterinary products, while the usual techniques of breeders did not allow to gain more than 42.780 dh\100sheep à la lutte. The shortfall is of 34 560 dh per 100 ewes, which is 80%.



Small ruminants



PROMOTION AND COMMUNICATION OF RESEARCH ACHIEVEMENTS

Towards a sustainable agriculture preserving environment

The adoption of the no-tillage system begins to grow. In fact, areas concerned during 2008 exceeded 1200 ha for 73 beneficiaries against 800 ha in 2007, divided into 300 plots in four different agro-ecological zones. The beneficiaries of this programme are NGOs and individual farmers in the region of Chaouia. The results showed that no-tillage simplifies work, buffers the effect of climate hazards and restore depleted soils. Moreover, it can match the best conventional crop management practices and even exceed them, while reducing costs and risks from the start of the campaign. In fact, at the Jemâa Ryah region for example, the yield of no-tillage plots ranged between 5 and 12 quintals/ha while those of the conventional did not exceed 5qx/ha.

Improving water use efficiency of citrus irrigation

With the aim of improving irrigation management at citrus farm level in Tadla, tests were conducted at citrus growers. The results showed that the production parameters of the «Morocco Late» variety are influenced by the irrigation ways. In fact, flowering and fruit set seem to be favoured by a regime of 100% Etc that gave the lowest quantity of fruit drop. Moreover, at summer magnification stage of the fruit, the response to water is remarkable and becomes maximum under 110% Etc regime. The cultural coefficients of the variety studied were determined.

The introduction of a technical package including drip irrigation and fertigation showed that it is possible to save between 2788 and 2060 m³/ha without significantly affecting the yield. Water use efficiency is 5.18 kg/m³ against 4.62 kg/m³ for the control test at farmer.

Appropriate technological packages to improve cereals food legumes productivity

Cereals

Diagnosis of cereals technical conduct in the Rural Municipality of Had Ait Mimoun, Khemisset Province, showed that weeds control, disease and drought are the main constraints to wheat cultivation. Tests conducted with a technical itinerary based on the main research achievements led to yields of about 90 quintals/ha. Achtar variety helped in developing supplemental irrigation better than the other varieties (**Figure 17**).

A platform for demonstration tests on 5 varieties of wheat and 5 varieties of durum wheat in the Experimental Station of Sidi Allal Tazi confirmed the benefit of supplemental irrigation in terms of productivity. Thus, for varieties of wheat Arrehane, Aguilal and Ashtar, yields ranged between 66 and 69 quintals/ha while the witness Marchouch reached 50qx/ha. For durum wheat, Amria, Chaoui and Marwan varieties reached 59 to 62 quintals/ha (**Figure 18**).

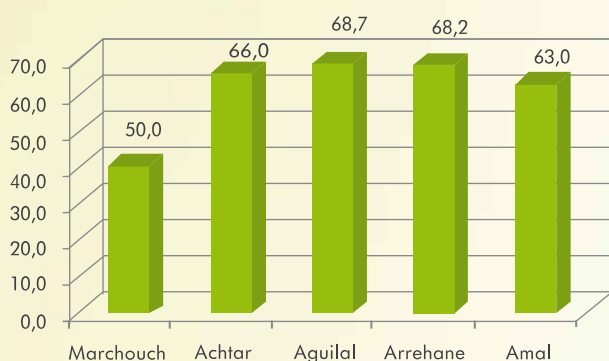


Figure 17 : Yield of five varieties of durum wheat (q/ha).

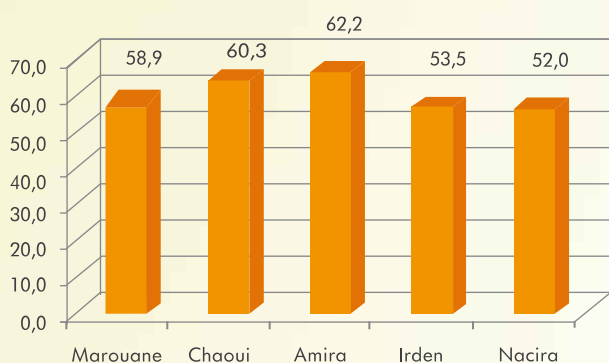


Figure 18 : Yield of five varieties of wheat (q/ha).

Food legumes

Analysis of the effect of three planting methods in rows twinned in pairs, in simple lines, by broadcasting, on the performance of two fava Alfia 17 varieties and Alfia 21, at Sidi Allal Tazi Experimental Station showed the importance of planting in line compared to broadcast sowing. In fact, the increase in yield reached 36% compared to broadcast sowing (**Figure 19**).

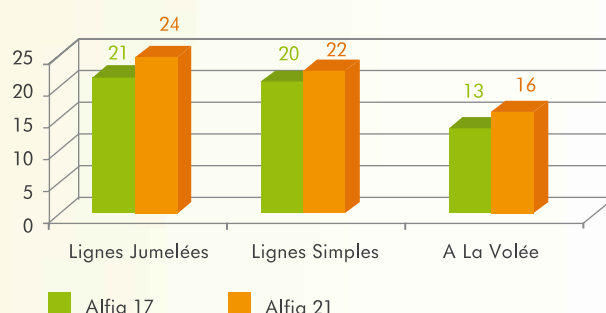


Figure 19 : Effects of three sowing modes on yield of two fava varieties (qx).

Development and domestication of alternative crops : the case of Muscari comosum in the Oriental

The study of Muscari comosum, an aromatic bulb plant, showed the existence of a highly positive correlation between leaf number and size of the bulb. This result is an effective means of harvest rationalizing. Moreover, the success of no-tillage for this plant opens an encouraging prospect for the control of its cultivation. Recommendations were formulated to ensure the success of seeds security operations, of harvesting and of marketing to enhance production.

New techniques to improve ovine and caprine performance

Ovine

Tests conducted in the region of Demnate for the conduct of animal Sardi phenotype among farmers, showed that reproduction performances of breeding tests are 90% for fertility and 103% for prolificacy, while

for control livestock, these parameters are respectively 85% and 106%.

Concerning the improvement of breeding conditions for Rahalya population in the High Atlas, results showed that reproduction performance recorded in test breeding were 98% for fertility and 106% for prolificacy, while those recorded in witness breeding were respectively 81% and 102% for the same parameters.

The numerical productivity of Rahalya sheep conducted using the techniques introduced is close to a weaned lamb per ewe, whereas this parameter is only 0.66 in witness breeding.

Weight productivity is 19.2 kg of live weight weaned per ewe put to the fight in breeding tests, while in witness breeding this parameter is only 8.26 kilograms, a superiority of 132% of tests compared to the witnesses.

Caprine

The results of the study conducted in Chefchaouen showed that in extensive conduct, supplementation of goats in

rangelands, after weaning at 3 months, slightly improves their weight at the age of 7 months. On the other hand, a ration of 400 g/goat/day, consisting of maize or triticale grain and wheat, with respective proportions of 2/3 and 1/3, can be recommended to supplement the kids in rangelands at weaning.

Technology transfer and capacity enforcement

More than 168 days of technology transfer, open days, training, information, animation and awareness were organized on more than 35 themes dealing with INRA achievements and technology destined to more than 4650 people including development agents of the Provincial Directorates of Agriculture (DPA) and the Regional Offices of Agricultural Development (ORMVA), members of agricultural cooperatives, professional agricultural associations and local development associations, extension agents, farmers and their sons, breeders and women (Figure 20).

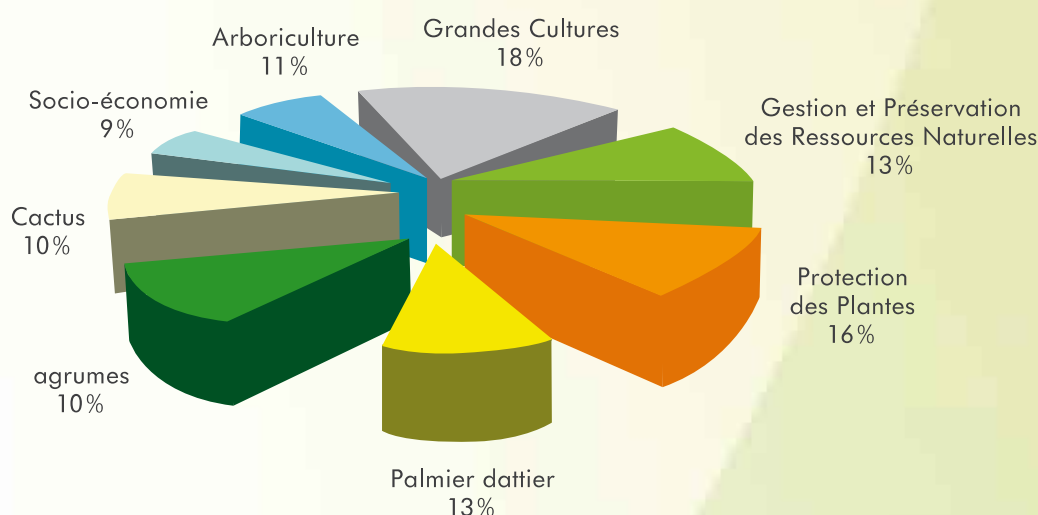


Figure 20 : Repartition of INRA manifestations according to theme.

The distribution of scientific and technical production of INRA researchers in 2008 shows that the scientific article remains the primary indicator of scientific activity. It is the preferred means for researchers reporting the results of their research. It represents

65% of production. In the second place are the papers in seminars and scientific symposia with 23%. The monographs or monograph chapter occupy the last rank with 12% (Figure 21).

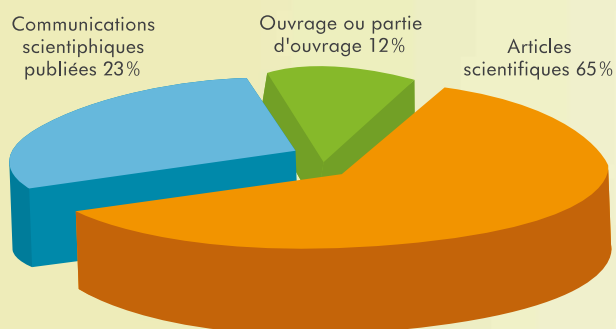


Figure 21 : Form of scientific and technical publishing of INRA in 2008.

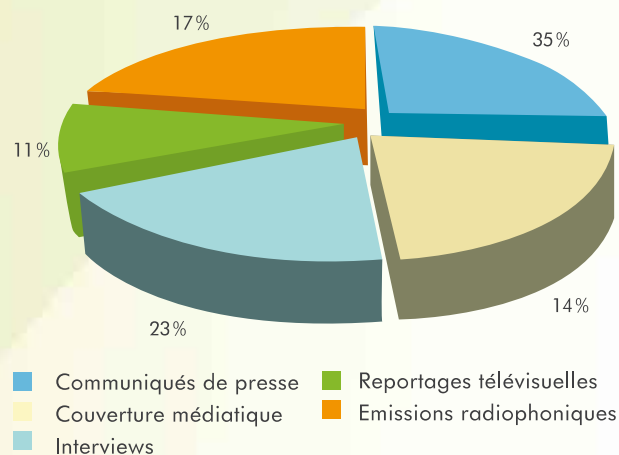


Figure 22 : Media relations.

Printed and audio-visual press : an efficient means of communication of research results :

- Distribution of press releases about scientific and technical events (24);
- Media coverage of several events (10);
- Interviews and discussions with officials and researchers (16);

- Broadcasting of television coverage on INRA (6) (**Figure 22**).

Virtual Library

Setting up the virtual library accessible on the local network at the center of Tangier, Meknes, Settat, Kenitra and Marrakech. Equipment of the other Regional Centers of Agronomic Research is scheduled for 2009.

Scientific and technical publishing, a tool to make known research results

The activity report IRA 2007

A communication tool published annually by the National Institute of Agronomic Research in order to describe activities conducted during the year. The aim is to inform IRA partners and customers of achievements and ongoing projects.

No-tillage systems for sustainable dryland agriculture in Morocco

The book presents the results of research on no-tillage in agriculture. In semi arid areas of Morocco, the tillage contributes to the sustainability of the agro-ecosystem through its positive impact on the environment and the socio-economic variability.

INRA brochure in French + CD

INRA, important achievements and expertise for sustainable development of Moroccan agriculture, also available on CD.

Technical sheet "Figs"

This sheet is a summary of research results obtained on fig tree, a species characterized by large diversity and originality of the national genetic heritage.

AL Awamia N° 118-119 and 120

Quarterly scientific journal published by the National Institute of Agronomic Research. It publishes original articles devoted to agricultural research and social issues that are related to agriculture and rural development.

Agenda 2009

Communication tool newly designed and developed at INRA to mark the new year 2009. It presents the Institute and its research activities.



COOPERATION AND PARTNERSHIP

Internationally, INRA continues to expand its partnership with a number of organizations such as ICARDA, CIMMYT, IAEA and IOC

Organizations	Fields of collaboration
ICARDA	IPM integrated pest management, conservation of genetic resources, rangeland management, goat farming and cheese production, integrated management of natural resources
CIMMYT	Biotechnology and genetic improvement of wheat
International Agency of Atomic Energy (IAEA)	Strengthening the use of nuclear energy in the field of agricultural research.
Olive Council International (COI)	Conservation of genetic resources of the olive.

At the regional level, collaboration between INRA and its partners continues through recherche themes.

Organizations	Fields of collaboration
AOAD	Bayoud early detection and improved control methods. Introduction of technical processes for the improvement and development of date palm cultivation and production dates. Training on the conduct of livestock in rangelands and arid.
AAAID	Encouragement of direct seeding technique.
IDRC	Optimization of small dams Rangeland Management

Regarding bilateral cooperation with European countries and America, INRA works to become more open cooperate fruitfully with its partners

Country	Fields of collaboration
USA	Applied Biotechnology
France	PRAD Breeding sheep, selected rootstocks of pome Rosaceae, olive and biotechnology. Hence, the INRA has signed a Memorandum of Understanding for the development of partnership between the Garden of tests Rabat and the Botanical Garden of Lyon.
Spain	Direct sowing of sunflower and mouth
Belgium	Breeding goats and making goat cheese
United Kingdom	Improving the identification, handling and preservation of seed conservation difficult

A twinning agreement in the field of security, quality and traceability of animal products and environment throughout food chain was signed with the Istituto Zooprofilattico Sperimentale della Sardegna.



INRA and ACSAD Directors

South - South cooperation. INRA as a research organization recognized for its expertise and its important achievements in agronomic research, puts its experience for the benefit of other organizations

Country	Fields of collaboration
Ivory Coast	Development of cereal crops in Côte d'Ivoire.
Mauritania	Exploring ways of collaboration in research and technology transfer
Saudi Arabia	Date palm and olive trees, development and protection of oases, camel and livestock development and rangeland management.
Libya	Biotechnology and improvement of crop and livestock production.

At the national level, INRA is interested in developing its partnership with various organisms

Organizations	Fields of collaboration
Universities and research institutions	<ul style="list-style-type: none"> Improving agricultural production (FST Settat/University Hassan 1). Management of natural resources, improvement of crops productivity, water analysis, soil and plants and training and supervision (FST Beni Mellal/University Sultan Moulay Slimane). Determination of dominant disease in goats in northern Morocco. (IAV Hassan II, Laboratory of Parasitology and Parasitic Diseases).
Organizations	Fields of collaboration
MAPM / PROFERD	Almond, pomegranate, walnut, stone Rosaceae, olive, argan, saffron, aromatic and medicinal plants, mint, potatoes, artichokes, goat, biological control of potato disease and analysis of institutional dynamics and collective action for sustainable management of water in mountain areas.
ORMVA, DPA	Strengthening capacities of dates farmers and animation of Technology Transfer days.
Regional Council Chaouia Ouardigha	Directed studies on agricultural development strategy.
The Hassan II Fund for Economic and Social Development, the Wilaya of the Region of Rabat-Salé-Zemmour-Zaer.	Rehabilitation and development of Jardin d'Essais Botaniques/ Rabat.
Agency for the Promotion and Development of Economic and Social Southern Provinces.	Valorisation of agro-industrial cactus and dates at Tighmert.

The private sector is an engine of national agricultural development with which INRA is working together to develop our national agriculture

Partnership with the Private	
The Domains	Citrus and date palm
Nurseries	Multiplication of INRA varieties of citrus and olive.
The Agricultural Investigation Society South AGRISUD	INRA technology transfer in seed production, cereal crops, market gardening, livestock production and alternative crops in the region of Doukkala.
The Ranch Adarouch S.A.	Production and marketing of INRA seeds varieties (cereals, food legumes and fodder crops).
Altadis Morocco Group	Burley tobacco in Morocco.



MANAGEMENT OF HUMAN AND FINANCIAL RESOURCES

Statement of recruitment under the fiscal 2008

In order to strengthen INRA staff, ten positions were planned under the Executive Law of 2008. They consist in transforming an Informatiste position into one of an State Engineer, and the recruitment of seven Chargé de Recherche A, a State Engineer, an Administrateur and two technicians.

Promotion of staff under the fiscal 2008

The number of officers promoted under the fiscal 2008 represents 9% of the total number of INRA staff.

The one hundred and eighteen changes of positions for promotions included in the Loi des Cadres and implemented during fiscal 2008 are as follows :

- 5 for detached officers benefitting from promotion within their original context ;
- 113 for officers benefitting from internal promotion proper to INRA, distributed as follows :
 - 97 posts reserved for competitions, professional aptitude tests, examinations and memoire soutenance organized for this purpose ;
 - 16 for promotions by choice of which joint committees were informed to a timetable for this purpose.

Targeted training for capacity strengthening

Training benefits to all categories of staff and takes into account the strategic directions of the institution. It responds to needs identified and is done taking into account the opportunities offered.

Diploma course

During the year 2008, 20 officers completed certificate courses including 9 new registrations (**Figure 23**).

Staff retirement

45 departures were recorded during the year 2008 as follows :

- 38 retirements by age limit ;
- 6 deaths ;
- A resignation.



Ceremony in tribute to retiring personnel, 2008.

Distribution of long periods training in 2008

	Doctorat	Master	1er Cycle	Licence Professionnelle	Total	Financement
In Morocco :						
Fac. Sc. Marrakech	5	-	-		5	Without fees
Fac. Sc. Kenitra	-	-	1	1	2	Without fees
Fac. Sc. Meknes	2	-			2	Without fees
Fac. Law Settat	-	-	1		1	Without fees
Fac. Law Rabat	-	-	-	1	1	Without fees
Abroad :						
Belgium	6	-	-		6	Belgian cooperation
Spain	-	1	-		1	CIHEAM/IAMZ
Australia	1	-	-		1	Institut Macaulay
Italy	1	-	-		1	GCP/Italian Coop
Total	15	1	2	2	20	

Researchers enrolled in Belgium and Italy follow their training by the mixed formula :

the theoretical part is carried out in the European country and research Morocco.

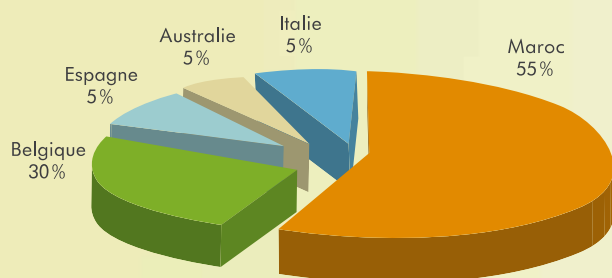


Figure 23 : Distribution of diploma courses by host country.

Training Abroad

In total, 45 courses were conducted for the benefit of 41 INRA officers among whom 37 researchers and four technicians (**Figure 24**). These trainings are divided according to host countries and sources of financing (**Figure 25**) as indicated below :

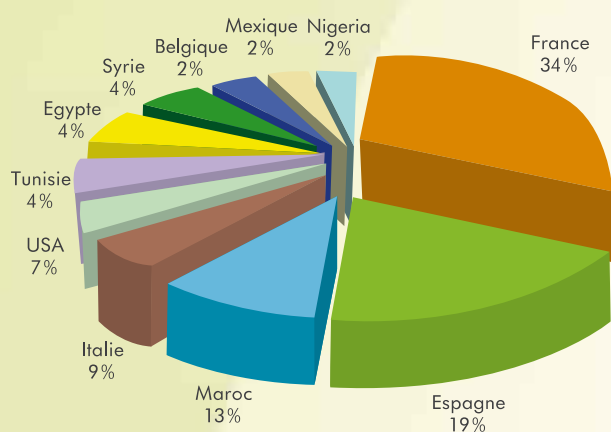


Figure 24 : Distribution of training by host country.

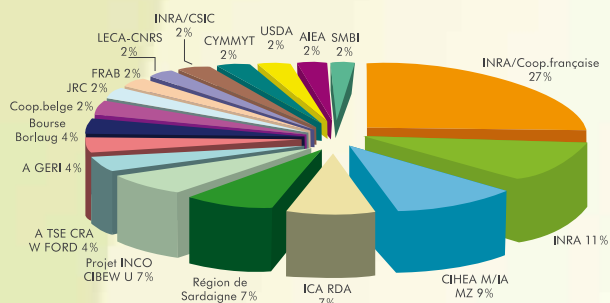


Figure 25 : Distribution of training by source of financing.

Missions and participation to scientific events

In sum, 131 missions abroad took place by 70 manager and researchers to 32 countries. They are a means for the exploration and implementation of various links of partnership and cooperation on research topics and research-development with a common interest (**Figure 26**).

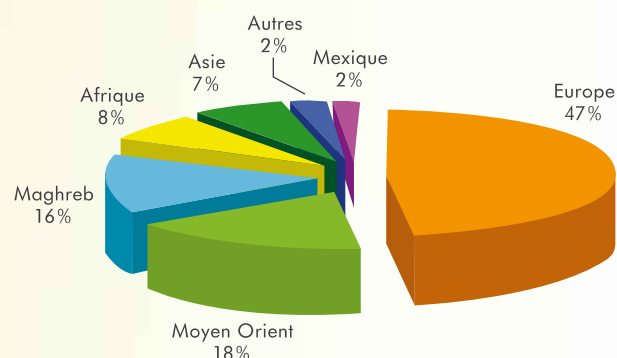


Figure 26 : Distribution of missions by Destination.

Some researchers go abroad at the invitation of international organizations and institutions of higher education to give courses or go in concerting and expertise missions in different fields.

Development sessions

INRA continues to act through training to support scientific policy and improve the management of the different resources. Training affects different categories of staff, and takes place in individual or group sessions, held internally or at external partners. It concerns among others : audit and management control, communication skills, public markets, debt recovery, participatory innovation and innovation management and scientific fields such as geographical information systems, bioinformatics, biotechnology, and the use of new information technologies of information.

Financial Resources

The budget of operation (**Figure 27**) allocated to INRA according to 2008 exercise was of \$ 135,934,507.00 Dhs distributed as follows :

- Staff expenses : Dhs 133,474,080.00 ;
- Material expenses : 2,460,427.00 Dhs.

The budgetary investment envelope (**Figure 28**) is of 72.929.310 Dh divided as follows :



Figure 27 : Distribution of operating Budget.

- Mission Support : 27,540,175 Dhs ;
- Headquarters : 6,104,000 Dh ;
- Regional Centers for Agronomic Research, Project PL 480 and federative research programs : 39,285,135 Dhs.

Total PL : 480 1.087.000,00 Dh

INPUTS AND SERVICES : 39,559,210.00 Dhs

Total : 72,929,310.00 Dhs

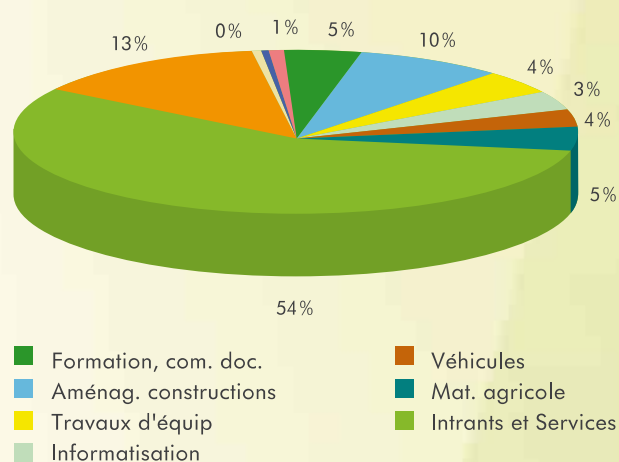


Figure 28 : Distribution of investment budget by operations realised.

ACRONYMES

AAID	Arab Authority for Agricultural Investment and Development	IAV	Institut Agronomique et Vétérinaire Hassan II
ACSAD	Arab Centre for the Studies of Arid Zones and Drylands	ICARDA	International Centre for Agricultural Research in the Dry Areas
IAEA	International Agency of Atomic Energy	INRA	National Institute of Agronomic Research
CIHEAM	International Center for Advanced Mediterranean Agronomic Studies	MAPM	Ministry of Agriculture and Maritime Fishing
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo	MCGP	Moroccan Collaborative Grant Program
COMADE	Confederation of Moroccan Agriculture and Rural Development	AOAD	Organization Development Arabic Agricole
IOC	International Olive Oil Council	NGOs	Non Governmental Organization
IDRC	The Research Center for International Development	ORMVA	Regional Office for agricultural development
CRRA	Regional Center of Agronomic Research	PRAD	Projects of Agricultural Research for Development CT
CT	Center Works	PRMT	Research Program Medium Term
DPA	Provincial Directorate of Agriculture	PROFERD	Projects Federators Research and Development
FAO	Food and Agricultural Organization	SIAM	International Exhibition of Agriculture in Morocco
STF	Faculty of Science and Technology		



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