

Royaume du Maroc



المعهد الوطني للبحث الزراعي
Institut National de la Recherche Agronomique

INRA 2009

ACTIVITY REPORT



His Majesty the King Mohammed VI



A WORD FROM THE DIRECTOR

The year 2009 is, in many ways, an important step in consolidating the achievements of agricultural research for the implementation of Green Morocco Plan. Enormous efforts have been made to harmonize and align our research programmes with the Regional Agricultural Plans.

No doubt that the date palm was the key product of Green Morocco Plan this year when his Majesty King Mohammed VI launched the extensive programme of rehabilitation and development of Moroccan palm groves. INRA is involved in the provision of tissue culture by producing strains from budding in vitro culture of the main productive varieties, resistant to date palm wilt (bayoud disease) with a high commercial value. The visit of Her Royal Highness Princess Lalla Hasnaa, President of the Mohammed VI Foundation for the Environment Protection, to the Regional Agricultural Research Centre of Marrakech, is an evidence of the importance paid to agricultural research for a sustainable development of oases in Morocco.

Works on genetic improvement of crops have been crowned by the registration in the Moroccan Official Catalogue of new varieties of lentil, chick pea and rapeseed, adapted to the specificities of agro-systems.

It should be noted with great satisfaction that the efforts of our researchers have been rewarded in several occasions namely 4 prizes in Grand Prix Hassan II for Invention and Research in Agriculture and the FAO Merit Award, without forgetting the great consecration of INRA as winner of the Khalifa Date Palm Prize.

We will continue on the same course to accompany the implementation of the Green Morocco Plan through strengthening and establishing new regional centres in the southern provinces and the modernization of management tools.

INRA will continue to strengthen its partnerships with institutions within the national agricultural research system, universities and international research and development centres.

One key to success in our mission is in making our knowledge available to producers and professional organizations through programmes-contracts between the government and the profession related to different production channels.

Pr. Mohamed BADRAOUI
INRA Director

HIGHLIGHTS

His Majesty initiates the development programme of Moroccan palm groves: research at the heart of this great project .



The date-palm sector, reinforced by the High Royal Guidance, has been given a particular attention due to its economic, social, environmental and cultural importance. It also represents the main agricultural activity in the oasis.

His Majesty King Mohammed VI has initiated, in the provinces of Errachidia and Ouarzazate, the date palm replanting projects in the oases of Tafilalet, Ouarzazate and Zagora, as part of the «Green Morocco Plan». These projects are part of a comprehensive programme of date palm development, aiming at planting 2.25 million date palm trees and the expansion of the palm grove area for 2015 horizon.

Several initiatives will be programmed in this context: introduction of vitro-plants resistant to Bayoud disease, cleaning of palm trees clumps, setting up a nursery for vitro-plants production and many dates processing units, farmers training, as well as instalment of hydro-agricultural works... INRA and the laboratories producing date palm

seedlings have signed two partnership agreements in the field of micro-propagation of date palm by tissue culture techniques. These agreements aim at initializing buds of different varieties and clones of date palm, and improving in vitro propagation techniques. They also have as objective to supply markets during the production period 2010-2020 with 2.9 million seedlings of adapted varieties tolerant to Bayoud and to other pests, and having a high commercial added value.

NEW VARIETIES REGISTERED IN THE OFFICIAL CATALOGUE

The Moroccan official catalogue is enriched with new varieties obtained by INRA :

- Lentil variety : Chakkouf
- Chickpea variety : Arifi
- Rapeseed variety : Moufida

INRA IN THE SPOTLIGHT

Marrakech Regional Agricultural Research Centre was visited on March 18, 2009, by Her

Highness the Princess Lalla Hasnaa, President of the Mohammed VI Foundation for Environment Protection. After inquiring about the protection and development of Marrakech palm grove, the Princess attended a detailed presentation of the technological innovations in date palm and olives micro-propagation as well as in vitro multiplication.

INRA, WINNER OF KHALIFA INTERNATIONAL DATE PALM PRIZE

Prof. Badraoui M., Director of INRA, received, on March 15th, 2009, from His Excellency Sheikh Nahyan Bin Mubarak Al Nahyan, Minister of Higher Education and Scientific Research (UAE), the Khalifa Date Palm International prize. This award is recognition for the research efforts made by INRA for several years to preserve, develop and protect date palm and control Bayoud disease.

A ceremony was held on April 13th, 2009 at INRA headquarters in honour of researchers, technicians and all staff having contributed to this nomination at the first edition of Khalifa International Date Palm Prize.

INRA AT THE SIAM 2009

Under the slogan «Together for the implementation of the Green Morocco Plan», INRA, alongside with IAV Hassan II (Institut Agronomique et Vétérinaire Hassan II/ Rabat), ENFI (Ecole Nationale Forestière d'Ingénieurs / Sale) and DERF (Direction de l'Enseignement, de la Recherche et de la Formation) participated to the International Exhibition of Agriculture in Morocco (SIAM) by a stand exhibiting new varieties and processed products illustrating INRA offer for the implementation of the Green Morocco Plan. The stand was visited by Mr Abbas El Fassi, the Prime Minister, who was provided explanations by Pr. Badraoui, INRA Director.

As a fringe event, INRA organized, with the contribution of ADA (Agency for Agricultural Development) and COMADER (Moroccan Confederation of Agriculture and Rural Development) a conference on the implementation of the Green Morocco Plan.

During the conference, Mr. Aziz Akhannouch, Minister of Agriculture and Maritime Fisheries, stated the government's precious support to agricultural research to enable it accomplish its research mission, and actively contribute to the implementation of Green Morocco Plan by increasing the budget allocated to agricultural research from 0.7% to 1% of the national PIBA in the horizon of 2012.

His Excellency also invited all the components of the National System of Agricultural Research to make up regional multidisciplinary and multi-institutional poles to respond to the needs of the regional plans of agricultural development.

The conference was also an opportunity to (i) ADA to present the needs for research - development to implement the Green Morocco Plan, (ii) INRA to describe the institution's achievements in terms of technologies developed to accompany the Green Morocco Plan, and (iii) COMADER to present the profession's vision in terms of research - development to support the Green Morocco Plan.

Several partnership and collaboration agreements were signed, during this occasion, between INRA and its national partners namely ADA, COMADER, IAV Hassan II, ENA Meknes, ENFI, SONACOS, DMN and OMPIC.

NEW INRA WEBSITE

www.inra.org.ma

A new INRA portal dedicated to researchers, national and internet partners and internet users.

The new website integrates the five main categories already presented in the old site along with modules for forums, webmail, multimedia space and a dynamic agenda. INRA chart was given a new look to integrate all managers' visiting cards.

As for research activities, a database to integrate details of research projects and researchers' CVs. Regional sites: The new portal integrates a new space for the different regional centres. The regional site is complementary to the central one while preserving its regional specificities. The main topics concern a presentation of the centre,

research projects and activities, research teams, research achievements and publications.

WORLD FOOD DAY

The 2009 edition of Hassan II Grand Prix for Invention and Research will mark the history of INRA. This edition crowned research works of our researchers in different fields.

The Awards Ceremony was held during the celebration of the World Food Day, October 15, 2009, at Bouznika. It was chaired by the Minister of Agriculture and Marine Fisheries, and attended by the Minister of State, Mr Mohamed Lyazghi, the members of the diplomatic corps accredited in Rabat and the FAO Representative in Morocco.

The winner of 1st Prize, Class «Technical and practical inventions» is our colleague Dr. Mohamed Jlibene, from CRRRA Meknes, for his research on: "Les Options génétiques d'adaptation du blé tendre aux changements climatiques: variétés à résistance multiple (sécheresse, cécidomyie, septoriose, rouille brune et jaune)".

Dr. Jlibene is a prolific writer having one hundred publications in plant breeding and genetic resistance to diseases and abiotic and biotic stress. During his career, Dr. Jlibene has developed 18 varieties of wheat which occupy over 80% of the wheat sown areas in Morocco.

The 2nd Prize, Class «Inventions and practical techniques» was awarded to a team of multi-institutional researchers: INRA, IAV Hassan II and ICARDA, led by Dr. Nsarallah Nasserlehaq, CRRRA Settlat, for research on: "Les progrès génétiques chez le blé dur visant la Productivité et la Qualité Technologique, les acquis d'un quart de siècle". The research team includes eminent researchers

such as Saadia Lhaloui, Miloud Nachit, Brahim Ezzahiri, Mouna Taghouti, Keltoum Ghrib, Jamal El Haddoury, Brahim El Yousfi, Hassan Ouabbou, Ali Amamou, Rachid Dahan, Moha Ferrahi, and Mustapha Labhilili.

The winner of the 3rd prize of the same class is our colleague Dr Mohammed Boujnah, from INRA, for his work on the development of new agro-industrial processes of agricultural products, and the development of technologies adapted to the socio-economic reality of the country and to the needs of farmers and rural women.

The 2nd Prize, Class: "Publication of Scientific and Technical Literature" was awarded to Dr. Rachid Mrabet, CRRRA Tangier, for his work on «No-tillage systems for sustainable dryland agriculture in Morocco». This book opens new horizons to the introduction and adoption of no-tillage as an alternative to hasten degradation, erosion and loss of soil organic matter for a sustainable agriculture protecting natural resources such as soil and water.

The 2009 FAO Merit Award was granted to a team of INRA researchers, led by Dr. Ahmed Oukabli, CRRRA Meknes, for their research work and achievements in the field of fruit trees. This award is a tribute to the late Dr. Mohamed Laghezali, a skilled and prolific scientist in this area.

These various awards confirm the relevance of the strategic choices and research programmes undertaken by the institute, and aiming at developing a sustainable agriculture. Works led to results of great importance and technologies adapted to the national context. They are considered as the technical basis for the implementation of the Green Morocco Plan.



Dr. Nsarallah and his team receiving the 2nd Hassan II Prize



Dr. Mrabet receiving the 2nd Hassan II Prize

ENVIRONMENT

SUSTAINABLE DEVELOPMENT, A RESEARCH PRIORITY

The National Programme of Land Suitability Maps

The National Programme of Land Suitability Maps continues the exploration of new regions: Meknes, Nador and Tetouan (**Figures 1, 2, 3**).

Study Area	Scale	Area (ha)	Crops
Meknes	1 / 50 000	172 890	wheat, chickpea, sunflower and olive
Nador	1/ 100 000	119 761	Wheat, olive, almond, barley and Atriplex
Tetouan	1 / 50 000	82 500	Wheat, chickpea, olive and almond

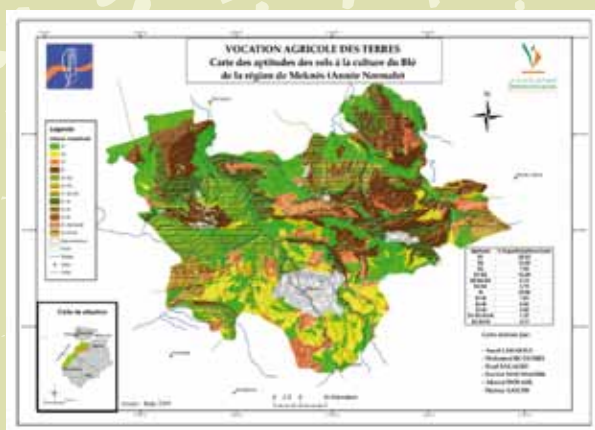


Figure 1 : Suitability maps of Meknes region for wheat.

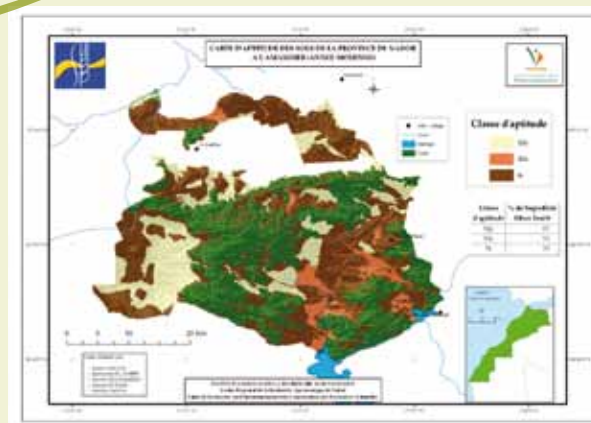


Figure 2: Suitability maps of Nador region for almond.

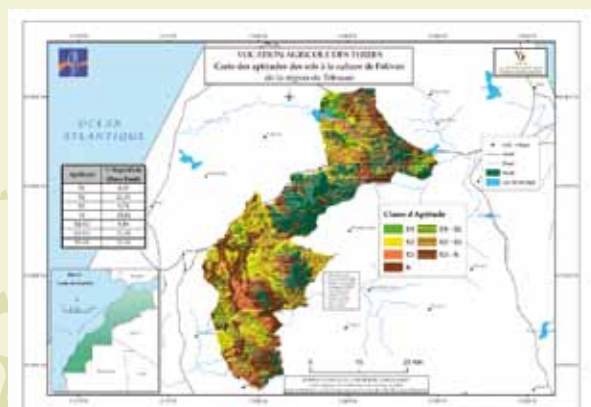


Figure 3: Suitability maps of Tetouan region for olive trees.

INRA has developed a computer application for the dissemination of agricultural suitability maps that can be accessed via interactive CD-ROM displaying cards easily and quickly (**Figure 4**).



Figure 4: CD-ROM Homepage for dissemination of agriculture suitability maps

Impact of climate change on alfa steppe in Oriental rangelands

A study was conducted to comprehend and explain climate trends and define the impact of climate change on rangeland, namely the alfa steppe (*stipa tenacissima*). By analyzing the rainfall anomalies using Lamb index, a considerable yearly variability is observed, and more important, negative indices values were noticed during the last three decades. These negative values were reached according to the statistical test of Pettitt, by a break in the chronological series of rainfall in the Oriental. At the end of the 1970s, rainfall decreased considerably in the region. Estimated loss for an average of 30 years before and after the break reached 20 to 30% of the average rainfall. Cartography results showed higher rainfall in the North than in the South, with a North-West/South-East gradient (**Figure 5**). The comparison of rainfall before and after the break during Winter and Spring seasons showed that the biggest rainfall deficit took place in Spring. The second weather variable studied is temperature. Its general evolution has been increasing by 0.5°C for minimum and average temperatures in Oujda since 1936. Maximum temperatures do not seem to have changed in concordance with the observations made in many parts of the globe.

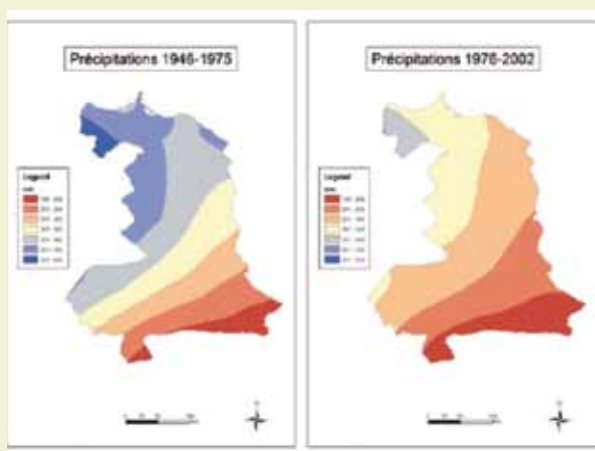


Figure 5: Carte des précipitations pour les périodes 1946-1975 et 1976-2002.

Two agro-climatic zoning have been established: one before and the other after rainfall break (1946-1975 and 1976-2002). Both types of zoning are related to climatic requirements of the alfa and its long growing period. During the first period, the weather seemed to be favourable to growth conditions of the alfa. During the second period, the area favourable to the alfa seemed to spread towards the northern part of the region. The central and northern parts of the region remained favourable areas for the alfa. Even if weather conditions are sometimes less optimal for the growth of this plant, they are sufficient. It follows that the degradation of alfa in these areas may be due to human intervention (grazing, cultivation, etc...). In the southern part of this area, weather conditions are not sufficient for optimal growth of the alfa. Alfa grass is declining gradually. In these areas, where climate change seems to be causing a decline in the limit of alfa, overgrazing can only accelerate this degradation.

Quality of irrigation water and soils of Tiflet market gardening areas

The current situation of salinity and alkalinity, both of soil and of water is not alarming. Indeed, more than 90% of irrigation water analyzed have a relatively poor power of alkalizing.

The quality of Tiflet irrigation water is average to poor. They are to be used with caution in poorly drained soils and for sensitive plants. They show a low risk of toxicity to chloride ions and of sodicity.

The soils studied were not greatly affected by salinity and showed no problems of alkalinity. Salinization by the capillary rise of the saline waters is not high in the region of Tiflet.

In this region, water depth is variable, ranging between 9 and 61 meters, with an average of 21.7 meters. The depth of most wells is between 10 to 20 meters. The groundwaters are relatively

polluted by nitrates, with a rate of 35% of polluted wells. This pollution is due, among others, to excessive use of nitrogenous fertilizers by market gardeners.

Assessment of chemical contaminants of crops irrigated with treated wastewater from Skhirat filtering station

The assessment of chemical contaminants of crops irrigated with treated wastewater from Skhirat filtering station showed a risk of molybdenum toxicity. The high concentration of molybdenum found in all soils shows a chemical contamination probably by the treated wastewater. However, crops analyzed are of a good quality, as regards heavy metals, with values lower than the average concentrations recommended by the standards of the European Commission and "Conseil Supérieur de l'Hygiène de France" (Figures 6, 7 and 8).

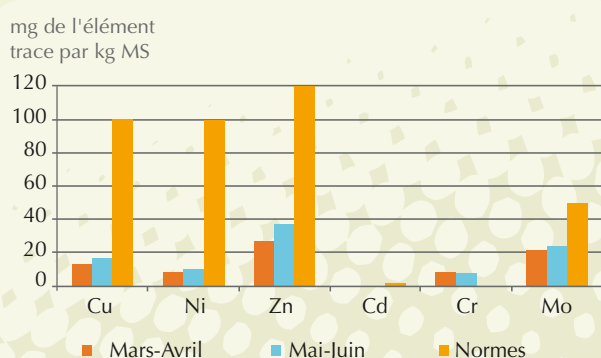


Figure 6: Average monthly content of traced elements in mint.

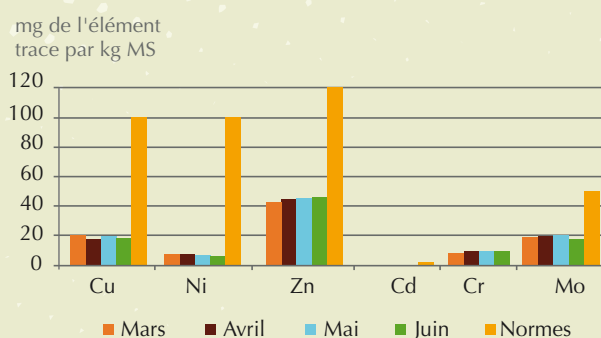


Figure 7: Average Monthly content/levels of traced elements in coriander.

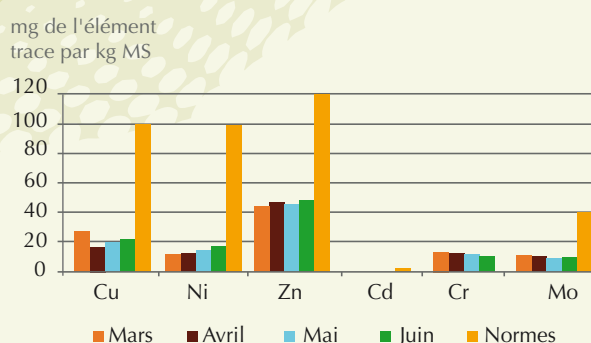


Figure 8: Average Monthly content/levels of traced elements in parsley.

Improvement of false cyst (*Anthyllis cytisoides* L.) seed germination rate by mechanical scarification

In eastern Morocco, false cyst (*Anthyllis cytisoides*) is a shrub of the Fabaceae family that has become very rare and found mainly in protected sites in the regions of Tancherfi, Guenfouda and Tiouli. Consumed by livestock, false cyst is now threatened with extinction in Morocco. The species has two ways of propagation: vegetative, by budding roots, and by the seeds. But the seeds of this species have a hard seed coat that prevents wetting and good germination. To this end, research has been carried out to improve the false cyst germination by mechanical scarification. The purpose of scarification is to abrade the seed coat to allow water absorption. Results show that hand scarification significantly improves germination of *Anthyllis cytisoides*. The germination rate of scarified seeds is eight times higher than that of non-scarified ones. Scarification is the safest pre-treatment method, and the percentage of germination that ensues is probably very close to germination capacity. The seed coat must not be notched because this can be prejudicial to germination.

VARIETY DEVELOPMENT

INRA CATALOGUE ENRICHED BY 3 NEW VARIETIES

Lentil variety: Chakkouf

The new lentil variety Chakkouf was included in the official catalogue in 2009. It is characterized by its resistance to rust and Ascochyta blight, its earliness and its adaptation to semi-arid areas. The average plant height is 45 cm. The grains are beige with yellow cotyledon. The protein content of seeds of this new variety is 21%; the levels of iron and zinc in mg/kg of the dry matter are, respectively, 76.7 and 62. Yields are of 15.35 quintals/ha at Jemaât Shaim (Abda region), 14.85 quintals/ha at Sidi El Aidi (Chaouia region), and 18.12 quintals/ha at Marchouch (Zaer region).



Chakkouf variety yield testing



Samples of lentil grains

Chickpea variety: Arifi

Arifi is a winter chickpea variety recently registered in the official catalogue. It was selected for its adaptation, and its high yield potential. On average, Arifi variety has reached 16.34 quintals/ha, exceeding Farihane by 8%. This variety has an upright bearing, an average plant height of 75 cm and a strong stem, making it well suited for mechanical harvesting. It blooms in 90 to 108 days in arid and semi arid areas and 83 days in favourable areas. It reaches maturity in 160 days.

The weight of 100 grains is about 40 g. Its husked seeds have 17.47% of protein.

Rapeseed variety: Moufida

A new rapeseed variety Moufida was registered in the Official Catalogue in 2009. This variety is a pure mid-early flowering inbred, with an average of 94.5 days between sowing and flowering, early at maturity, with an average of 157 days between sowing and maturity. It is characterized by a plant height of 1.60 m, a strong branching, average leaf teeth, well developed lobes, big leaves and bright yellow flowers. The average grain yield exceeds 20 quintals/ha. Seeds oil content is around 50% of the dry matter. Furthermore, it is a variety of canola quality or '00', without erucic acid, and its cattle cake has very low glucosinolate content. Moufida is recommended for Gharb, Loukkos and Sais areas.

Lines in process of registration

SPECIES	Lineage	Test Year
Durum wheat	D 22 M 67	1 st year
	INRA 5DW028	1 st year
	INRA 5DW030	1 st year
	BFIL 16	2 nd year
	D 25 M 78	2 nd year
	D 32 M 78	2 nd year
Bread Wheat	00HBW103	1 st year
	D 79M67	1 st year
	00HBW300	2 nd year
	D 65M78	2 nd year
	D 76M78	2 nd year

Durum wheat

In the durum wheat improvement programme, quality is considered as a priority. It is determined by the quantity and quality of two gluten components, gliadins and glutenins. Two molecular markers LMW-GS and HMW-GS were used to identify genes associated with these components in 11 durum wheat varieties. The genetic distance oscillated between 0.074 and 1.253, and reveals a high variability. These results showed that there is a potential to use a correlation between the profiles of markers LMW-GS and HMW-GS and durum wheat quality. These markers will be used to assist the selection of quality varieties of durum wheat.



PCR of high molecular weight glutenins (HMW) fractionated to a 6% polyacrylamide gel. (1) Irden, (2) Massa, (3) Jidara, (4) Anouar, (5) Nassira, (6) RGL0095, (7) Jawhar, (8) Yasmine, (9) Oumrabie, (10) Sarif, (11) Tarek.

To enrich the genetic basis of durum wheat programme, a collection of 4803 mutant strains of durum wheat resulting from the TILLING technique were evaluated for several traits related to yield and to reactions to disease. Among the 326 selected lines, 38 showed resistance to midge and to stem sawfly stubble. This resistance is confirmed by laboratory tests.



Screening of mutant strains in greenhouse

From the breeding programmes, thirty lines were selected for their resistance to rusts and to septoria. The application of quality tests namely those related to the yellow colour, to vitreousness and to protein quality led to 22 promising lines. These latter will be introduced to yield test for a probable proposition to the official catalogue.

Bread wheat

As part of the strategy for improving resistance to drought, the HVA1 gene, known for its involvement in drought tolerance, has been introduced by the biolistic and *Agrobacterium* -mediated methods for seven varieties of wheat (Achtar, Arrehane, Mehdiya Aguila, Marchouch, Amal and Rajae). The treatment of immature wheat embryos by these two techniques has allowed the induction of embryonic tissues before and after the application of selection pressure. For the biolistic technique,

the number of transformants from selected callus was of 12 for Marchouch, 7 for Rajae and 5 for Amal. Seedlings transformed will be used as intermediary material in the improvement programmes of wheat's adaptation to drought.

Nuclear irradiation by gamma rays was used for the creation of new genotypes tolerant to salinity. Five Moroccan varieties of durum wheat and three of wheat have been irradiated. Mutants were produced, developed and evaluated for salinity under controlled conditions. The morphological and physiological assessment led to the selection of wheat mutants tolerant to high salinity reaching 20 g/l. After multiplication and development of specific populations, these selected mutants will be a promising material for the identification and for molecular characterization of genes associated with salt stress.

Fababean

Control of broomrape - major constraint to fababean production - is a priority in the breeding programme of this crop. The use in a controlled environment of new criteria for evaluating the resistance to *Orobanche*, based on host-parasite couple, has led to the distinction between tolerant and sensitive lines. The lines ILB 4980, ILB 4984, 8/9-137 and 18035-S were confirmed tolerant. Furthermore, the direct organogenesis of plants from cotyledonary nodes in combination with *Agrobacterium* has been used in Defesa fababean variety to introduce genes with resistance to drought and HVA LEA3. Plants having integrated these genes were identified by PCR. This result will be confirmed at the physiological level. Another gene, sarcotoxin, antagonistic to the development of broomrape, was used.

Citrus

As part of the research for rootstocks, alternative to sour orange, tests have been initiated on thirty clones from several varieties in different citrus fruit producing regions. Promising results were observed on a number of new rootstocks. In fact, rootstocks *Citrus volkameriana* and *Citrus macrophylla* and other rootstocks led to encouraging results in terms of production, fast fruit set and juice quality in Nules clementine and Nour in the Souss. Regarding Maroc Late, the results obtained in the Souss region, Haouz and Tadla revealed the performance of new rootstocks compared to those commonly used. In the Souss region, *Citrus volkameriana* conferred

to Maroc Late the best production in comparison with the sour orange. The data obtained allow us to note some advantages of these new rootstocks compared to sour orange. In addition to their resistance to tristeza, they have a high productivity, an early fruit set and an improved fruit quality.

Olive

The selection of genotypes adapted to drought and intended for cultivation in rainfed areas has been undertaken by surveys and collections in the local genetic material contained within the old olive groves. In fact, 90 individuals were selected for their production regularity, high oil content, tolerance to drought stress and some bio-aggressors. All genotypes have different genetic and distinct profiles from the Moroccan Picholine. These 25 genotypes detected, are divided into two distinct groups.

The in situ assessment of nine local olive genotypes selected in this gene cluster confirmed their agronomic and biochemical performance. The V103 genotype was characterized by its large-bore (8 g) with pulp on stone of 4.5, which can be used for table olives. For the other genotypes, the weight of their fruit was similar to that of the PM standard (2 to 3 g). All have average oil content ranging 24 to 32% (of fresh weight) and remain above the average rate of oil in Moroccan Picholine (18-22%). The quality of their oil is better, their contents of total polyphenols ranged from 2053 to 2134 ppm. They also have oleic acid content ranging from 75.5 to 76.9%. For linoleic acid, the average content is between 9.6 and 10.2% **(Figure 9)**.

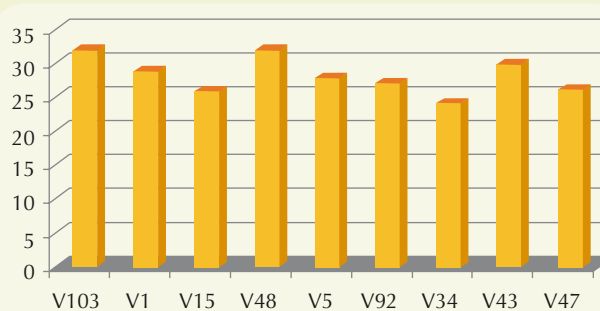


Figure 9: Oil content in selected olive genotypes (fresh weight).

In the breeding programme for irrigated areas, the assessment of populations obtained by crosses, ten years after being planted, led to the selection of five genotypes showing good agronomic traits. Among them, two genotypes showing low vigour can be recommended in the super-intensive system.

Date Palm

Multiplication by in vitro organogenesis allowed the production of vitroplants in conformity with the mother plant. Production reached 17278 vitroplants of several varieties (Nejda represented half of this production). It was delivered to the "Domaines Agricoles" for industrial production. Moreover, more than 78% of strains are from clones resistant to Bayoud. The use of tissue taken from inflorescences of date palm also led to successful initiation of the multiplication in 12 cultivars. The adaptation programme of this technique to other varieties is in progress.

Almond

In the breeding programme of Almond, the rehabilitation of the varietal association based on 'Marcona' variety requires the selection of a suitable pollinator with fruits having good pomological characteristics. Crossings with selected parents was directed towards the selection of productive genotypes with simple kernels and high pomological properties equal or superior to that of Marcona.

The screening of 30 hybrids from 10 different families for productivity showed the good performance crosses with the parent 'Ardéchoise' (Ard) and "Ai". Hybrids (Ard x Bart) 35 and (Mar x Ai) 119 improved significantly in hull performance that exceeded 10 kg/tree. The kernels size ranged from 1 to 1.3 g and the skin was light coloured. These two hybrids were selected to be associated to the 'Marcona' variety as pollinators of good qualities and therefore replace the variety of Fournat de Brezenaud.

Carob tree

Prospecting and characterization of carob tree populations led to the identification of high performing genotypes based on their productivity, their pod and seed quality, and their adaptability to poor soils. The number of grains per pod among selected individuals, considered as the main selection criterion, ranged from 13 to 38%. However, some compensation between pod size and fertility was observed in selected genotypes. In fact, the genotype MK11 with the highest fertility had a small-sized pod (10 cm long and 5 g of weight) while HD7 had the second highest fertility and the longest pod, with an average weight (15 cm of length and 6.5 g of weight). The productivity of the tree depends also on another component of performance which is the number of pods per tree.

Plum tree

Among the constraints to the production of dry plums there is the limited range of varieties destined for drying, dominated by the Stanley variety. This latter completes its maturity phase during the first week of September. This causes some pressure on the drying ovens and effects fruit quality. Therefore, a hybridization programme was initiated to develop new drying varieties with characteristics similar or better than those of the «Stanley» variety and with an out of phase maturity period. Stanley-Ente plum crossbreed was made and the hybrids are in stratification stage.



Plumtree

Cactus

The study of the variability of morphological characters within 63 cactus genotypes of different Moroccan origins demonstrated the existence of a large genetic variability. The results led to a significant correlation between the region of origin of the opuntias studied and the East-West diameter of the plant, and the cladode length.

Regarding the variability analysis and the estimation of genetic parameters of the agro morphological characters in cactus (*Opuntia ficus indica* (L) Mill.) of 30 cactus genotypes the results showed the existence of a very high phenotypic and genotypic variability for most of the traits measured. At the plant level, the trait number of fruits per plant showed the greatest phenotypic variation (CVP = 131.81%). The hereditary proportion of this variability is very important (CVG = 121.47%), and the genetic gain for the next generation (29.15%) and the correlation between this character and

most other plant traits are very high. These criteria are very important for a breeding programme.

At the cladode level, a large phenotypic variability was observed. The heritability part for the number of spines (81.85%) and for the longest spine (78.22%), and the genetic gains are very high. The other traits showed relative gains between 1.32% and 13.10%. In terms of fruit, with the exception of sugar content (Brix), the proportion of hereditary seed weight per fruit and fruit weight, is very high (over 40%), with very good genetic gains (29.38 % and 13.51%, respectively). The strong association of these two characters ($r = 0.81$) indicates that a breeding programme based on these two traits could be efficient. Peel weight and sugar content are strongly influenced by the environment. The heritability of other traits varies between 0.27 and 0.38.

Ex situ preservation of plant genetic resources

Surveys conducted last year led to collection of 87 accessions divided into 14 species from several regions of Morocco. With these acquisitions, the total number of accessions maintained in the genebank reached 25000. Five genera represent more than 72% of all the accessions. These kinds are *Triticum*, *Hordeum*, *Medicago*, *Avena*, and *Helianthus* (Figure 10).

As regards regeneration, 407 sunflower accessions were multiplied in the experimental station of Sidi El Aydi. These accessions were subject to a preliminary characterization. The results showed a wide genetic variability regarding some of the phenological traits studied.

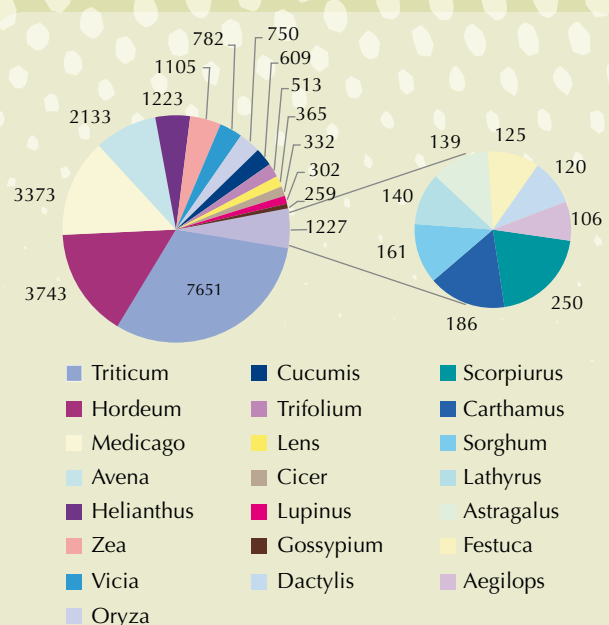


Figure 10: Number of accessions per genera at INRA genebank

AGRONOMY AND MECHANIZATION

CROP MANAGEMENT

Optimization of wheat fertilization and irrigation in the Sais

Supply of 120 to 160 kg N/Ha led to an average yield of wheat over 50 quintals/ha, i.e., an increase of 53% compared to the control and 18% compared to a supply of 40 to 80 kg N/Ha.

Water use efficiency (WUE) for grain and for dry matter was also dependent on the rate of nitrogen. The rates of 160, 120 and 80 kg N/ha gave the highest WUE for the grain (6.64 kg/mm/ha). This WUE was higher by 46.58 and 16.5% in comparison to 0 and 40 kg N/ha rates, respectively. The same significant effects of nitrogen were observed for harvest index and total biomass.

Also, durum wheat response to nitrogen and phosphorus supplies led to yields ranging from 28 to 62 quintals/ha according to treatments. The maximum grain yield (62 quintals/ha) were obtained with the supply of (30 N – 18 P) and (90 N-9 P) kg/ha.

Improvement of irrigation water management for wheat in Tadla

The traditional Robta is the irrigation technique most used in the irrigated perimeter of Tadla. Its efficiency is very low, requiring a significant mobilization of dam water. Testing Raised Bed Irrigation in comparison to the traditional method Robta on wheat was investigated. The «Raised Bed Irrigation» improved both yields and water productivity. «Raised Bed Irrigation» has improved yields to 55 qx/ha against 50 qx/ha for Robta, and has improved water productivity of wheat to 1.3 kg/m³ compared to 0.8 kg/m³ for Robta.

Improvement of irrigation water management for sugar beet in Tadla

This study was carried out to determine water requirements for germination-emergence of sugar beet for different kinds of seeds: «multigerm», «monogerm» and «monogerm ready to germinate». The results showed that «monogerm» seeds

show a higher need for water than «multigerm» varieties. «Monogerm ready to germinate» seeds are less water demanding than «monogerm» seeds not ready to germinate. «Multigerm» seeds with a pattern of 30, 40 and 50 mm and the seeds «monogerm ready to germinate» with patterns of 40, 50 and 60 mm have provided the best germination-emergence rate.

Integrated management of Souss basin water

A hydrological and economic model was used for an integrated management of the Souss Water Basin. This model of nonlinear optimization uses water resource to maximize net agricultural income. It takes into account constraints such as hydrological, agricultural and of resources availability. Results analysis revealed significant differences between the economic water price according to agricultural areas. The average economic price of water in the basin is 2 DH/m³. This explains the scarcity of water in this basin. In fact, ground waters are scarce even in normal years, -6 Mm³ for Chtouka groundwater and -54 Mm³ for Souss. This situation is further complicated in years of drought. For areas that are pumping groundwater, the financial price is approaching the economic price because there is no limitation on the groundwater resource, including taxation. As a result, the water pricing policy applied currently is insufficient to manage efficiently the use of water resources in the long term.

IMPROVEMENT OF MARKET GARDENING SUSTAINABILITY

Pesticides monitoring in Loukkos market gardening

The analyses were carried out to determine the quantities of pesticide residues on the potato farming in the Loukkos perimeter, based on 84 samples randomly taken. Pesticides sought are chlorothalonil, a fungicide, methomyl, deltamethrin, dimethoate and carbendazine (insecticides); and linuron herbicide.

The majority of these substances are harmful to health and some of them are banned in the European Union. Results showed that 95.3% of the samples contained no detectable residues, while four samples (4.7%) had residues with values below the maximum limits. Pesticides detected are methomyl and deltamethrin used as insecticides in crop, generally applied at the final stage of the crop where the attacks of insects and aphids increase.

Analyses were also conducted to determine pesticides level in the Rmel area of the Loukkos perimeter and their impact on the contamination of Rmel groundwater through a survey of 87 randomly selected farmers. The main crops concerned are strawberry, potato, paper, peanut, cucurbit, sugar cane, forage crop, wheat, tomato and citrus. Strawberry is the largest pesticide consumer with an average of 24.2 kg/ha, followed by potato (18.3 kg/ha), pepper (18.0 kg/ha), tomato (15.7 kg/ha), zucchini (15.3 kg/ha), beans (15.0 kg/ha), citrus (14.5 kg/ha), melon (14.4 kg/ha), watermelon (13.4 kg/ha), peanut (12.4 kg/ha) and wheat (5.9 kg/ha). The average amount of pesticides used is 13.6 kg/ha. 83 trade specialties corresponding to 67 distinct active materials were listed, dominated by fungicides with 48.4% followed by insecticides with 30.4%, acaricides / nematicides with 13.2% and finally herbicides with 8.0% (**Figure 11**). Among the products most commonly used as fungicides are: mancozeb, carbendazine, maneb, hexaconazole; Methomyl is the most widely used insecticide, followed by deltamethrin, chlorpyrifos, carbofuran, and dimethoate. Abamectin followed by oxamil, phenamiphos and clofentezine represent the major acaricides / nematicides used while linuron and 2,4-D are the most widely used herbicides.



Figure 11: Average pesticides use per crop

Potato irrigation management

The present work aims to investigate irrigation management strategies of potato. During the years 2008 and 2009, the response of potato crop varied according to the degree of water stress during plant development. Treatment with irrigation reduced to 60% of water requirements (ETc) with the following distribution: 64mm in 30 days after planting (1.7 mm/d), 104mm for 32 days (3.25 mm/d) and 39.42 mm during the following 29 days (1.35 mm/d) and 24.28 mm during 23 days of maturity (1.05 mm/d) has led to high yields of 41 tonnes/ha and a better grading of tuber.

Improvement of potato farming practices

The assessment of plant response to different treatments (biofertilizers and colours of plastic mulch) was based on parameters related to potato growth and yield. Research on the effects of biofertilizers showed a significant treatment effect on the stem growth reaching an average of 66 cm versus 60.5 cm for the control. On the contrary, the use of biofertilizer showed no effect on yield and its components. The black mulch induced a total yield increase of 4.3 tons/ha compared to cultivation without mulch and 13.16 tons/ha compared to white mulch. The technical mastering of this type of farming can be an asset for improving potato production.

Management of greenhouse «multichapelle» and «Canarienne» microclimate in the Souss Massa

Research is underway to make available to farmers a practical management tool for greenhouse environment in Souss region, to optimize the additional expenses and provide satisfactory quantity and quality yields while protecting crops against pests. The study of microclimate and productivity change of two structures (greenhouse «Multichapelle» and «Canarienne») led to the identification of microclimate and production malfunctioning factors in tomato farming. Tomato yield losses were estimated to 18% and the average size of fruits per cluster showed a reduction of 4%. This poor performance of productivity under «Canarienne» greenhouse is mainly due to its architecture and height that do not allow an adequate ventilation and water-resistance to store more heat, and remove the excessive moisture with its homogeneous stratification inside the greenhouse. The «Multichapelle» greenhouse with metal support is recommended because of its flexibility towards external climate change due to

its architecture and its more important ventilation surface that can be improved by ridgepole openings. In parallel with this structure, installing a complete kit to measure climate and mensuration parameters in the greenhouse is strongly recommended to facilitate the management and the monitoring both of the microclimate and of other production factors, irrigation and fertigation in greenhouses.

Organic market-gardening in the Souss

The choice of substrates is a critical operation for soilless crop success to replace methyl bromide. Sand and gravel substrate-based mixture was tested with the proportions of 33% of sand and 66% of gravel for soilless tomato farming, green beans and vegetables such as lettuce and cabbage. This substrate showed a positive effect on water saving compared to other commonly used substrates. For tomato, it allowed 33% of water saving compared to the coconut fiber and an overall yield of 207 tons/ha. The results on cabbage, lettuce and pepper were also very interesting with yields respectively of 36, 20 and 73 tons/ha. The use of this substrate for four years led also to a high yield stability associated to better fruit quality, and water economy and fertilizer use reduction. It has offered significant economic gains.



Round cabbage grown on local mixed sand and gravel substrate in Melk Zhar Experimental Field (Agadir).

Improvement of argan tree and carob cuttings and grafting

For the argan, the plant material consists of tree cuttings from two areas in the region of Ait Melloul Admine forest and from trees in CRRA Agadir. The results showed varying rates of budding without leading to rooting of semi woody cuttings at

different concentrations with hormones. Roots emission at an early stage at a low and variable rate from 8 to 33% was observed (with the exception of a 50% rate noticed for one tree with 6000ppm of AIB). For grafting, the results showed a 60% success by grafting in cleft apically and 30% by substituting grafting twigs under room conditions and 20% graft by a simple approach.

For carob, the plant material consists of branches removed from female trees from five sites: Admine, Temsia, Tiznit (Dar Ajil and Idre), Ida ou Tanane and Asgherkiss at in Ait Baha. Propagation by cuttings in the greenhouse showed a very low percentage of rooting due to high temperatures recorded in July and August 2009. For the grafting technique, relatively high success rates ranging from 20 to 60% were obtained depending on the type of grafting achieved; the terminal cleft grafting was the most interesting, followed by bud grafting and bevelled grafting. However, these techniques are far from being mastered, and further studies are needed to improve the success of these regeneration methods.

Study of the effect of the harvesting stage on the quality and yield of essential oils of Thyme

The results obtained showed that the yields of essential oils of flowering thyme from Bni Ider are more important than for early harvested thyme (3.2% in full bloom against 0.5% for seedlings). Concerning the chemical composition of this oil, it also differs depending on the cutting stage. Essential oils of thyme seedlings showed more constituents than those of thyme essential oils cut at flowering stage (98 compounds against 59 at full bloom).

Evaluation of the antibacterial and antifungal activity of Pouliot mint, Thyme and Oregano

The results obtained by the disk diffusion method showed that all these oils have proved active against bacteria, but their effects vary from one oil to another depending on their major compound. The oil having the highest activity of all the oils studied is that of *Thymus vulgaris* and *Origanum compactum*, while that of *Mentha pulegium* seems to be the least active. These essential oils have shown a capacity to inhibit mycelial growth of two fungi (*Aspergillus flavus* and *Fusarium solani*) at low concentration values.

PLANT PROTECTION

EXPLORATION OF CEREALS AND FOOD LEGUMES DISEASES, PESTS AND WEEDS

Cereal diseases: yellow rust expands Morocco-wide

Exploration of wheat diseases revealed a dominance of *Septoria* due to *Septoria tritici* (Desm.) Rob. (Teleomorph *Mycosphaerella graminicola* (Fuckel) Schroeter and *Stagonospora nodorum* (Berk.) Castell. & Germano (Teleomorph *Phaeosphaeria nodorum* (E. Müll.) Hedjar), of brown rust (*Puccinia triticina* Eriks.) and yellow rust (*Puccinia striiformis* Westendorp f. sp. *Tritici*). Other infestations of less importance were caused by powdery mildew (*Blumeria* (Erysiphe) *graminis* f.sp. *tritici*), root rot and stem rust (*Puccinia graminis* Pers.: Pers. F. sp. *Tritici* Eriks. E. Henn) (**Figure 12**). Yellow rust, usually of minor importance, was present in almost all wheat growing areas with an incidence ranging from 41% to 100% in Chaouia, in Sais and Sraghna. This is likely due to changes in the spectrum of pathogen virulence and, consequently, the genes loss of efficiency, in this case the gene Yr27.

The genetic diversity of *Septoria tritici* populations taken from the same wheat plot was studied using SSRs (Simple Sequence Repeat) technique with four specific markers (ST1A2, ST1D7, and ST1E3 ST1E7). The combination of 4 markers (A2, E3, E7 and D7) showed 5 haplotypes in type strains MAT1-1 with a dominance of one haplotype to 67%. But, at strains MAT1-2, 5 haplotypes were identified of which two are frequent in 40 and 30% of strains, respectively. This suggests that the types MAT1-2 are more polymorphic than the MAT1-1 ones.



Figure 12 : Prevalence of cereals diseases per region.

In the case of barley, the fields explored were attacked by net blotch (*Pyrenophora teres* Drechsler) with an average severity exceeding 75% (**Table 1**). Infestations of brown rust (*Puccinia hordei* GH Otth.) were also encountered but to a lesser degree. The attacks of rynchosporiose (*Rhynchosporium secalis* (Oudem.) Davis) and of powdery mildew (*Blumeria graminis* (DC.) Speer (Erysiphe *graminis* F. sp. *Hordei*) were especially significant in Chaouia region. Traces of covered smut (*Ustilago hordei* (Pers.) Lagerh.) were noticed in Tadla and Chaouia.

Table 1: Medium impact of major barley diseases in different regions during the 2008-2009 campaign.

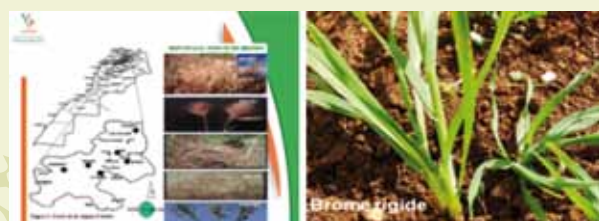
	net blotch	Brown rust	covered smut	Rynchosporiose	Powdery Mildew
ABDA	75	0	0	0	37
CHAOUIA	74	42	3	8	23
TADLA	70	2	trace	trace	29
RHAMNA	64	13	0	0	22
STAGHNA	68	13	0	0	15

The study of 0.9 similarities among 51 Moroccan isolates of barley blotch allowed the identification of 11 morphologically different groups according to their culture mode. This morphological diversity should be taken into account in the breeding programmes.

Cereals weeds: a competition with an enormous shortfall

The inventory of weed species in 78 fields of wheat in Chaouia, Doukkala, Abda, Rhamna, El Kelaa des Sraghna, Tadla, Zair, Sais and Taza regions revealed the presence of 188 species. The most dominant ones are: *Avena sterilis* L., *Papaver rhoeas* L., *Chrysanthemum coronarium* L., *Melilotus sulcata* Desf., *Bromus rigidus* Roth., *Lolium multiflorum* Hamk., *Emex spinosa* (L.) Campd., *Antirrhinum Orontium* L., *Plantago afra* L., *Cichorium endivia* L. and *Diploaxis Catholica* (L).

In the Sais and Middle Atlas, wheat fields were greatly affected by the development of a diverse range of weeds, 91% of which are dicotyledonous. Monocotyledonous ones were dominated to 89.2% by different species of brome. Heavy infestations of more than 350 plants per m² were noted in 40% of the plots. *Bromus rigidus* Roth represented a maximum relative frequency of 55% and a maximum recovery of 48.4%. Under these conditions, yield losses due to weeds and to *Bromus rigidus* in particular were estimated to more than 44 q/ha, i.e., about 9760 Dh per hectare.



Main brome species in Sais and Middle Atlas.

Furthermore, characterization of the major late weed species associated with cereals in the Gharb allowed the identification of 91 annual species, 17 of which are a real disturbance to farming. Among these latter, *Phalaris* sp., *Avena sterilis* L. and *Bromus* sp are particularly dangerous and are difficult to control. Along with the heavy and prolonged rains in this region, a second type of late vegetation appears throughout the whole cereals cycle, and requires targeted control means. These weeds are *Ridolfia segetum* Moris, *Ammi majus* L., *Cichorium endivia* L. *Centauria dilute* Aiton and *Picris echioides* L. .

Hessian fly, a risk for late sowing

In the case of cereals pests, Hessian fly attacks were less important this year in comparison with the previous seasons. However, losses were estimated to approximately 50% for late-sown fields.

Enemies of food legumes

Fusarium wilt (*Fusarium oxysporum* Link) was observed in more than 43% of the chickpea fields prospected, followed by *Ascochyta* blight (*Ascochyta rabiei* (Pass.) Labr.) and root rot (*Macrophomina phaseolina* (Tassi) Goid.). Significant losses of fusarium wilt were observed in the regions of Zaer-Roummmani and Gharb.



Lentils plot.

RESEARCH IN CEREAL AND FOOD LEGUME PEST CONTROL

Identification of resistance sources to major diseases and pests

The evaluation of a wheat differential nursery in Meknes, carrying genes with resistance to yellow rust, showed that genes Yr1, 5, 10, 15 and YrSp are highly efficient against the Moroccan pathogen populations. These genes will be proposed for

integration in the best Moroccan wheat cultivars and in advanced lines. This study also revealed that the gene Yr27 confers no resistance to the Moroccan populations of the pathogen.

Greenhouse experiments for the evaluation of resistance to *S. tritici* of bread and durum wheat collection from CIMMYT and ICARDA showed a wide diversity of reactions in this material with percentages of immune material reaching 4 and 22, respectively. All wheat Moroccan cultivars were sensitive, except one durum wheat variety showed an acceptable level of resistance.

An evaluation method in greenhouse conditions of wheat resistance to root rots caused by *Bipolaris sorokiniana* (Sacc.) and *Fusarium roseum* f.sp. *cerealis* cv. 'Culmorum [Anamorph] Snyder, Hansen & Oswald, has been developed in order to have a reliable indication of field resistance efficiency. This method is based on estimating the numbers of dead seedlings, white ears, mature ears and the total biomass after separate or mixed inoculation of different pathogens. In this framework, the evaluation results of resistance of wheat varieties, grown in Morocco, showed reactions of tolerance / resistance of the variety Ashtar to *B. sorokiniana* and of Saada variety to *F. culmorum* sp. *cerealis*. While Saba and Khair varieties showed the same behaviour towards the 2 pathogens.

In the case of the Hessian fly, evaluation in greenhouse conditions of a nursery with 390 F7 lines of wheat led to the selection of 240 lines highly resistant and 17 resistant. In this material, 109 lines confirmed their resistance in the field and provide an opportunity to broaden the genetic basis of resistance to this pest.

The evaluation of a chickpea nursery at Sidi El Aidi consisting of registered varieties, lines from ICARDA, advanced lines and lines derived from national yield trials allowed the selection of 11 genotypes resistant to *Ascochyta* blight.

Chemical control of cereals and food legumes enemies

Treatments to control foliar diseases of wheat

The comparison of the efficiency of a range of chemicals at Jmaat Shaim experimental field, generally recommended for the control of major foliar diseases of wheat (tan spot, septoria and brown rust) showed the importance of foliar treatments in the crop management of cereals,

particularly, for susceptible varieties. It has been demonstrated that the adoption of chemical treatments for foliar diseases control is beneficial both in terms of quality and quantity.

Successful chemical weeding of *Broomus rigidus* and of *dicotyledonae* associated with wheat

A very significant control of rigid brome and *dicotyledonae* in wheat was obtained in a trial at Douyet with metribuzin treatments at a rate of 350 + 350 g a.i./ha applied early and late at tillering stage, followed by prometryn at a rate of 750 g a.i./ha and propoxycarbazone-sodium + Frigate at a dose of 42 g a.i./ha + 200 cc/ha applied early at tillering stage of Amal variety.

Furthermore, the results of work on the residual effect of sulfosulfuron on wheat succeeding crops showed negative effects on the size of the bean, of green peas, and of lupine, respectively, by 65, 39 and 59% compared with the control. Sunflower and sugar beet have not been able to grow for two successive years on plots of wheat treated with sulfosulfuron and/or by propoxycarbazone-Na+.

At Sidi El Aidi, 2 herbicides containing sodium lodosulfuron + mesosulfuron sodium + diethyl Mefenpyr controlled over 95% throughout the cycle of ten weed species dominated by *Polygonum aviculare* L., *Glaucium corniculatum* L., and *Avena sterilis* L. These treatments have led to yield gain of over 50%.

Interaction between the level of infestation by hessian fly and sowing rates of durum wheat varieties

Interaction between the level of infestation by hessian fly, *Mayetiola destructor* Say, and rates of sowing for different varieties of durum wheat demonstrated that the best yields were achieved with high sowing rates of 180 to 200 kg/ha. On the other hand, in dry years, the best yields were achieved with low to medium seeding rates. The seed rate is a complex factor involving diverse elements such as genetic characteristics of the variety, weather conditions of the growing season, sowing date, seed production system and farmers' economy. It follows that recommending a given dose can only be done for each variety in specific farming conditions. Thus, it was recommended that in case of late sowing, only resistant varieties would be able to promote durum wheat growing and give good yields.

Pilot sites of integrated participatory control of wheat and food legumes main enemies

Pilot sites of integrated control by participatory approaches were installed at farmers' fields in different regions. Within this framework, technological packages were tested and adopted by farmers for wheat and fababeans for integrated pest management based previous achievements. In general, the yields of the pilot sites were significantly higher than the average in these regions. In this context, the «Arrihane» variety was used to a large extent in Chaouia, Abda, Doukkala and Tadla regions, as a result of a good spread of this variety from pilot sites.

Technological innovation for the creation of new wheat and barley varieties resistant to stress

The following are studies initiated to contribute to the development of improved lines of wheat with high yield potential and good tolerance to biotic and abiotic stress, of good quality, and adapted to local conditions by taking advantage of the new techniques of molecular biology and identified sources of resistance.

Genomics tools for wheat breeding programme

The haploid plants from the crossbreed made last year between the Moroccan variety (Tilila) and Yacoro Rojo variety were tested by three molecular markers, and those selected were treated with colchicine to restore their fertility. The doubled haploid plants obtained were sorted by three markers: resistance to yellow rust (primer UHW89), the high protein content (primer GLU D3 22) and the presence of chromosome R (primer iag95). The doubled haploid plants selected constitute an improved germplasm and will integrate crossing blocks of wheat as sources of resistance to brown rust, yellow rust and quality. In the same context, more than 950 other haploids are under selection.

INTEGRATED CONTROL OF CITRUS PESTS

Prospecting citrus diseases and pests

The characterization of the pathogenicity of a collection of isolates from gummosis

(*Phytophthora citrophthora* (RE Sm. & EH Sm.) Leonian), from the main citrus-growing regions of Morocco, has demonstrated a great variability in symptoms severity. A change in the behaviour of some strains has been noted according to the inoculated organ.

In the case of citrus pests, the study of structure and population dynamics of thrips on Navel and Clementine in the Tadla region showed an intense activity during the flowering period. The spontaneous plants helped the pest survive and multiply, hence playing the role of reservoirs that is a continual threat to citrus.

Antagonists of citrus pests, an asserted way of biological control

The inventory of natural enemies of citrus orchards in the Gharb region, achieved during spring, showed the presence of six auxiliary species with varying population densities in time. These are *Chilocorus bipustulatus* (Linnaeus), *Coccinella septempunctata* (Linnaeus), *Chrysoperla carnea* (Stephens), *Aphytis melinus* (Debach) *Euseius stipulatus* (Athias-Henriot) and *Aphelinus aphidymiza* (Rondani).

Furthermore, in a laboratory test, the application of aqueous extract of mandrake showed no significant effect on the predatory activity of *C. bipustulatus*, *C. septempunctata*, *C. Carnea* in contrast to the essential oil of cedar having an insecticide effect on these auxiliaries and on aphids. This result confirms the selectivity of the aqueous extract of mandrake vis-à-vis the Mediterranean fruit fly (*Ceratitis capitata* Wied.), and opens a perspective for inclusion in a programme of an integrated management of this fly.

The results of a test for evaluating the efficiency of biological products on California red scale *Aonidiella aurantii* (Maskell), in citrus orchards in the Belksiri region showed reductions in population levels of 74, 51 and 2.53, respectively, by treatments with chlorpyrifos, a new formulation of oils and of buprofezin-based oils. Chemical treatments also affected the evolution of natural enemies, particularly predation by *C. bipustulatus* and parasitism by *A. melinu*. The effect of oils-based treatments on the auxiliary fauna remains insignificant. This product can be considered as a potential alternative to the conventional chemical control of California Red

Scale and can be recommended for an integrated control programme.

The comparison of the effect of kaolinite with spinosad for the treatment of Marisol clementine trees in Belksiri infested by the Mediterranean fruit fly showed the same level of efficiency of the two products. However, a greater reduction of fruit infestation was obtained by an application of kaolinite at a high rate of 3%.

Towards the improvement of diagnosis techniques of citrus virus diseases

Protection was conducted in citrus orchards of the Gharb region in order to assess the incidence and distribution of the psorosis disease. A preliminary test for the standardization of the technique DTBIA has been made for the development of a protocol for monitoring the virus in the Gharb region. The application of this technique revealed an average percentage of infection of 23.12% on 160 samples analyzed. The variety Valencia Late represented the highest percentage of infection with an incidence of 25.55% followed by Washington Navel with 15% of infection.

In the case of tristeza virus, and following the detection of Larache outbreak in the Virology laboratory of CRRRA Kenitra, extractions of total RNA from an infected plant were made for the detection of VCT by the RT-PCR molecular technique.

Biological control for pest protection for mint

Research was conducted in order to develop a strategy against the main pests associated with mint in the Gharb and Sais regions. The results allowed the identification of the major ones. It was shown that the leaf-eating caterpillars are the main phytosanitary problem that pushes producers to use pesticides. The main species of defoliating caterpillars identified in this framework are: *Helicoverpa armigera* (Hübner), *Utographa gamma* (Linnaeus), *Chrysodeixis chalcites* (Esper), *Thysanoplusia orichalc* (Fabricius), *Pyrausta aurata* (Scopoli). Other enemies have also been observed. They include *Aphis spaericola* (Patch), *Chrysolina menthastri* (Suffrian), mites, rust and weeds.

The surveys, on the other hand, led to an inventory of the main active ingredients used by farmers for crop protection. These were:

Dimethoate, Chlorpyrifos-ethyl and Hexaconazole. These products, although efficient, cause levels of residues exceeding permitted levels, which is a reason to ban their use in mint farming.

In addition, control tests of defoliating caterpillars using organic products has proved the efficiency of Spinosad resulting in a mortality rate of around 91% in the 3rd day after treatment, followed by *Bacillus thuringiensis*-based treatment with an average efficiency of 67% for 10 days after application of the product.

DIVERSIFICATION OF CONTROL MEANS FOR PLANT PROTECTION OF DATE PALM

Genetic control of Bayoud disease, a promising way for the selection of new resistant varieties

In order to select and characterize high-performance date palm genotypes, the overall analysis of available genotypes has been pursued by:

- The development of ten or so of variety cards;
- The identification of high-performance genotypes regarding heat requirement, fruit quality and/or resistance to be proposed for registration and protection. These include genotypes INRA-3003, INRA-1445, INRA 3010, INRA-6002, and INRA-6004. Among this material, some genotypes have been proposed to the in vitro culture laboratory for multiplication by inflorescences in order to have a sufficient number of vitro-plants to confirm their resistance to Bayoud;
- The recovery of seeds from 16 crossings from last year in Zagora Experimental Field for use in testing resistance to the disease;
- The inoculation of other plants from 13 crossings taking place in Menara Experimental Field between male and female genotypes descendant of the 5th and 6th generations of some varieties like Mejhoul and Deglet Nour. The plants studied will also be used for genetic tests by the molecular marker DNA. After selection, resistant plants will be transferred to the Experimental Field of Zagora for monitoring and field observation.

New data on the variability of *Fusarium oxysporum* f.sp. *albedinis*

The study of genetic variability of a collection of 45 strains of *Fusarium oxysporum* pathogenic or saprophytic composed of 19 strains of *Fo* f.sp. *albedinis* (*Foa*) from Moroccan and foreign origins (Algeria and Mauritania), 22 strains of *F. oxysporum* (*Fo*) of different origins and 4 strains of *Fo* f.sp. *canariensis* (*Foc*) of Moroccan origin showed that:

- On growing environments Czapeck and PDA, *Foa*, *F. oxysporum* and *Foc* strains exhibited various morphological types due to genetic variability, namely in the *Foa* showing different growing features on the two environments studied.
- A significant polymorphism, revealed by 184 polymorphic molecular markers generated by RAPD and microsatellite ISSR techniques, exists within the special form *albedinis* and a genetic proximity between some *Foa* strains and *F. oxysporum* strains. This suggests that *Foa* might derive from a saprophytic strain.

Research for the formulation of biopesticides to control Bayoud

In order to formulate agents for biological control of Bayoud, different growing mediums and conservation substrates were tested. Results have led to a good growth of bacterial strain B505 in PYA medium, and a better conservation in the soil. On the contrary, fungus FA1 showed an optimal development in Czapek and Richard mediums and a good conservation in talc substrate. Moreover, the study of the in vitro effect of three natural products on the causal agent of Bayoud showed a total inhibition of spore germination and a partial one of mycelial growth under the different parts of vetiver (*Chrysopogon zizanioides* Linnaeus) and of the extract of shrimp cuticle. However, the effect of adding pomegranate leaves to the growing medium has been evident in mycelial growth.

Genetic diversity of date palm tree and molecular markers associated with resistance to Bayoud

Polymorphism estimation in 34 date palm types using 16 RAPD primers and 22 microsatellite ISSR has led to the existence of many diversified markers compatible with the individuals studied.

These markers could be useful in distinguishing female and male individuals at an early stage. Some markers are interesting in distinguishing and grouping resistant varieties. The analysis also confirmed that date palm resistance to Bayoud cannot have only one origin.

Chemical control of other date palm diseases

In vitro estimation of five fungicides action on the mycelial growth of *Maugeniella scaetiae* (Cav.), agent of inflorescence rot "Khamej", and *Stenphylium* sp., drying agent of palms, has shown the possibility of using chemical control for these two fungi. In fact, the two products Benomyl and Methyl thiophanate proved to be very efficient against *M. scaetiae* at rates of 50 and 100 ppm. In the case of *Stenphylium* sp., a significant reduction in mycelium growth has been reached by Maneb, Mancozeb and Thiram at rates of 50 and 100 ppm.

PLANT PROTECTION OF OLIVE TREE

Survey on treatment products of olive pests

A survey in Marrakech, Tensift, and Haouz region of 60 olive orchards demonstrated that insecticides are the most important class in chemical control (64%) with the dominance of Organophosphates. The survey also showed clear deficiencies in the management, traceability and choice of treatment products.

Furthermore, conclusions of a study conducted in Essaouira region on the estimation of the adoption rate of the different farming techniques influencing

the olive tree health status, showed the necessity to identify some practices namely, Winter treatments, cutting and chemical control in order to improve national production both in quality and yield.

Biotechnology for a better understanding of olive Verticillium wilt

Research for polymorphic markers likely to be associated to resistance or tolerance of olive to Verticillium wilt (*Verticillium dahliae* (Kleb)) was conducted on 20 olive genotypes descending from crossings in Menara Experimental Field (Marrakech).

Molecular analysis by RAPD and microsatellite techniques ISSR revealed a relatively large number of polymorphic markers that provide information on the diversity level within this population F1. However, these markers could not distinguish between the stunted and vigorous trees as a consequence of the sensitivity and tolerance of the olive tree to Verticillium wilt. Furthermore, the combination of both techniques (RAPD and ISSR) has generated a dendrogram clarifying not only the kinship between the descendants, but also in a global way differences between hardy and stunted trees. These results provide a basis for research of molecular markers that may be associated with olive trees resistance or tolerance to Verticillium wilt by genetic analysis of molecular profiles of descendent genotypes.

TOWARDS THE DEVELOPMENT OF A STRATEGY TO CONTROL FIRE BLIGHT

The results of surveys on the fire blight disease (*Erwinia amylovora* (Burrill) Winslow et al) confirmed the presence of the disease in Meknes, Meknes-El Menzeh, El Hajeb, Agourai, Azrou, Ain Leuh, Khenifra, and Sefrou region. Morphological and biochemical characterization of a collection of 151 strains from these regions revealed a wide phenotypic and biochemical variety of this bacteria. Moreover, a reliable diagnosis of the

disease was developed through the use of PCR molecular technique involving a pair of primers (FliC1 2dl & FliC1 2re) capable of identifying all these strains.

The use of serological (IF with polyclonal antibodies) and molecular (primer FliC1 2di & FliC12re) techniques allowed the detection of *E. amylovora* on pear branches up to 1 meter beyond the infection point on the apparently healthy part. This information should be taken into consideration by growers in infested orchards.

The two antagonistic strains Ach 2-1 and Ach2-2 (*Aureobasidium pullulans* (de Bary) Arnaud), previously proved excellent biopesticides in apple post-harvest diseases (*Penicillium expansum* Link and *Botrytis cinerea* Pers.) also allowed a good protection of pear immature fruit (var. William BC) against *E. amylovora* exceeding 90%.

Furthermore, in an in vitro test using different essential oils to control *E. amylovora*, preventive treatment with thyme (0.05%) proved efficient in protecting immature pear, apple fruits and apple seedlings.

However, the assessment of resistance in 4 Marmoura pear types, *Pyrus communis* L., has shown a high sensitivity of these rootstocks to fire blight.

The Z1 strain for biological control of apple storage diseases

Evaluation in controlled conditions of the Z1 strain (*Pichia guilliermondii* Wickerham) protective activity against the major post-harvest diseases of apple (Golden Delicious) showed levels of protection up to 100% regarding *Alternaria* (Table 2). This result opens new horizons to the use of this bio-product in the control of apples post-harvest diseases in addition to its previously proven efficiency against citrus fruits post-harvest diseases.

Table 2: Level of protection of strain Z1 (*Pichia guilliermondii*) vis-à-vis post harvest of apple

	Protection Percentage	
	7 days of incubation at 25° C	10 days of incubation at 25° C
<i>Penicillium expansum</i>	70	30
<i>Alternaria alternata</i>	100	100
<i>Botrytis cinerea</i>	100	95

Exploration of plant resistance to control capnodes

The evaluation of a collection of stone rosaceae rootstock resistance to capnodes (*Capnodis tenebrionis* Linnaeus) larval attacks, has demonstrated a better tolerance of cultivars Delpatriarca and Agdez compared to Myrobolon, GF677 and V12.

Towards mass production of a bio-pesticide for controlling potato bacteria

A complete protection of potato tubers from *Erwinia pectinolytic* (Jones) was obtained as a result of preventive treatments with Ach2-1 (*A. pullulans*) strain thirty six hours before their contamination by the bacteria under laboratory conditions. With the view to trace the strain, a semi-selective medium was also developed to improve mass production of this bio-pesticide according to the fed-batch mode (43.76 g l⁻¹).



A



B



C



D

The different stages of *A. pullulans* strain Ach2 A-1 formulation. A: recovery of the pellet after centrifugation; B: paste made from biomass harvested and the corn starch; C: paste as cylindrical particles of 1 mm diameter; D: particles drying.

ANIMAL PRODUCTION

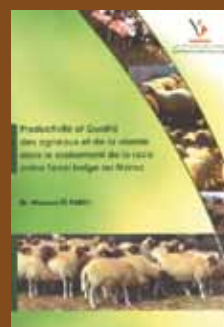
VALUABLE ACHIEVEMENTS FOR THE DEVELOPMENT OF SMALL RUMINANTS BREEDING



Dr. Moussa El Fadili, Head of the Department of Animal Production, INRA, receiving OADA Scientific Innovation Prize 2009.

This prize was awarded to Dr. El Fadili for his research on “Productivité et qualité des agneaux et de la viande dans le croisement de la race Texel au Maroc”. The results of this work

open new horizons for Moroccan local ovine breed for quality meat production in particular, and for ovine channel development in general.



CHARACTERIZATION OF GOATS' GENETIC RESOURCES IN MOROCCO

The results of the analysis of tissue samples from 150 goats in 8 provinces, namely, Beni Mellal, Khouribga, Azilal, Tangiers, Larache, Chefchaouen, Errachidia, Zagora and Ouarzazate showed that the study of genetic polymorphism has led to the definition of 97 distinct haplotypes with high diversity ($H_d = 0.9925$). This high diversity indicates that the domestic goat populations having colonized Morocco showed a great heterogeneity.

The analysis of molecular variance showed that the population had a significant effect on mitochondrial polymorphism with a low setting value index. It appears that 92% of the variation is observed in the same population and only 7.5% between populations, indicating that for

the mitochondrial DNA, the difference between individuals belonging to the same race is more important than that existing between individuals of different races. The geographic area also had a significant effect on the mitochondrial polymorphism of local goats with a low fixation index. The intra-region variation is the most important, i.e., 93% against 6.8% of the explained variation between the sampled regions. This can be explained by the fact that all haplotypes were mixed at their arrival in Morocco.

Furthermore, analysis of goats genetic structure in Morocco showed that all individuals are close to haplogroup A, knowing that there are six mitochondrial DNA haplogroups (A, B, C, D, F and G) in the world. The Neighbor-joining phylogenetic tree representing the 97 haplotypes identified in Morocco shows that all these latter are in the same group (**Figure 13**). It was concluded that there is a large mitochondrial diversity poorly structured according to regions and populations.

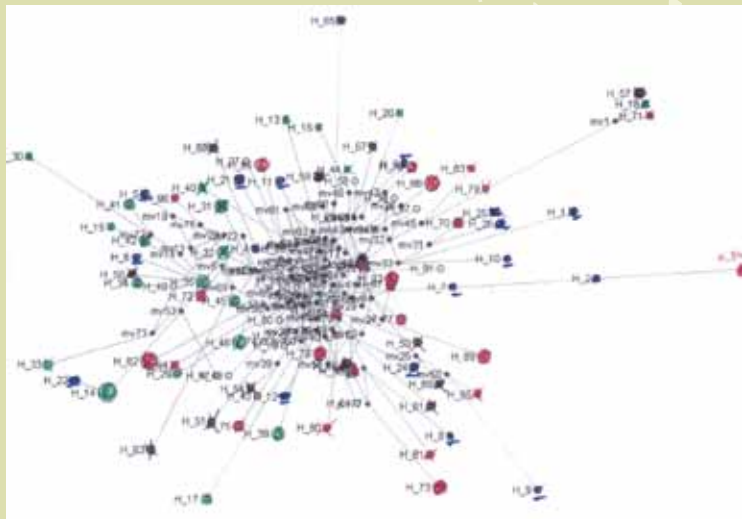


Figure 13 : Phylogenetic tree representing the 97 haplotypes identified with their geographical regions; Green: Northern region, Red: South-East region, Blue: central mountains, Black: central plains.

REPRODUCTIVE APTITUDE OF CROSSBRED SHEEP 'D'MAN X TIMAHDITE'

As part of the characterization of F1 to F4 generations of crossbred animals, within D'man and Timahdite crossbreeding, the study of puberty for crossed lambs and ewes as for parental parents was conducted under natural conditions at El Koudia station. The results obtained showed that the average age of puberty was 252 days for ewes, with a significant genotype effect. D'man ewes were the 1st to show signs of estrus (220 days), the Timahdite were the last (267 days), and the crossbreed at intermediate ages, 236, 256, 260 and 253 days for generations F1, F2, F3 and F4, respectively. Puberty for males was at an average age of 132 days, earlier than for females (**Figure 14**). As for females, D'man lambs have a precocious puberty (124 days) followed by the crossbreed (127 days), but later on for Timahdite lambs (144 days). The average testicular parameters, measured for all genotypes combined, are 6.09, 4.13, 2.25, 21.7 cm and 0.31 ml for length, testicular diameter, caudal diameter of epididymis, circumference and scrotal volume of ejaculate, respectively.

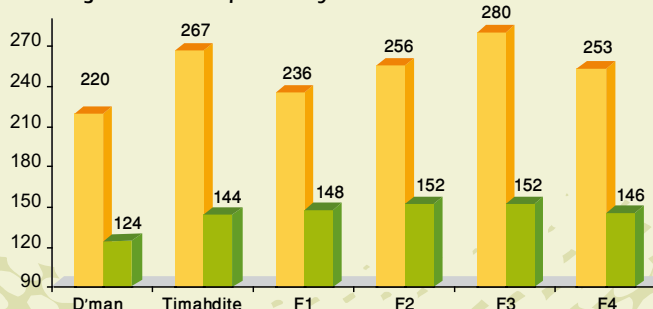


Figure 14: Ewes and lambs puberty reaching according to genotype (days).

Moreover, the study of the post-partum anoestrus duration for F1 to F4 generations ewes of D'man x Timahdite crossbreeding was performed by direct endoscopic examination of the ovaries 4 to 10 days after heat detection. Results showed that all the ewes involved in this study resumed their oestrous and postpartum ovulation activity. The average duration of post-partum anoestrus and ovulation rate at first oestrus, calculated for all genotypes combined, is respectively 49 days and 1.55 ovulations. D'man ewes resumed their oestrous activity after 40 days with an ovulation rate of 2.17 ovules, whereas this took place later for Timahdite females and F3 crossbreeding. Crossbred ewes F1, F2 and F4, on the other hand, are in an intermediary position between the parental breeds D'man and Timahdite, with shorter post-partum anoestrus duration than that for Timahdite.

The conclusion is that crossed animals D'man x Timahdite have shorter postpartum anoestrus duration. Crossbred lambs and ewe lambs are sexually precocious compared to the local Timahdite race. With this quality, 'D'man x Timahdite' crossbred ewes give the possibility of an accelerated lambing to improve and intensify sheep production in Morocco.

REPRODUCTION PARAMETERS OF 'BOUJAAD' OVINE RACE

In order to better characterize the Boujaad ewes, oestrous cycle study was conducted over a period of 44 days on 10 ewes. The results showed that the duration of the oestrous cycle of Boujaad race varies between 17 and 19 days. The evolution of the progesterone in plasma has the same tendency for all ewes.

Figure 15 illustrates the average profile of plasmatic concentration of progesterone during two sexual cycles. Indeed, the concentration is minimal during oestrus (0.2 to 0.3 ng/ml) and increases progressively during the 3rd and 4th cycle days to reach a maximum (6 ng/ml) at the 7th day to be maintained until the 14th -15th days, to drop sharply further due to the luteolysis of the yellow body induced by F2 prostaglandin. If the ewe is gestating, the progesterone plasmatic profile is maintained throughout the period analyzed (**Figure 16**).

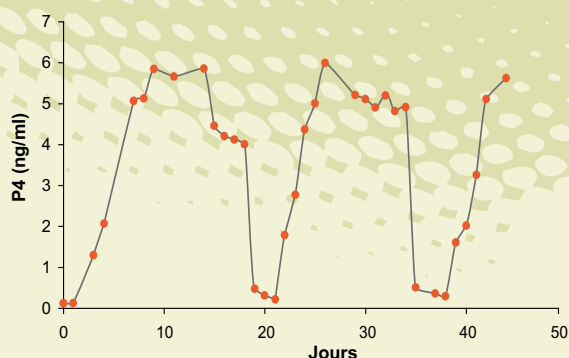


Figure 15: Average plasmatic profile in P4 at empty Boujaad ewes.

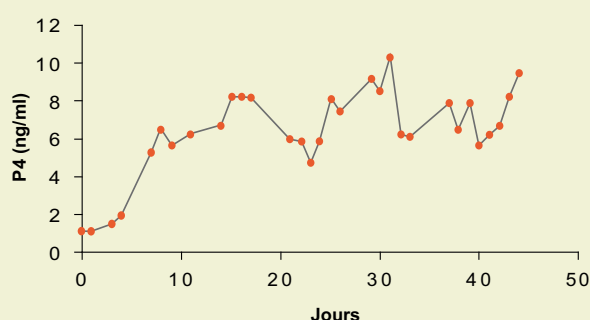


Figure 16: Plasmatic profile in P4 at a gestating Boujaad ewe.

Furthermore, the results of follicular dynamics showed that pure Boujaad ewes rarely give two ovules, even in induced oestrus at doses of 200 and 400 IU of PMSG.

For Boujaad male lamb, the study of the season effect on testicular parameters and sperm production along with the effect of two diluents (milk vs. Tris/yolk), of temperature (4°C and 37°C), and of storage time on sperm mobility was performed. The results showed that it is possible to preserve semen for a longer period while keeping good spermatozoid mobility.

In the diagnosis study of pregnancy and reproduction monitoring, Proteins Associated to Gestation (PAGs) were tested by radio-immunoanalysis (RIA), by Ouchterlony technique and by the Western blot on 'D'man x Boujaad' crossbreed ewes at Deroua station during gestation and three weeks before post-partum. The aim was to compare these techniques and choose the simplest one to implement in Moroccan laboratories for early gestation diagnosis. The results showed that only RIA systems are capable to detect PAGs low concentrations. In addition, even samples rich in PAGs (after RIA dosing) revealed no positive reactions either in Ouchterlony or in Western blots.

HEAT SYNCHRONIZATION OF NORTH GOATS

The study of heat synchronization and of reproduction stimulation during seasonal anoestrus period by the vaginal sponges method

vs. the IMA-PRO2 method led to the conclusion that the use of FGA and IMA PRO2 treatments is efficient for the stimulation and the synchronization of heat and of ovules at seasonal anoestrus period for the local goat of the North. The FGA treatment allows a more important and precocious response of goats, and the use of a dose of 450 UI of eCG at the multipara is considered necessary.

CHARACTERIZATION OF MAIZE SILAGE IN THREE REGIONS OF MOROCCO

Diagnosis work of the quality of maize silage in three regions of Morocco (Gharb, Loukkos and Tadla) showed a low mastering of the silo technique for maize silage by livestock farmers. In fact, silos show a high temperature along with decomposition. Similarly, storage of maize forage in plastic bags is practised in 75% of the cases at random. However, no difference in silage practices in the region was observed. The study also showed the emergence of two maize silage forms: one devoted to dairy farms, and the other to bovine and ovine fattening. This latter category deals with maize forage cut late (45-50% MS). The results of the chemical analysis of silage are reported in **Table 3**.

Table 3. Characteristics of maize silage in 3 regions of Morocco.

	Regions		
	Tadla	Gharb	Loukos
MS (%)	27,9	29,1	37
PH	3,7	-	4,4
NH3	10,1	12,3	7,7
Starch	161	235	115
MAT	5,9	7,0	6,2

The microbiological analysis showed a total of 500 purified isolates collected in the three areas studied. Tadla isolates showed a hetero-fermentation predominance (fermenting sugars mainly with CO₂), those of the Gharb showed a homo-fermentation predominance (fermenting sugars mainly to lactic acid), and Loukkos isolates showing the two characteristics. However, silage from Tadla reflects a lower fermentation quality compared to silage from the Gharb.

Moreover, the study of the effect of incorporating cactus rackets as alternative to straw in four diets for ewes on water quantity drunk was achieved. The results showed a significant effect of the incorporation of cactus rackets on the amount of water drunk. Animals with diets without cactus drank a high water volume (2.22 litres). Those receiving 75% of cactus rackets drank only 0.92 litres. The contribution of cactus rackets in the total water taken by the animals was 81.62, 66.67 and 44.78% for diets 75, 50 and 25%, respectively (**Table 4**).

Table 4: Water consumption per ewe and weight gain according to cactus incorporation rate in diets

Cactus incorporation rate in intake (%)	Water volume drunk per day (Litres)	Cactus contribution in total water drunk per day (%)	Average daily gain (g/d)
0	2,22 a	-	75
25	1,77 b	44,78 c	87
50	1,38 c	66,67 b	87
75	0,92 d	81,62 a	70

PROFITABILITY STUDY OF GOAT BREEDING IN THE NORTH

The economic analysis of the goat cheese channel in the north region showed that the profitability per goat improves significantly by integrating processing and production activities of milk into cheese in the farm. In fact, profitability per goat goes from 15 DH for goat breeders producing meat without supplements to 890 DH for goat breeders farm cheese producing. Similarly, the economic analysis of the goats' channel showed that the production of goat meat without supplements is a secondary activity that does not improve the income, which is only 1%; while goat meat production with supplements, dominant in the region, contributes to 67% in farmers' income.

The conclusion is that goat for milk production, especially cheese, generates income to meet consumption needs and farmers budget. Thus, home-made cheese generates a significant added value of 1120 DH/goat, industrial cheese production generates 680 DH/goat, and traditional cheese production generates some added value of 500 DH/goat.

VALORISATION OF GOAT MILK IN THE OASES OF SOUTH-EASTERN MOROCCO

The incorporation of essential oils of thyme, rosemary and myrtle on the physicochemical, microbiological and sensory characteristics of semi-refined goat cheese was performed. The results showed that the pH and the acidity were influenced by the supply of essential oils with an acidity decrease from 225.86°D to 176.57°D. The presence of essential oils also led to a significant reduction of microbial flora in flavoured cheese vs.

control. Indeed, inhibition of unwanted germs, yeasts and mould, was observed in flavoured cheese at the first week. On the sensory level, plain cheese was the one mostly preferred; among the flavoured cheeses, the one with myrtle seemed to be the least appreciated.

The chemical composition of Draa goat milk is slightly superior to that of the Alpine breed, ie., 13.9 vs 12.3% DM (**Figure 17**). Draa goat milk and cheese have higher rates in protein, suggesting the hypothesis of a better cheese ability of Draa breed milk.

The sensory study of cheese in four cooperatives in Ouarzazate showed that the difference is most evident between fresh goat cheese of Alpine breed and Draa breed. In fact, consumer preference was for cheese made from mixed milk (goat + cow) and from milk of the Alpine breed.

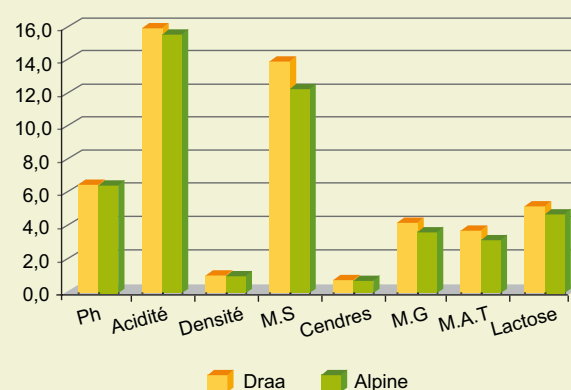


Figure 17: Chemical composition of goat milk.

BIOMASS EVALUATION FOR FOREST-PASTORAL AREAS IN NORTHERN MOROCCO

With the aim of improving the management system in forest-pastoral areas, quantitative and qualitative evaluation study of the vegetation of a pastoral land in Chefchaouen region was achieved in the forest station of Ain Rami region dominated by oak wooded stratum (*Quercus suber*).

The results showed that this region is characterized by rich and very important flora. The highest biomass production was recorded at an area with dense wooded stratum (4753 kg DM/ha) followed by a moderately dense area (2280 kg DM/ha). However, overgrazing, lack of organization among the users of pastoral land and the abusive exploitation of forest resources are factors responsible for the low biomass production and the low recovery observed in clear areas. The biomass produced in the latter areas do not exceed 1100 kg DM/ha, with a maximum recovery of 40% at the clear zone.

SOCIO-ECONOMICS

PERCEPTIONS OF ACTORS AND OF AGGREGATION CONCEPT IN THE HEART OF AGRO-SOCIO-ECONOMICS RESEARCH: CASE OF MEKNÈS-TAFILALET REGION

Research results show that the conversion of cereals production to high-added value farming is a goal highly valued by the different actors, provided that the mechanisms of implementation and realization are clarified. These should take into account the constraints inherent in 'crop-livestock integration, and the management of the transition period namely the compensation of non-production periods and in the case of fruit-trees planting.

Actors' perceptions of the Green Morocco Plan are mixed: potential aggregators, from their side, focus on defining the roles and responsibilities of each one directly involved (State - aggregators – agrégés) in pre-financing, supervision and accountability, and, in the other side, the 'agrégés', express their fears in terms of win win collaboration guarantees.

IRRIGATION WATER MANAGEMENT

By adopting an approach based on nonlinear optimization techniques, researchers have developed a hydrological and economic model (river basin model) for the use of water resources in order to maximize net farm income while taking into account hydrological, agronomic and

resources availability constraints at the Souss-Massa basin. The results show that the average marginal value of irrigation water use is 1983 dirham per cubic meter. This means that if we increase water use by a unit equivalent to 1m³, the «objective function» which represents the agricultural profit, will increase by 1983 DH.

PROFITABILITY OF FORAGE CROPS IN THE NORTH

The evaluation of the technical process for oats and triticale crops recommended by researchers and applied by farmers in two villages in the region of Chefchaouen, showed that beneficiaries margins (BM) showed a clear improvement:

Locality	Oat (DH/Ha)			Triticale (DH/Ha)		
	MB initial	MB improved	Difference	MB initial	MB improved	Difference
Ain Beida	7795	13200	+70%	4861	5650	20%
Dardara	2195	8150	+70%	3995	5899	50%

ADAPTATION OF RURAL WOMEN TO CLIMATE CHANGE

Workshops in favour of women at Lamzoudia (Chichaoua) showed women's role as bearers of livelihood means and solutions to confront the devastating impacts of droughts, and their contributions to the collective adaptation effort both at home and at the communities levels.

RESEARCH AND DEVELOPMENT

RESEARCH ACHIEVEMENTS FOR FARMERS

Potato optimal irrigation management

Potato irrigation reduced to 60% ETC according to the following distribution: 64mm during 30 days after planting (1.7 mm/d), 104mm for the following 32 days (3.25 mm/d), and then 39.42 mm the next 29 days (1.35 mm/d) and 24.28 mm for 23 days before maturity (1.05 mm/d), led to important yields of 41 t/ha and a better distribution of tuber size.

Adaptation of rural communities to climate change

The experiment conducted with the participation of the populations at the watershed of "Asgherkiss", Ait Baha region, showed that rackets of cactus ecotypes planted have experienced a good recovery, which will encourage the population to plant more and, hence, limit the small dam silting.

Similarly, the introduction of drip irrigation through two trials at two "Douars" in the mountainous area of Ait Baha for potatoes, tomatoes, turnips and saffron allowed water use efficiency of approximately 100%. It also helped limit water loss through evaporation, reduce irrigation time and control crop needs. In the case of potatoes, for example, a water economy of 35% was recorded in addition to improved yield of 100% and an almost total control of weeds.



Visits of demonstration trials

Introduction of new food legumes varieties

Lentils in Ouazzane region

Results show farmers preference to grow Bakria or Chaouia varieties in arison to Bichette variety although it has reached good yields in Ouazzane region compared to Khénichat. Thid preference is due to date of maturity which helped avoid drought risk (**Table 5**).

Table 5: Performance of four lentil varieties in Ouazzane region.

	Aabda	Bichette	Chaouia	Bakria	Moyenne
Yield (q/ha) in Ouazzane (2008-2009)	9	13	10	10	10.5
Yield (q/ha) at Khénichat (2008-2009)	18	16,3	23	25	20,5



Growth stage of tested lentils

Chickpea in Ouazzane region

The purpose of this trial is the introduction of a new late chickpea variety «Mazouzia» in the region of Ouazzane for the diversification of crops and plant materiel and the improvement of yields. The results show that this variety yielded 14 q/ha while the local average is only 6 q/ha, i.e., an increase of about 133%.



Growth stage of tested chickpea

Demonstration trials

These trials aimed at demonstrating to development partners different durum wheat, wheat, barley, triticale, oats, vetch, chickpea, lentils and peas varieties at the experimental fields of Sidi El Aydi, Khemis Zemamra and Jemaa Shaïm. Among the 17 varieties of wheat tested, the best yields were obtained at Khemis Zemamra using Salama and Arrihane for which the grain yields exceeded 5 t/ha (Figure 18).

Technology transfer and capacity building

During the year 2009, INRA organized more than 170 technology transfer days, field days, training, information, team coordination and awareness-raising sessions on more than 70 topics covering various INRA technologies and achievements. These have benefited to more than 3,500 people including managers and technicians of the "Direction Régionale d'Agriculture" (DRA), agricultural cooperatives and associations, farmers, sons of farmers and rural women.

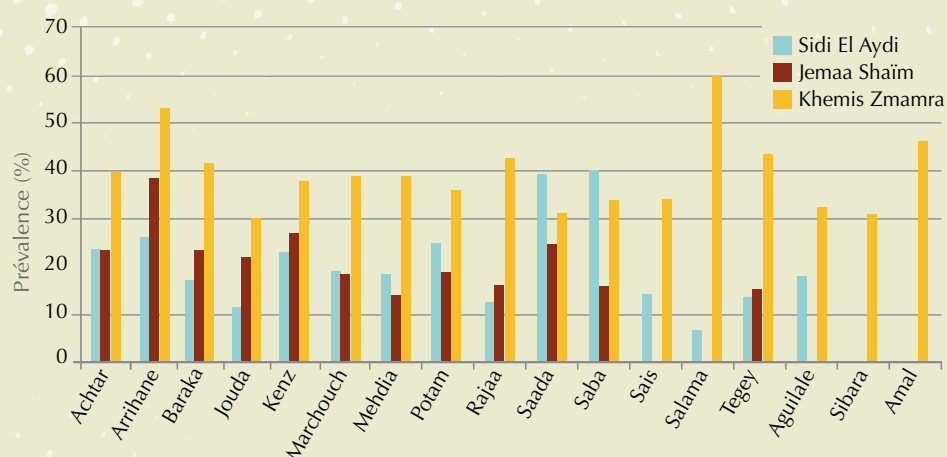


Figure 18: Wheat yield in three experimental stations, CRRA Settlat, 2008-2009 season.

COOPERATION

At the international level, INRA continues to expand its partnership with **ICARDA** in the areas of integrated pest management (IPM), conservation of genetic resources, rangeland management, goat farming and cheese production, and integrated management of natural resources. Also, with the FAO through training scientists from Saudia Arabia on Bayoud disease on date palm; with the IAEA by organizing an international course on molecular analysis and introduction of bioinformatics for researchers (15) from different African countries; with the IOC on the conservation of genetic resources, the study of olive oil composition and variety identification.

At the regional level, collaborative programmes were strengthened with **ACSAD** (exchange of visits, implementation of the Memorandum of Understanding signed between both institutions); with **AOAD** (date palm, rangeland); wit the **AAAI** (no-till); with **IDRC** (water management, adaptation to climate change, impact of small dams, participatory management of rangelands...) and with **UMA** (INRA hosting the 10th Session of the Maghreb Agricultural Research, Training and Extension Authority).

Bilateral cooperation with countries from Europe and America: a delegation of U.S. Department of Energy visited the irradiator at the Ionization Station of Boukhalef SIBO to identify and assess needs in terms of equipment and training.

Also, a Memorandum of Understanding with the Instituto Nacional de Tecnologia Agropecuaria (INTA) of Argentina was signed to develop research in the fields of agricultural mechanization, no-till technology, animal husbandry and health, dryland and desert development, plant and animal genetics and biotechnology.



INTA delegation (Brazil) visiting INRA.

Brazil: two representatives from EMBRAPA visited INRA, and a draft Memorandum of Agreement between INRA and the Brazilian institution is being finalized.

INRA prepared a draft Agreement of Cooperation with the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Mexican United States.

France: 13 PRAD are in progress, related to various research areas (plant protection, plant breeding, biotechnology, animal production).

A French delegation (CIRAD-INRA France) visited INRA Morocco. Exchanges of visits between managers from INRA France and INRA Morocco have taken place.

Spain: two research projects on ICT and olive were selected for funding by the Joint Inter University Committee Morocco-Spain.

Andalusia: launching of a project entitled: «Evaluation de l'opportunité du croisement des caprins locaux du Nord du Maroc avec la race Andalouse Payoya».

Catalonia: a delegation from the Research and Food Technology Institute (IRTA), Catalonia, visited INRA to develop research projects in the areas of goat farming and fruit trees.

Other collaborative projects are in progress with the universities of Zaragoza and Sevilla dealing with goats from northern Morocco.

INRA continues its collaboration with Belgium especially with the Walloon region through a project entitled «Study of the genetic diversity of the argan tree of Morocco» and a project FRAB «Etude du capital de production de l'élevage caprin du Nord du Maroc et proposition de voies de développement durable».

Collaboration continues also in the areas of goat breeding and goat cheese.

With **Hungary**, INRA has prepared a proposal in collaboration with a Hungarian team from the Faculty of Veterinary Medicine, Üll University, Hungary, entitled «Use of assisted reproductive practices for improving production of Boujaâd sheep breed».

South - South cooperation: relations between INRA and the African countries are characterized by the desire of both parties to develop south - south cooperation and collaboration for the development of agriculture in Africa. This is through the dissemination of its expertise in agricultural research and supervision (consultancy). Case of Djibouti: Assistance for the introduction and development of date palm was given by INRA.

With Egypt: Sixth session of the Morocco-Egyptian agriculture commission: common research areas were identified dealing with: genetic improvement, biotechnology, crop protection, technology transfer and training.



Egyptian delegation visiting INRA to strengthen cooperation links.

The Experimental field of Merchouch was visited by a delegation from **Mali** interested in research on soil fertility management.

A delegation from the Centre for Research in Citrus CERAGRU, **Democratic Republic of Congo**, visited INRA to be informed about the progress made in citrus research.

On the other hand, an INRA researcher went on a mission to **Mauritania** for the creation of a laboratory for early detection of Bayoud (Requested by AODA).

Regarding the cooperation with other countries, INRA continues to receive **Japanese** senior volunteers in various areas including: Plant pathology, pesticide and disease control, management of rangelands and resources.

Saudi Arabia: a technical cooperation agreement was signed with the Saudi Ministry of Agriculture, concerning training and exchange of expertise in: Oasis, development of date palm, control of date palm diseases, development of olive farming and livestock production (camel breeding) and the development and management of rangelands.

INRA has also received the visit of an Indonesian delegation led by the Indonesian Minister of Agriculture, and a Jordanian delegation headed by the Jordanian Minister of Agriculture.

INRA is also working to develop other partnerships and alliances, In this context, a Chinese delegation visited INRA and new opportunities of collaboration were discussed with the Chinese institute of Research and Teaching through UNEP.

At the national level, INRA develops partnership with various institutions.

With the Ministry of agriculture (MAPM), 18 PROFERD related to various research areas (plant

protection, genetic improvement, development, water management, tree breeding, biotechnology, crop production, animal production, medicinal and aromatic plants (PAM) and local products) are undergoing.

With ORMVAs, agreements were signed and include the completion of demonstration tests on various crops, the introduction of new crops and the demonstration of good practices for rangeland rehabilitation in mountain areas, strengthening decentralized research and technical assistance.

Other agreements were signed with the DPAs (Directions Provinciales d'Agriculture) and DRAs (Directions Régionales d'Agriculture) aiming at the dissemination of decentralized research achievements and development of products such as cactus, fodder crops and milk goats and cows in northern Morocco.

To diversify partners, INRA is working with: CNESTEN, to develop a local system of caprine progesterone dose by RIA technique; and the **Agency of the South**, for the improvement of ovine and goat productivity in the South of Morocco.

During SIAM, INRA signed six agreements with:

- The Agency for Agricultural Development (ADA) in the areas of research and development, technology transfer through commonly defined concrete programmes to be integrated into the objectives of the Green Morocco Plan;
- IAV Hassan II, ENA Meknes and ENFI Salé to develop scientific knowledge and ensure the training of future managers, researchers and lecturers;
- COMADER, for cooperation in research and development, technology transfer, production of seeds and seedlings, and improvement of food quality;
- SONACOS, for research & development in plant breeding and variety development;
- OMPIC, for promoting technological patents;
- DMN (Direction de la Météorologie Nationale) for the realization of research and development projects in agro-meteorology.

Other agreements were signed this year with:

- Office de Commercialisation et d'Exportation (OCE) for assistance in setting up aggregation plans;
- SONACOS for the implementation of the Partnership Agreement by setting up seed and fertilizer storage sites ;
- **Ministère de l'Industrie, du Commerce et des Nouvelles Technologies** in technology transfer and research enhancement regarding food industry;
- **Direction de l'Aménagement du Territoire;**
- PNUD, Convention for technical assistance in agricultural research for the implementation of a sustainable territorial development programme in Tafilalet oases POT;
- **Agence pour la Promotion et le Développement Economique et Social des Provinces du Sud du Royaume**, development of aromatic, medicinal, and tinctorial plants in Laayoune, Boujdour and Es-Smara.

COMMUNICATION



AL AWAMIA number 120 edited, and N° 121 is under press.



Le feu bactérien des rosacées fruitières à pépins.
(Available in Arabic and French).



Productivité et qualité des agneaux et de la viande dans le croisement de la race ovine Texel belge au Maroc, by Dr. Moussa El Fadili.



Amélioration génétique du blé tendre au Maroc à l'aube du 21ème siècle, by Dr Mohammed Jlibene.



INRA Activity Report 2008.
(Also available in Arabic, French and English).



Apple
(*Malus domestica* Borkh).



Almond (*Prunus amygdalus* miller).



INRA Institutional Brochure
(Also available in Arabic, French and English).

Communication tools : Calendar and Greetings Card 2010



Calendar : New 2010 calendar focuses on technologies developed by INRA for crops according to farming campaign.



Greetings card 2010: new INRA greeting card was widely distributed both locally and abroad.



Internal Newsletter :

A monthly newsletter was set and dispatched in order to strengthen internal communication.



DIC also edited several communication media such as leaflets, posters, shirts, etc...



During 2009 intense activity in scientific and technical publication, many activities related to various events and press media were witnessed. The following figures illustrate these activities (**Figures 19 to 25**).

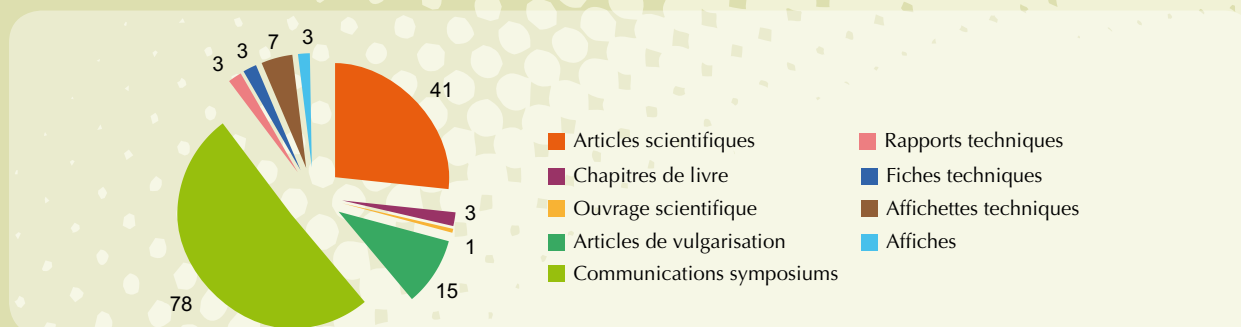


Figure 19 : Scientific and technical publications

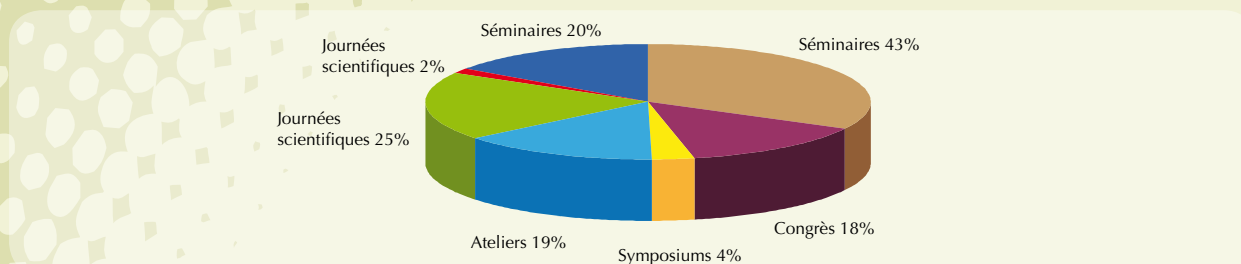


Figure 20 : Scientific and technical events

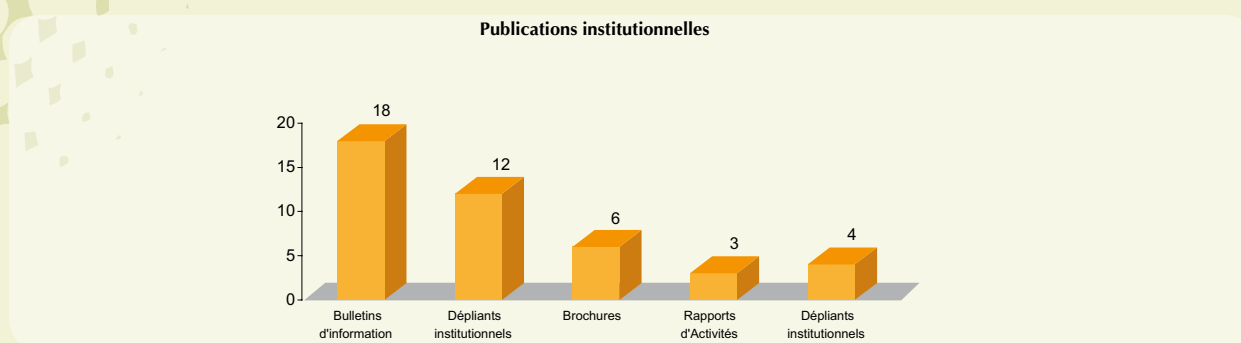


Figure 21 : Institutional publications

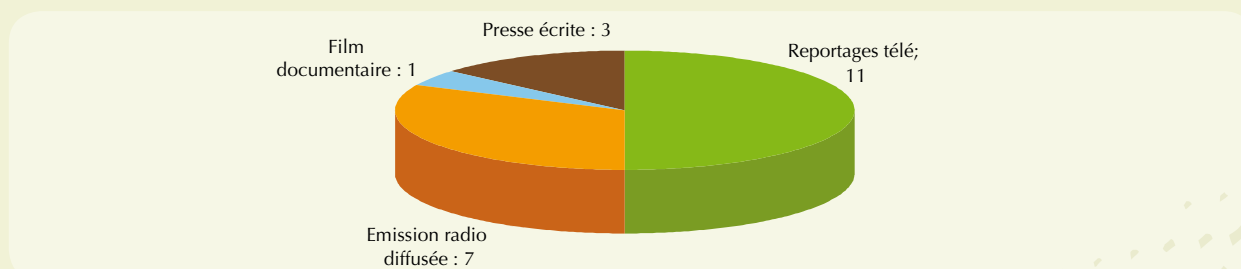


Figure 22 : Press and Media

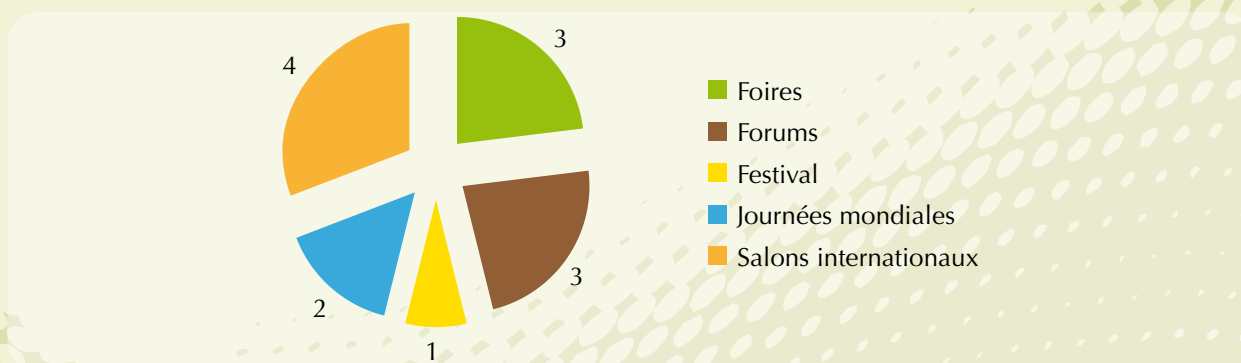


Figure 23 : Exhibitions and fairs

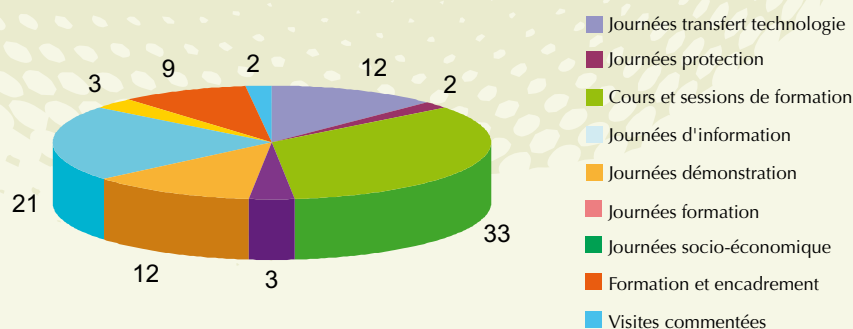


Figure 24 : Information days

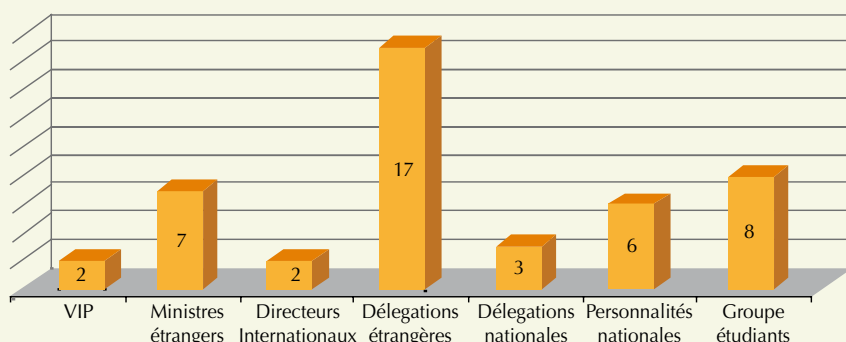


Figure 25 : Visits

Documents are managed through acquisition and processing of documentation. Thus, the central library received in 2009 about 64 books and 47 journal issues.

Concerning the exchange, AL AWAMIA number 120 was sent to 28 national and foreign institutions as follows: 16 countries, 4 in the USA, 17 from Europe, 4 from America and 3 from Africa with 1 from Morocco. The Documentation Service received in return the documents published by these institutions, and others from the Central Library.

INRA WEBSITE UPDATED: A MONITORING INFORMATION TOOL

A monitoring tool to serve INRA managers in their search for information was set. This tool "a bulletin" has reached its 32nd number and is issued weekly. Two numbers "INRA Special" are programmed every six months.

SUPPORT TO RESEARCHERS: DOCUMENTARY RESEARCH

Database on CD-ROM and access to local database: over 320 bibliographical search in different agricultural related fields.

INRA WEBSITE

A new INRA portal was set up. It integrates the institution's chart with a new design. Regarding maintenance, the GPP management tool allows a level of decentralized updatings. On the content level, the new site integrates the five main categories already presented in the old site in addition to forum modules, webmail, multimedia space and dynamic agenda. The integrated organizational chart shows visiting cards of INRA managers. Furthermore, the new portal integrates a new space for the regional centres. The data contained in it are complementary to those of the central site, but, are specific to each centre.



MANAGEMENT OF HUMAN AND FINANCIAL RESOURCES

HUMAN RESOURCES

Recruitment

- 12 job opportunities and positions were released according to recruitment policy.. These consist in recruiting eight (08) researchers (Chargé de Recherche A), and four (04) Technicians.

Promotion

- 127 agents promoted according to the Managerial Staff Law 2009;
 - 8 agents promoted in their origin administration;
 - 119 agents promoted internally in INRA.

The number of promoted agents is 10% of the total number of INRA staff for the year 2009.

Voluntary redundancy

- 211 departure cases in 2009, as indicated in the following:
 - 166 voluntary redundancy;
 - 38 retirements due to age;

- 6 deaths
- 1 resignation

INRA staff number in 2009 went from 1296 to 1102, a 15% reduction.

Civil servant status

Amendment n°8/2009 of INRA particular Civil Servant Status was approved. It deals with the extension of decree n°2.08.340 of Rajab 5th, 1429 (July 9th, 2008) modifying and completing decree n°2.04.403 of Chawal 29th, 1426 (December 2nd, 2005) concerning the promotion conditions of the State's staff.

Training: a strategic goal of the institution

Diploma training

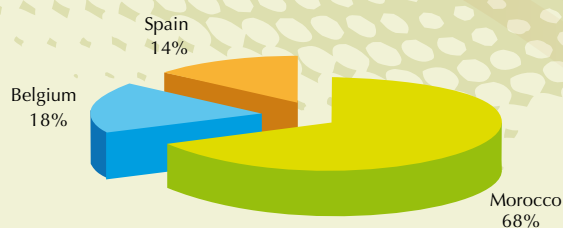
28 agents took diploma training, 17 of them newly enrolled.

Researchers enrolled in Belgium follow their training according to a mixed formula. The theoretical part is taking place in Belgium and research in Morocco (**Table 6**).

Table 6 : Repartition of diploma training

	Ph.D	Master	1st year of Licence	Licence	Total	Financing
In Morocco						
F.S.T.Marrakech	3					
F.Sc.Kénitra	7	2				Without
F.Sc. Meknès	1					Without
F. Droit Settat			1			Without
F. Droit Rabat				1		Without
F. Droit Meknès				1		Without
F.S.T. Settat				1		Without
F. Sc. Semlalia	3					Without
Abroad						
Belgium	4	1				Belgium cooperation
Spain	1	3				CIHEAM/IAMZ
Total	19	6	1	3	29	

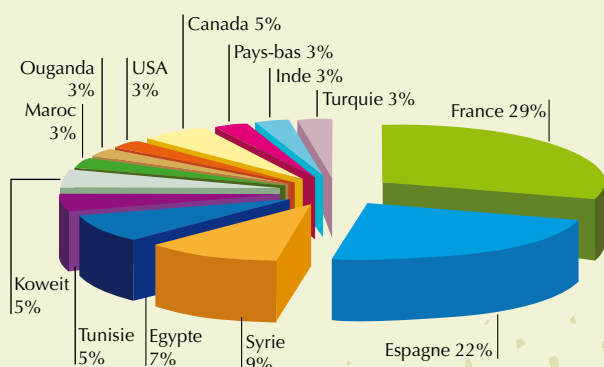
Distribution of diploma training by host country



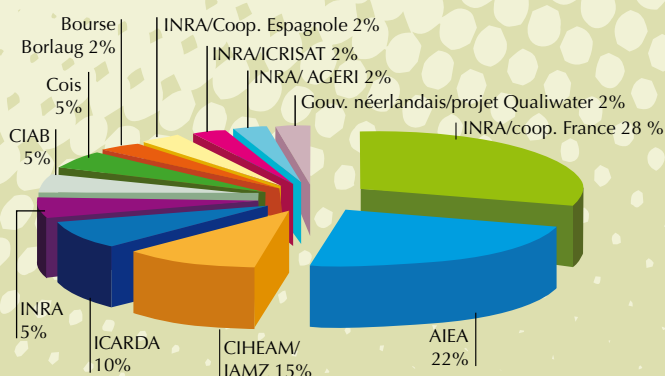
Training courses abroad

In total, 41 training courses in favour of 38 INRA agents, 33 of them are researchers and 5 Technicians. These training courses are given according to host country and financial support:

Training courses according to host country



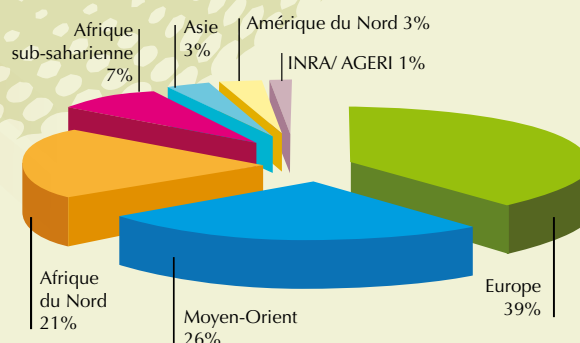
Distribution of training courses by organization or international institution



Missions and participation to scientific events

In total, 87 agents, managers and researchers went on 140 missions in 28 countries to take part to meetings, cooperation project workshops, conferences, international and regional events dealing with subjects of interest to INRA.

Missions according to destination



Training

All INRA staff categories were targeted. The training concerned mainly: Audit and Management Control, Accounting, Geographical Information Systems, Bio-informatics, Biotechnology, Foreign languages, and Computer Sciences.

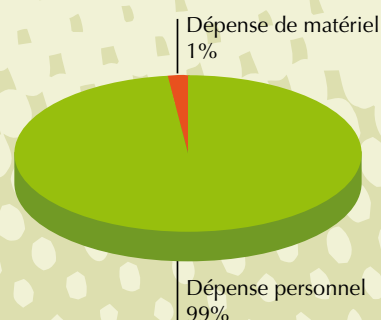
Financial resources

Operating budget:

171,653,357.00 Dh divided as follows:

- Staff expenses : 169,192,930.00 Dh
- Material expenses : 2,460,427.00 Dh

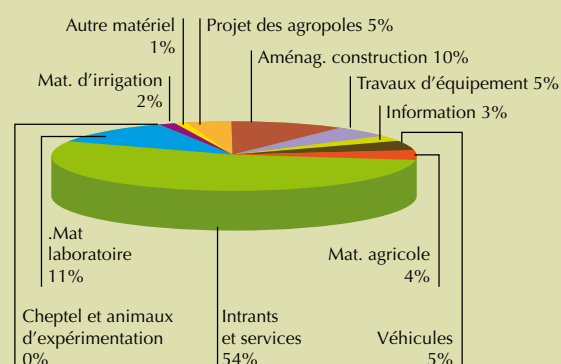
Repartition of Operating Budget



• Capital budget : 80,889,656 Dh divided as follows :

- Mission assistance : 27,282,763 Dh
- Central administration : 13,645,000 Dh
- Regional centres : 39,961,893 Dh

Distribution of Capital Budget according to accomplished operations



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المعهد الوطني للبحث الزراعي
Institut National de la Recherche Agronomique

Avenue de la Victoire,
BP: 415 Rabat Principal - Maroc
Tél. : 00 212 537 770 955 / 772 642
Fax : 00 212 537 770 049 / 777 355

www.inra.org.ma