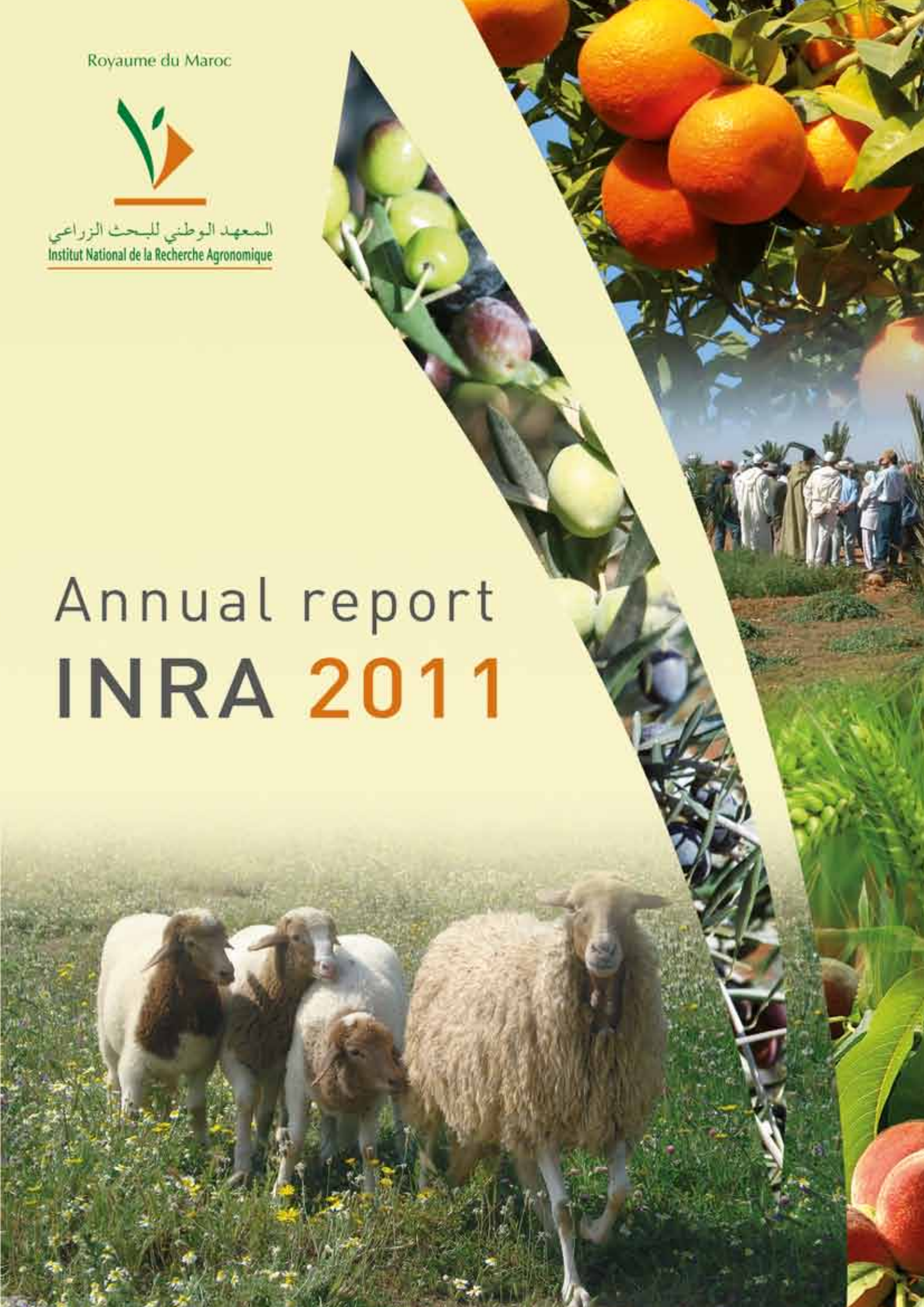
Royaume du Maroc

المعهد الوطني للبحث الزراعي
Institut National de la Recherche Agronomique

Annual report
INRA 2011



His Majesty King Mohammed VI, May God Assist Him

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Foreword

The year 2011 will be engraved in golden letters in the history of our institution. This is a special and particular year. His Majesty King Mohammed VI has wanted to surround the institution, and through it the national agricultural research system, with his great Royal solicitude.

Tribute to our institution has been paid by the actual and official inauguration by his Majesty King Mohammed VI of the new National Laboratory of Date Palm Tissue Culture in the Regional Centre of Agricultural Research of Errachidia. This event places the date palm at the Morocco Green Plan concerns and positions the INRA as a key player in the upgrading of this sector and in the process of moroccan palm grove regeneration.

On this occasion, we had the great honour to present to his Majesty the King «The Atlas of Date Palm in Morocco», a book richly illustrated and commented, bringing together the most national research achievements, the main existing date palm varieties and a brief guide on cutivation of date palm orchards.

Another sign of this high concern is the Royal visit to the INRA exhibition stand, on the occasion of the 2011 edition of the International Date Palm Exhibition (SIDATTES) in Erfoud, when His Majesty the King inquired about the progress of INRA date palm research. The INRA participation was focused on new varieties developed by our institute, some of which are resistant to the Bayoud disease and will be multiplied in INRA tissue culture laboratories.

The year 2011 was no exception to the rule of INRA researchers tireless effort and flourishing result in crop breeding, the spearhead of agricultural science, with the selection and registration of several new varieties of date palm, citrus, fruit trees and the creation of new synthetic sheep breeds.

During 2011, INRA has strengthened its partnership, leveraging its expertise at the service of the profession and the agricultural development. The model of partnership and complementarity is amply illustrated by the close and fruitful collaboration between INRA and ANDZOA (The National Agency for development of Oasis areas and the argan tree), particularly in the organization of the SIDATTES Erfoud, the organization of the first International Congress on the argan tree and the edition of the first Atlas of Date Palm in Morocco.

Sharing knowledge and technologies with the public underpins our communication to reach all user categories through the online and digitized thematic databases to support decision making, namely the maps soil fertility, conducted in the partnership agreement framework between the Ministry of Agriculture and Fisheries and OCP Group (Office Chérifien des Phosphate). This program is implemented by joint teams of the consortium INRA, IAV Hassan II and ENA Meknès.

To claim the achievements of agricultural sciences research and provide widespread access to scientific resources held by the major information producers, our institution has tuned itself to the new information and communication technologies by the on line and full text AGORA access agreements. This data base set up by FAO, contain 1900 specialised journals in agriculture.

The year 2011 has also seen the launch of a major social housing project at the INRA experimental station El Koudia for the benefit of our staff. This project had the approval of the Board of INRA. It represents for us a social success in recognition of the efforts made by all categories of the institute staff.

Prof. Mohamed BADRAOUI
Director of INRA

HIGHLIGHTS AND MEMORABLE EVENTS 2011

Royal inauguration of the National Laboratory of date palm tissue culture

The inauguration by his Majesty King Mohammed VI of the national laboratory of date palm tissue culture

The new national laboratory of *in vitro* culture of date palm in INRA-Errachidia was officially launched by his Majesty King Mohammed VI. Its primary vocation is the preparation of budding strains necessary for the production of vitroplants by accredited multiplication laboratories. With a production capacity of 40,000 strains, this laboratory will contribute to the regeneration of the Moroccan date palm Grove together with the INRA-Marrakesh laboratory with its production capacity of 20,000 strains annually.

Morocco's date palm Atlas presented to his Majesty King Mohammed VI

The Director of INRA offering a copy of the Morocco's date palm Atlas to his Majesty King Mohammed VI

Developed jointly by the INRA and the ANDZOA, the Morocco's date palm Atlas, that contains 200 illustrated pages, brings together the essential information on the Moroccan date palm chain, the major moroccan date palm varieties and a comprehensive guide for the establishment and management of date palm orchards.

INRA at the SIDATTES Erfoud 2011

Focused on new date palm varieties, the INRA exhibition stand at the 2nd Edition of SIDATTES was honoured by the Royal visit when his Majesty inquired about the INRA research progress on the date palm chain within the framework of the Morocco Green Plan. The INRA exhibition stand showed first good quality date varieties having confirmed resistance to the Bayoud.

Photo of the assistance to the scientific conference on date palm (SIDATTES 2011)

INRA at the SIAM 2011

The INRA participation to the 5th edition of the International Exhibition of Agriculture in Morocco (SIAM) was crowned by the royal visit to the INRA stand. At this exhibition, the following events were committed:

- The presentation of posters on INRA achievements in plant and animal production, plant protection, and newly released varieties.
- Remote video conferencing on technical themes: cereals harvesting methods and post harvest technology, the olive chain, the date palm chain and date valorisation.
- Presentation of soil fertility maps at the OCP group exhibition stand to his Majesty the King with the presence of the Minister of Agriculture and Fisheries and the President of the OCP Group. These maps have received special attention from many visitors because of the multiple benefits they provide for our agriculture.
- Dispensing and sharing information with visitors of the INRA stand by a pleiad of researchers during the whole period of the SIAM.

A model of partnership for knowledge sharing: INRA/Consortium-OCP

Knowledge sharing underlies the INRA communication action to reach all users categories, by implementing online soil fertility maps, a tool for decision-making in close collaboration with the Cherifian Office of Phosphates (OCP group). A new type of collaboration sanctioned by a supra-national cooperation between Morocco and India.

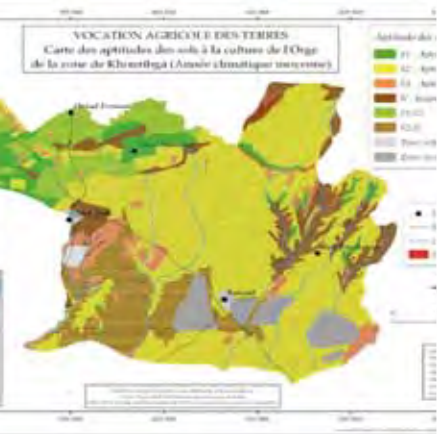
His Majesty the King enquiring about the fertility soil maps project

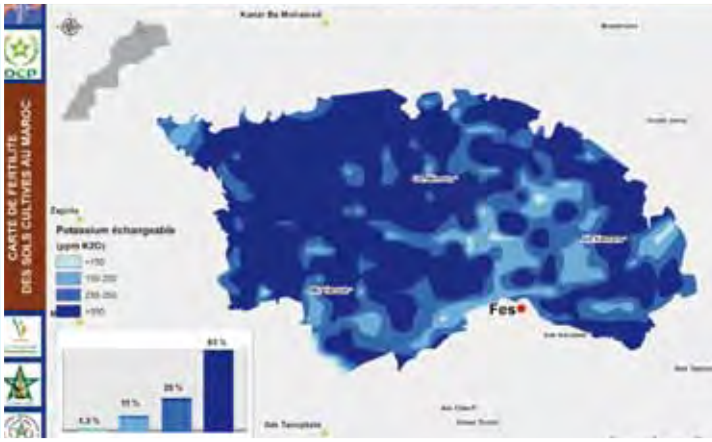
Full access to the AGORA program

To assert achievements of agricultural science research and allow access to scientific resources, our institution is agreed to AGORA online and full text access (Access to Global Online Research in Agriculture) implemented by FAO. Among other things, this action allows to share knowledge among institutional and para institutional organizations with 1900 specialized journals, and several databases.

Social action : El Koudia housing project

It is the housing project in the experimental station El Koudia for the benefit of the INRA staff. This project has been submitted and approved by the last INRA administration Council, a first event in the annals of our institution which will allow its staff to possos of land lots to build decent housing.





ENVIRONMENT AND NATURAL RESOURCES

Agricultural soil fertility maps in Morocco

In the agreement signed between the OCP group, the MAPM and INRA in 2010, the project of «Agricultural Soil Fertility Maps in Morocco» is part of the Green Morocco Plan (PMV). Established by the consortium INRA, IAV HassanII and ENA Meknes, the main objective of this project is a better knowledge of the soil fertility in Morocco (8.7 million ha) in view of better crop fertilization reasoning.

The first year results are presented below by component:

1. All available rainfed areas soil maps were compiled on GIS and installed in the GIS-Web program, a total area of about 6 million hectares. This area represents approximately 68% of the overall area in the convention (Figure 1).

2. The first year of the project concerned 6 agricultural regions in Morocco: Fez, Meknes, El Hajeb, Khemisset, Rabat and Settat, covering an area of 2.025.300 ha. 11.943 soil samples were collected. Soil analyses have shown the following trends:

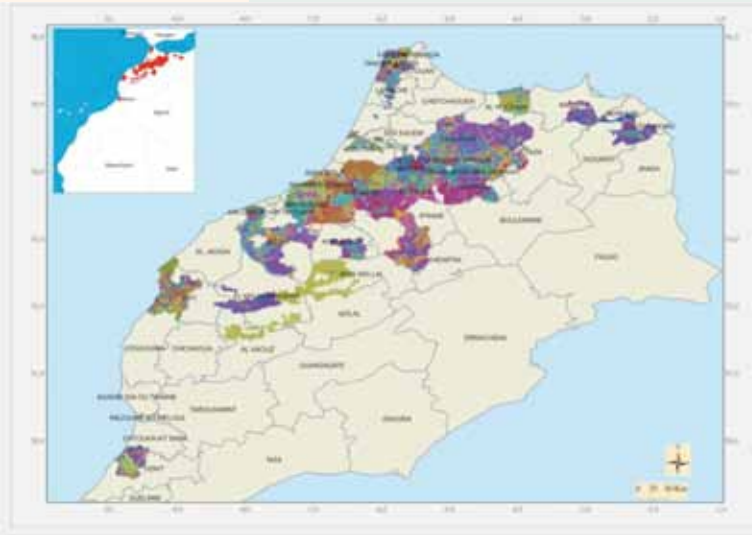


Figure 1: Location map of 22 compiled areas

- The regions of Fez and Meknes are dominated by soils with basic pH, followed by El Hajeb and Settat, with proportions of soil pH neutral to slightly basic most important. By cons, the regions of Rabat and Khémisset, are rather dominated by soil pH slightly acidic to neutral because of the importance of light textured soils.
- Throughout the six regions, organic matter content is low to moderate.
- In General, more than two thirds of the studied areas are poor soils in assimilable phosphorus.
- In General, soils are moderately rich in exchangeable potassium, except Khemisset and Rabat areas that are poor soils in this element.
- During the first year, 34 soil calibration trials for the determination of soil fertility standards and crop fertilization have been installed in six major areas and for 15 crops. The results of these trials are under interpretation and will be presented in the report of the second year.

3. Regional medium formulas are proposed taking into account fertility soil condition (Table 1). These formulas can be used by farmers who did not use soil analysis of their plots.

For farmers who require more specific recommendations, the Computing Solution (expert system) developed and placed under Web can be used.

4. For areas not covered by pedologic studies (Tetuan, Al Hoceima, Nador, Khémisset, Beni Mellal, El Kelâa Sraghna and Agadir), exploration plans have been prepared for their mapping. These areas cover approximately 1.27 million hectares. Public procurement for the sampling of these areas has been launched, assigned and currently in progress (Figure 2).

Table 1: Proposed regional medium formulas according to the fertility soils condition

Region	Recommended formulas	Observations
Fès	Southern part: DAP (18N-46P_2O_5-0K_2O)	Formulas produced by OCP and available on the market
	Northern part : 22N-14P_2O_5-4K_2O	
Meknès	22N-14P_2O_5-4K_2O	Formulas produced by OCP and available on the market
El Hajeb	Southern part: Apport d'azote seulement	Formulas produced by OCP and available on the market
	Partie Sud-Ouest: DAP (18N-46P_2O5-0K_2O)	
Khémisset	Southern part: 22N-6P_2O_5-20K_2O	New proposed formulas
	Eastern part: DAP (18N-46P_2O_5-0K_2O)	
Rabat	Northern part : 22N-6P_2O_5-20K_2O	New proposed formulas
	Southern part: 22N-14P_2O_5-4K_2O	
Settat	Northern part : 16N-11P_2O_5-20K_2O	Formulas produced by OCP and available on the market
	Southern part: DAP (18N-46P_2O_5-0K_2O)	

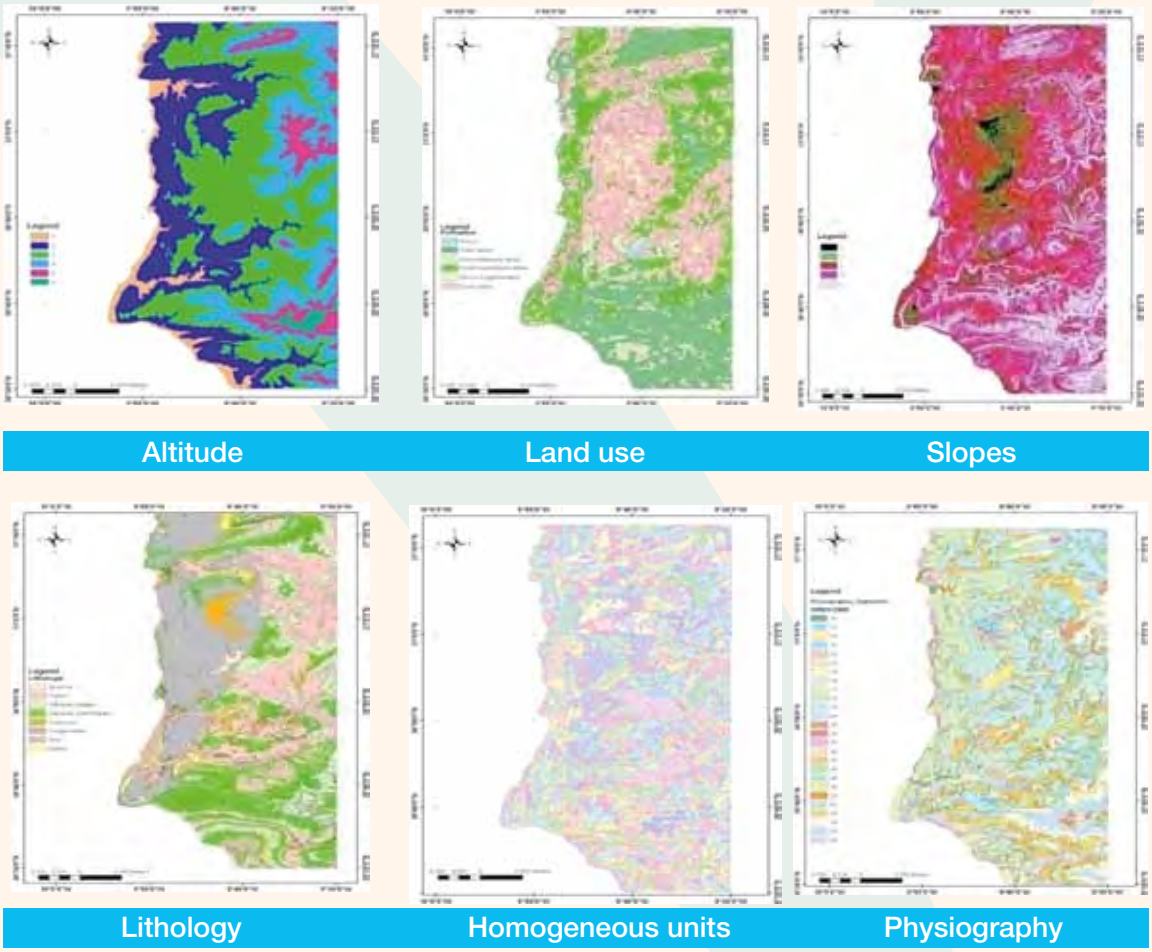


Figure 2 : Example of exploration plans for mapping areas not covered by pedologic studies in Agadir region

5. The Computer Solution (Web-GIS) has been fully implemented according to copyright-free solutions. All compiled fertility maps were introduced. Layers of additional information with regard to the study terms of reference were also included in the CS menu. The CS is available online with free access at the following address: www.fertimap.ma. The ferti-advice units, planned for the extension of the rational and balanced use of fertilizers can use the CS through prior training. A working group consisting of DDFP, the DEFR, the OCP and the consortium INRA-IAV-ENA was formed to prepare terms of reference relating to the establishment of ferti-advice.

6. Currently, six operational zones of soil fertility maps were completed and exhibited in the SIAM 2011 (Figures 3, 4, 5 and 6).

The national program of agricultural land suitability maps

The National Program of Agricultural Land Suitability Maps has concerned in 2011 the Khouribga zone with 120.000 hectares for five crops: wheat, barley, lentil, olive and carob tree. The main soil constraints in this zone are: pH level, calcareous content and Useful Reserve(UR). Indeed, pH is alkaline for all soils, exceeding 8 for several units. High levels of calcareous are observed especially in carbonate soils and less developed soils. Finally, the UR of several soil units is either weak (the case of skeletal soils and rendzina) or dependent on the calcareous slab level (the case of brown calcareous soils) (Figure 7).

In this zone, barley is more appropriate (74% of land is high to moderately suitable), while for lens, only 26% of land are suitable to moderately suitable against 58% marginally suitable to unsuitable. In fruit tree production, the carob tree is the most suitable to the area, with 38% of land suitable to moderately suitable, and 19% for olive tree (Figures 8, 9, 10 & 11).

Figure 3: Map of soil pH Spatial distribution in Fès region

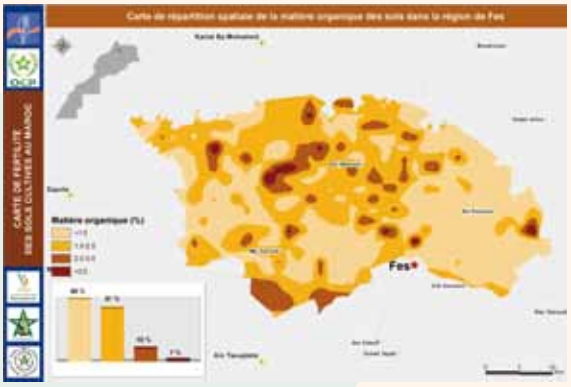


Figure 4: Map of organic matter spatial distribution in Fès region

Figure 5: Map of assimilable phosphorus spatial distribution in Fès region

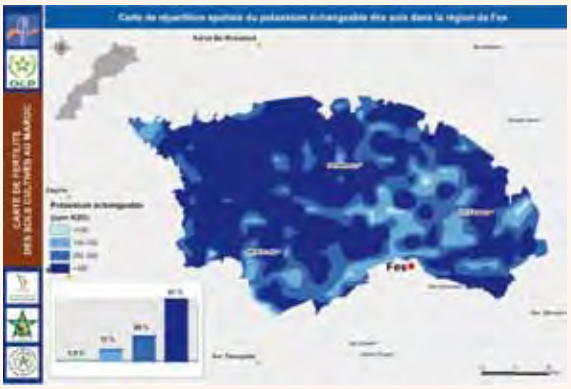


Figure 6 : Map of exchangeable potassium spatial distribution in Fès region

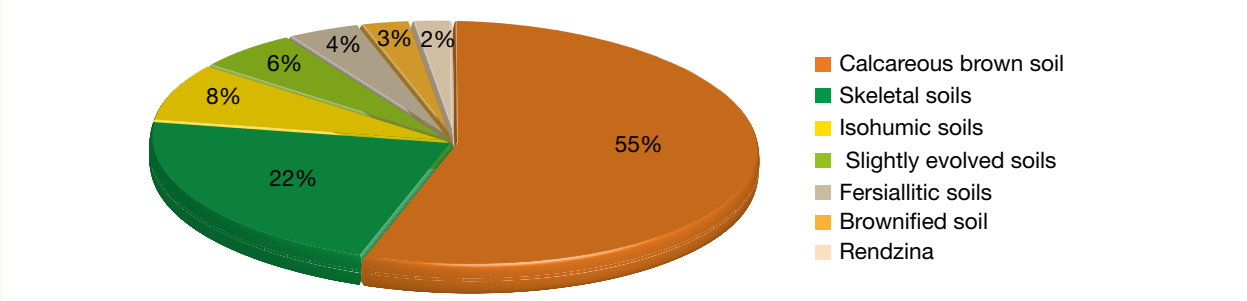


Figure 7: Importance of dominant soil types in Khouribga zone

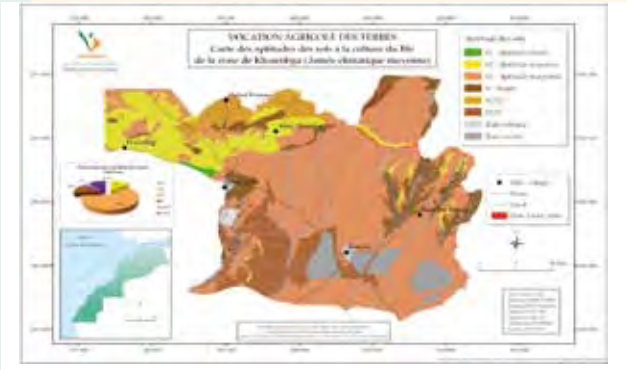


Figure 8 : Land Suitability Map of wheat in Khouribga zone

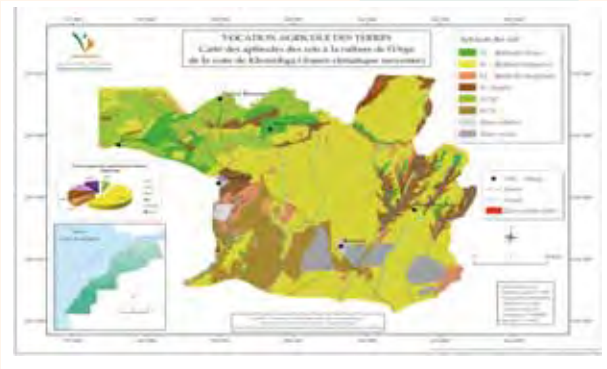


Figure 9 : Land Suitability Map of barley in Khouribga zone

Figure 10 : Land Suitability Map of olive tree in Khouribga zone.

Figure 11: Land Suitability Map of carob tree in Khouribga zone

Integrating climate change in the implementation of the Green Morocco Plan

Project of integrating climate change in the implementation of the Green Morocco Plan (PICCPMV) aims the capacity-strengthening at the institutional level and at the farmer level for adaptation to climate change in five targeted regions of Morocco. The project is funded by the Special Climate Change Fund (SCCF), with a sum of 4.35 million $US. For the period 2011-2014. This project capitalizes the results of the impact of climate change on Moroccan agriculture carried out in 2009 by the Food and Agriculture Organization (FAO), INRA and the Direction of the National Meteorology (DMN). This project developed by INRA is piloted by the Agricultural Development Agency and executed by Regional Directorates of Agriculture.

The project involves two components: (1) capacity-strengthening of public and private institutions for adaptation to climate change in agriculture in five targeted regions, and (2) dissemination of technologies for adaptation to climate change in agriculture for farmers in the five targeted regions.

Adaptation measures to be included in the PIC-CPMV sub-projects aim to manage blue water and green water in Morocco, through technologies and agricultural practices developed by INRA. They focus on selection of adapted varieties, rainwater collect, supplemental irrigation, seeding date, no-till farming, fertilizing and good agricultural practices in addition to farmer training.

Assessment of climate change mitigation potential by no-till farming in Morocco

The objective of this research funded and coordinated by the International Food Policy Research Institute (IFPRI) is to quantify the mitigation potential of climate change in Morocco by direct seeding system (Figure 12). This quantification was performed for wheat, by using the simulation model CropSyst, according to four climate models (CNRM-CM3, CSIRO-Mk3.0, ECHAM5, MIROC3.2) and three climate change scenarios on the horizon 2050. Carbon content in soil at 30cm depth was simulated under wheat in six provinces, under the no-till and conventional till, as well as pluvial and irrigated farming (Figures13 and 14).

The results show that direct seeding and irrigation significantly improve the soil carbon content in all studied provinces. However, the positive effect of direct seeding decreases gradually until the 2050s due to climate change.

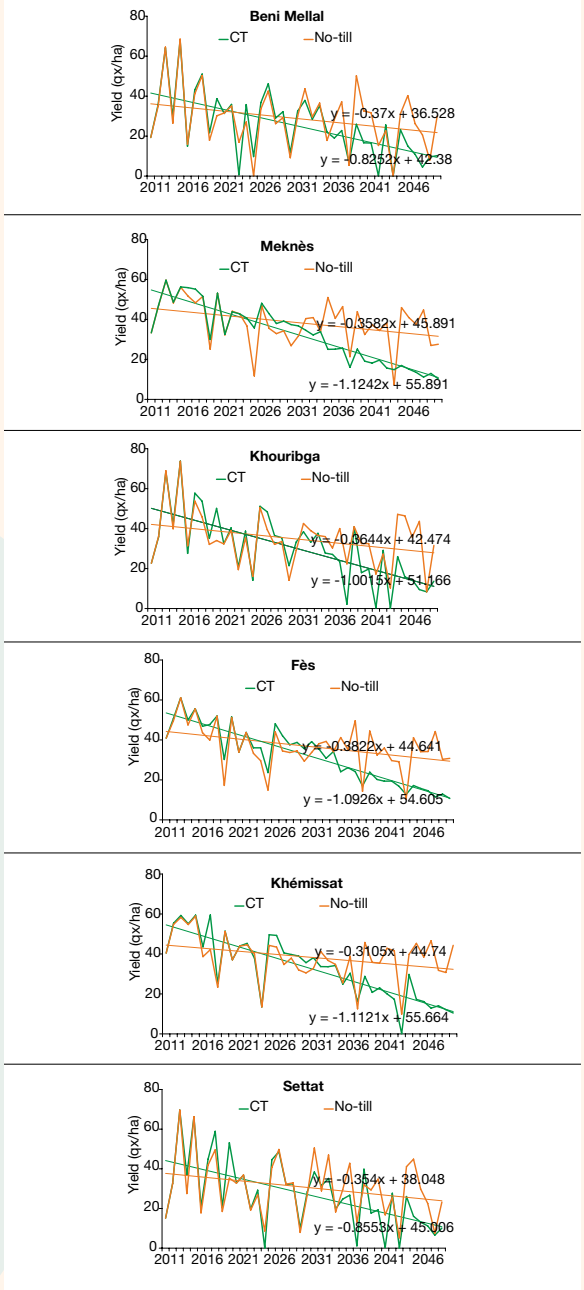


Figure 12: Wheat productivity simulated by the CropSyst model in conventional and direct seeding, under the climate change effect, until the 2050s (CT : conventional tillage)

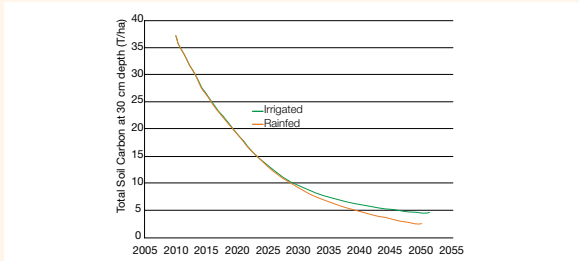


Figure 13: Simulation of irrigation effect on soil carbon content at 30 cm depth under wheat in Morocco bour areas

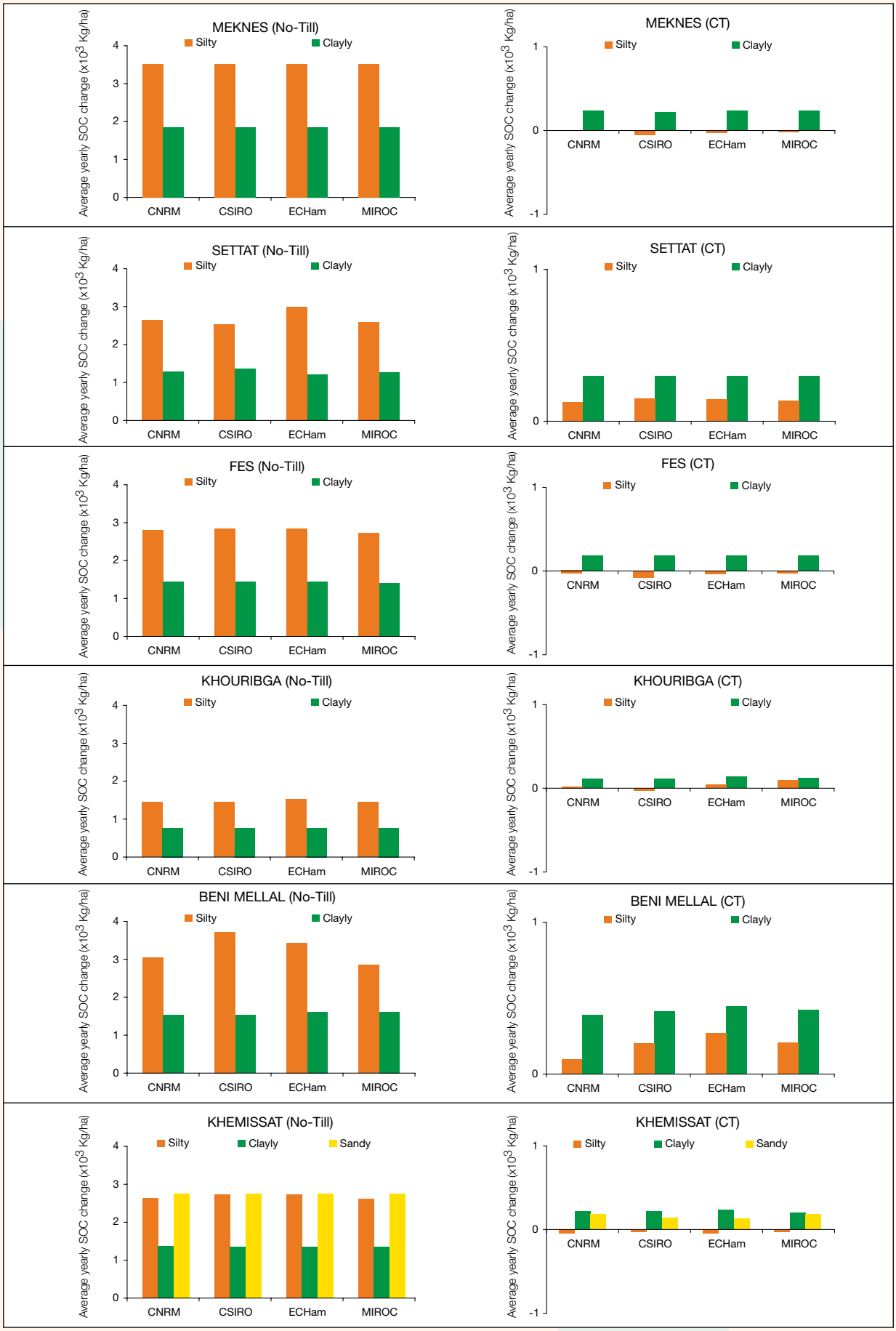


Figure 14 : Medium annual change of soil carbon content for three textures (silty, clayly and sandy) in six provinces of Morocco, with conventional and direct seeding for four scenarios of greenhouse gas emissions (CT : conventional tillage)

Soil conservation, water use efficiency improvement and climate change mitigation under direct seeding sytem

Trials were conducted in Zaer region to study soil conservation and improvement of rainwater use efficiency by direct seeding, in crop rotation wheat - lentils. No-till trials were conducted at Merchouch experimental field (INRA) for the 7th consecutive year and at two farmers in Zaer region.

Results show that direct seeding improves wheat and lentils yield by a better rainwater soil retention.

Direct seeding also allows to improve the soil organic matter rate and decreases carbon emissions (Figure 15), thus participating in the climate change mitigation.

Direct seeding also improves soil quality in comparison with conventional seeding, but requires the maintenance of 50% of crop residue to significantly reduce water erosion.

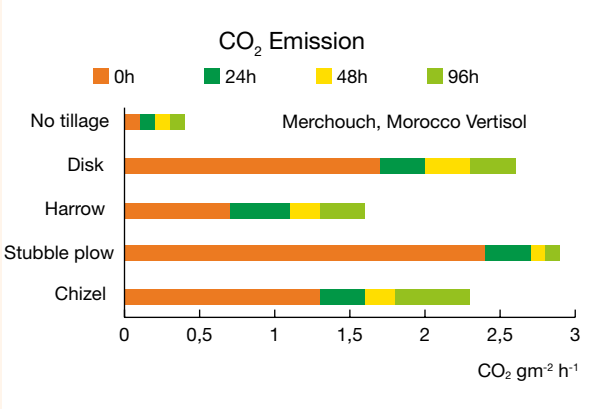


Figure 15: Measurement of carbon dioxide (CO2) flux for various tillage systems

Organic farming in Souss-Massa

Effect of compost and organic nitrogen fertilizer on soil fertility, growth and yield of zucchini and melon in greenhouse

The arid climate of Souss-Massa generates a very strong mineralization of organic matter. Trials were installed for compost input evaluation on varieties of zucchini «Natura» and melon canary yellow type «Starplus» and Galia pineapple type «Raymond». Results showed that, in all cases, the compost improves simultaneously crop growth, development and yield parameters, and soil organic matter accumulation.

For zucchini, the highest yield is obtained when the nitrogen requirements are provided half by the compost before planting and half by the fertilizer (1/3 in 30 days after planting, 1/3 in 60 days after planting, 1 1/3 in 90 days after planting) (Figure 16).

For melon, higher yields were obtained for compost dose of 25 T/ha (Figure 17).This dose also helped improve soil fertility, an enrichment in soil assimilable phosphorus and total nitrogen and an impoverishment in exchangeable potassium, calcium, magnesium and sodium. Similarly, fertilization allowed reducing soil nitrate content, especially towards the end of the melon growing cycle.

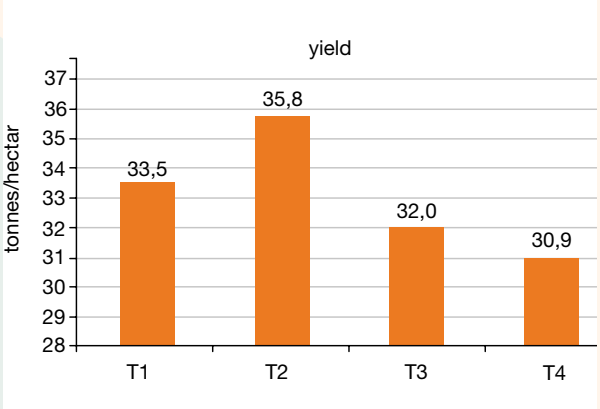


Figure 16 : Effect of compost on zucchini yield in Souss-Massa. T1: 100% of compost; T2: 50 % compost + 50% organic fertilizer. T3: 25% of compost, 75 nitrogen fertilizer; T4: 100% organic fertilizer.

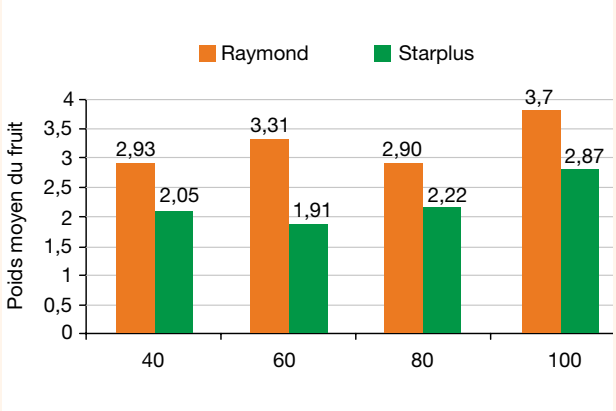


Figure 17 : Effect of compost on melon medium weight (Kg) of Starplus and Raymond varieties in Souss-Massa. The compost doses tested are 40 (10 T/ha), 60 (15 T/ha), 80 (20 T/ha) and 100% (25 T/ha).

Effect of organic amendment on soil fertility and zucchini productivity under greenhouse tunnel

The results of research conducted in Melk Zhar experimental field showed that organic amendments improve Zucchini growth, development and yield parameters on the one hand, and soil organic matter rate, on the other hand. The input of organic matter allows also an enrichment of soil assimilable phosphorus, calcium, magnesium, and total nitrogen and impoverishment of exchangeable potassium, sodium and trace elements iron, Mn, Cu and Zn. Similarly, organic fertilization reduces the soil nitrate content, especially towards the end of the growing cycle. Also, the organic amendment improves the soil microbial life (Figures 18 & 19).

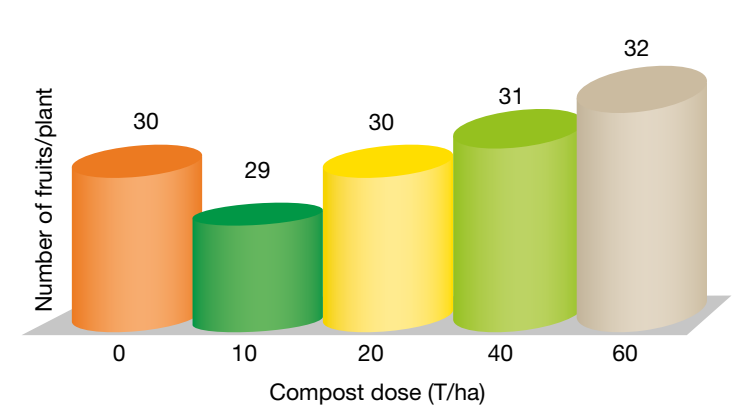


Figure 18: Effect of compost on total number of Zucchini fruit in experimental field of Melk Zhar

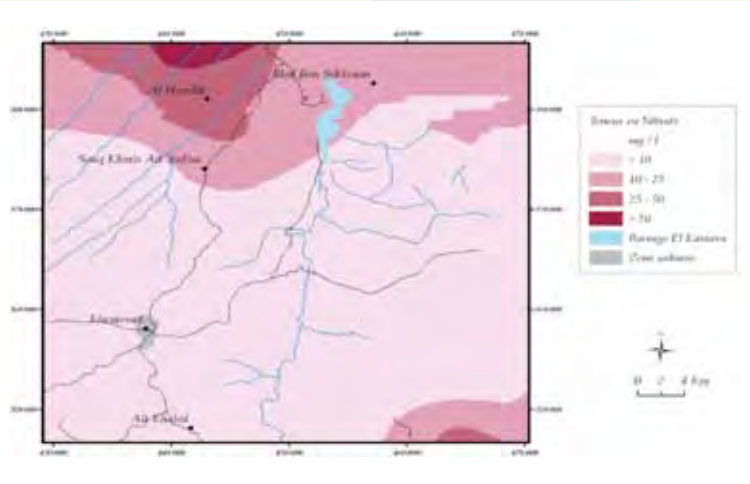


Figure 19: Evolution of soil organic matter rate during the growing cycle of zucchini in Melk Zhar experimental field

Study of irrigation water and soil quality in market gardening zones in Khemisset region

This study aims to characterize the irrigation water and soil quality in the market gardening zones of Khemisset region. Water is moderately to highly saline. The risk of irrigation water alkalinization is relatively low. The risk of toxicity in chloride ions is high in 50% of the analysed samples. The results of well water measurements on show some variability, but are for the most part (73%) below the pollution level according to standards of the World Health Organization (Figure 20).

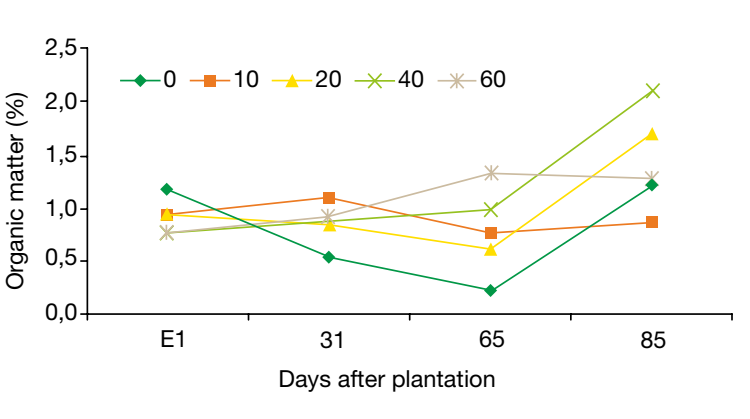


Figure 20 : Spatial distribution map of water nitrate content in Khemisset region

Qualitative and quantitative evaluation of sylvo-pastoral areas in the Oued Laou Valley

The studied sites are characterized by a rugged topography. The vegetation is composed essentially of matorral and cork oak tree stratum. The three sylvo-pastoral sites Akoumi, M'hinine and Taghbalout showed high to intermediate levels of biomass production, while the Bettara rangeland is in a degraded state with an invasion of pastoral species not palatable and of low biomass production. About 120 plant species have been recorded in the Valley (Figure 21).

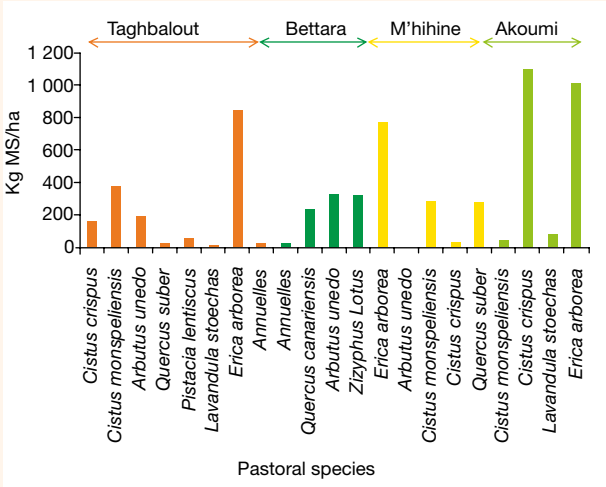


Figure 21 : Phyto-biomass produced by pastoral species in four rangelands of Oued Laou Valley (Tétouan).

CROP IMPROVEMENT

New registered varieties in the official catalogue

Durum wheat

The D27M78 line is the first durum wheat variety registered with a high level of yellow pigment. Results of quality tests carried out in collaboration with the National Federation of Flour-Milling (FNM) are satisfying in terms of industry required quality.

Bread wheat

The bread wheat line "00HBW300" is the second variety obtained from the haplodiploidization technique through anther culture. This technique allows accelerating the selection cycle by stabilizing lines in segregation in a few generations.

Triticale

"04DHTCL17" triticale line, whose qualifications are described in (Table 2), is obtained from the haplodiploidization technique through anther culture. This technique is now well integrated in INRA cereal selection strategy.

Table 2 : Agronomic and technological characters of "04DHTCL17" Triticale variety, registred in the official catalogue in 2011

Parameters	Crop year	Value
Yield (q/ha)	2009-10	34.28
	2010-11	41.4
Specific weight (kg/hl)	2009-10	74.25
Thousand seed weight (g)	2009-10	36.23
Protein rate (%)	2009-10	10.75
Humidity (%)	2009-10	11.81
Zelleney (ml)	2008-09	35.33

Lines in registration (Table 3)

Table 3 : Cereal lines in registration

Species	Lines	Trial year
Durum wheat	MD101119	1° year
	MD 101118	//
	DM979	//
Bread wheat	HI 50	//
	MD 1011 69	2° year
	MD 1011 95	//
	MD 1011 93	//
Triticale	O4 HDTCL 10	1° year
	O4 HDTCL18	//

Durum wheat

The stability of membrane cell plays a leading role in drought tolerance mechanisms. 50 Lines were tested for their drought resistance, leading to the selection of ten accessions with good agronomic characters and productivity. They will be involved in crosses for selection of new varieties.

Also, to identify drought tolerance sources, a new technique for detection of genes forms not prospected yet in crop improvement was used. This technique is based on the use of a unique collection of durum wheat mutants obtained after chemical mutagenesis, and allows direct identification of durum wheat plants on candidate genes.

These lines also showed high levels of filled stems, a character that confers resistance to the Hessian fly and the wheat stem Sawfly (Photo 1).

Photo 1 : Hessian fly resistance Screening in greenhouse

Bread wheat

The use of genotypes with drought resistance characters may contribute to increase the water use efficiency. Morphological and physiological key criteria in water stress adaptation were measured on contrasting lines.

Results achieved during the last two years showed that the yields obtained in different trial sites were highly inheritable(H=0,74), suggesting a possible improvement of yield by using lines with high yields as cultivars or parents (Figure 23). The germplasm tested is highly superior to the witness (Arrihane).

A number of synthetic hexaploid wheat has been identified as resistant to Hessian fly. This germplasm could be used for expanding the genetic range against this disease in Morocco.

Triticale

Among goals of hexaploid triticale genetic improvement, bread-making quality and grain colour are important. In this sense, crosses were made between high potential yield varieties and white grains lines with the application of the anther culture technique as a method of hybrids fixation. Two lines "04HDTCL10" and "04HDTCL18" were selected and presented to official catalog.

Bean

To fight broomrape, works were initiated to develop bean transgenic plants expressing the sarcotoxin gene known to inhibit the broomrape development. The sarcotoxin gene is cloned into a binary vector after its introduction in two strains of *Agrobacterium*. The plasmid introduction was confirmed by Polymerase Chain Reaction (PCR) (Figure 22). The Gene strains vectors were inoculated in bean plants. This genetic material is being grown in greenhouse.

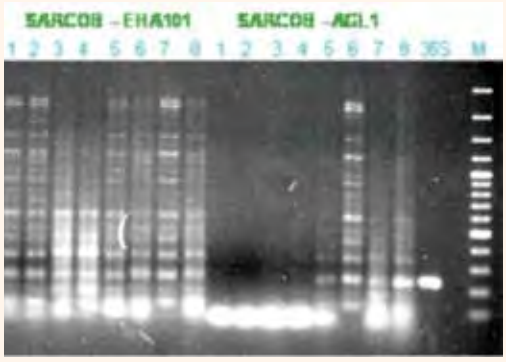


Figure 22 : 35 S. amplification by PCR to confirm integration of plasmids containing the Sarcotoxin gene in different Agrobacterium strains

Citrus tree

To replace the *Citrus aurantium*, 14 rootstocks were introduced and tested on Valencia Late variety. The obtained results allowed determining new rootstocks with significant performance.

Citrumelo 4475, *Citrus volkameriana*, the hybrid mandarin Sunki X PT, *Citrus Macrophylla* and the hybrid mandarin sunki x PT are promising rootstocks to improve the Valencia Late productivity. Rootstocks Citrumelo 4475 and PT B6Z13 could be used in high density plantations to improve yield per area unit. Rootstocks *Citrus volkameriana,* P.TB6CZ24, P.TB6CZ13, Mandarin Cleop. X *C.C.*, Mandarin Sunki X PT Citrumelo 4475 and Citrumelo 1452 brought a significant improvement in the juice rate of the Valencia Late variety. Rootstocks *C. Carrizo,* Mandarin Sunki X PT, Citrumelo 1452, Citrumelo 4475, Mandarin Sunki X PT, Mandarin Sunki X PT, P.TB6CZ24 and P.TB6CZ13 improved the acidity percentage and the degree of Brix of the Valencia Late variety.

Furthermore, 9 rootstocks of Citrumelo group have been tested for salinity in comparison with Rangpur lime which is recognized as the most resistant rootstock to salinity. Only J10 and J14 have been found resistant to salinity.

Olive tree

Descendants of crosses between olive varieties Menara and Arbequine were characterized by RAPD markers.

Molecular analysis of descendants by 6 RAPD primers showed polymorphisms and can serve as markers. This result allows selecting hybrids and reducing the lines number to evaluate in olive variety development programs.

Date palm

In the framework of the Palm Grove Reconstruction Program, INRA ensures the multiplication of budding strains to provide industrial multiplication units. The production program of this year is presented in Table 4.

The delivered strains varietal profile is composed of 76% of Najda (bayoud resistant) and 24% of Boufeggous, Mejhoul and bouskri (bayoud sensitive). All varieties are high quality dates.

Fruit trees

Almond tree: works were conducted on the selection of auto-fertile almond varieties which is an appropriate way to overcome pollination complications for production optimization.

Fig tree: The evaluation of vegetal material in collection helped to retain four varieties for varietal behaviour study and genetic analysis. The aim was to show the importance of genetic diversity and identification of genitors for selection of adaptive potential lines.

Caper shrub: Caper genotypes of various origins have been morphologically characterized. The results showed that the fruit firmness, which is an important indicator of caper commercial quality, differentiates clearly the types of Safi in comparison with those of Fes and Meknes regions.

Gene bank

The gene bank holds more than 47.000 accessions in active collection and more than 23.594 accessions of durum wheat lines as a genetic stock of basic collection.

Eight genera maintained at the gene bank are more than 77% of the total accessions. (Figure 23).

More than 7.994 introductions (19%) are multiplied for an eventual diffusion for research purposes.

More than 6.211 accessions (14.4%) have been distributed for research purposes.

The use of four microsatellite markers for characterization of 500 local varieties of durum wheat was applied. This type of research for the first time in Morocco led to better valorising available resources of durum wheat (Figure 24).

INRA contributed fully in new version of GRIN system. This is to provide to gene banks in the world global information management system.

Table 4: Date palm strains delivered to private laboratory for industrial multiplication

Varieties	Issemghy Biotechnologies	Domaine El Bassatine	Palmagro
Najda	4518	2352	5116
Majhoul	576	432	0
Bousekri	912	864	240
Boufegouss	163	216	298
Total/laboratories	6169	3864	5654
Total	15687 strains		

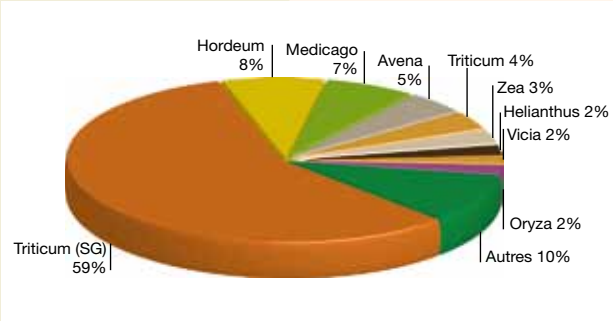


Figure 23 : Major genera maintained at the gene bank of Settat (September 2011).

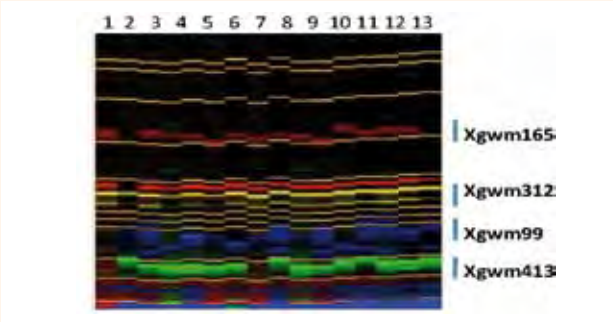


Figure 24: Characterization of local breeds of durum wheat by microsatellite markers

AGRONOMY AND AGRICULTURAL MACHINERY

Improvement of rainfed crops productivity in Saïs region

Improvement of bread wheat productivity by varietal choice, supplemental irrigation and nitrogen fertilization

A trial was conducted to test the yield improvement of bread wheat through three factors: (1) improved variety (2) nitrogen dose and (3) supplemental irrigation.

Results show that varietal choice and nitrogen fertilization can significantly improve the bread wheat yield. In the tillering or heading stage, supplemental irrigation also helped to improve yield but at low levels because of the high rainfall of the crop year (516 mm).

Improvements of yield and water use efficiency for grain production (EUEg) were proportional to the nitrogen quantity provided for the three tested genotypes (Arrehane, Achtar and LAVII). However, the yield of Arrehane variety and the advanced line II were equal but higher than those of Achtar whatever the level of nitrogen supply, and the same is true for EUEg (Figure 25).

Wheat productivity improvement by no tillage and crop rotation

This research aims to study the bread wheat productivity improvement in Saïs region by different tillage systems (Disc Plough, Chisel, disc harrows and direct seeding) and different crop rotations (Bread wheat in monoculture, bread wheat/chick-peas, bread wheat/sunflower, bread wheat/chick-peas/fallow and bread wheat/sunflower/fallow).

Trial results show that the biennial rotations wheat / chickpeas and wheat / sunflower gave the best yield components: grain yield, straw yield, harvest index, grain number / m^2, thousand grain weight. Figure 26 shows the yields obtained by different rotations and tillage.

Improvement of faba bean productivity by phosphorous fertility in Saïs

Productivity of faba beans in Morocco is generally low because of the low fertilization. The objective of this research is to show that phosphorus fertilization can improve faba bean. Figure 27 shows the continuous improvement of faba bean productivity by increasing phosphorus doses.

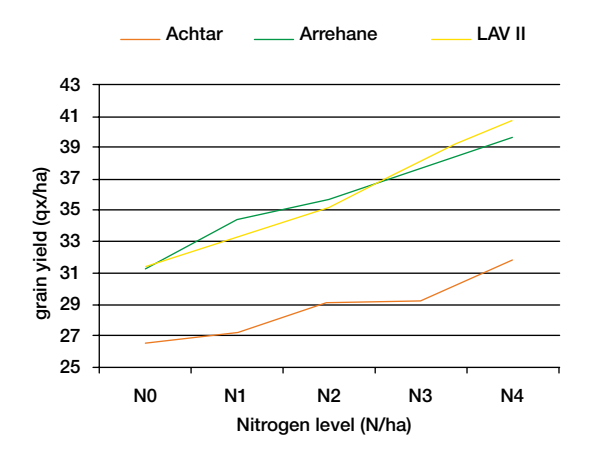


Figure 25 : Grain yield (quintals/hectare) of three bread wheat genotypes by five increasing doses of nitrogen (No. = 0, N1 = 40, N2 = 80, N3 = 120, N4 = 160 kg N/ha) in Douyet experimental field (FES), during the 2010-2011 crop year. (LAV : Advanced line)

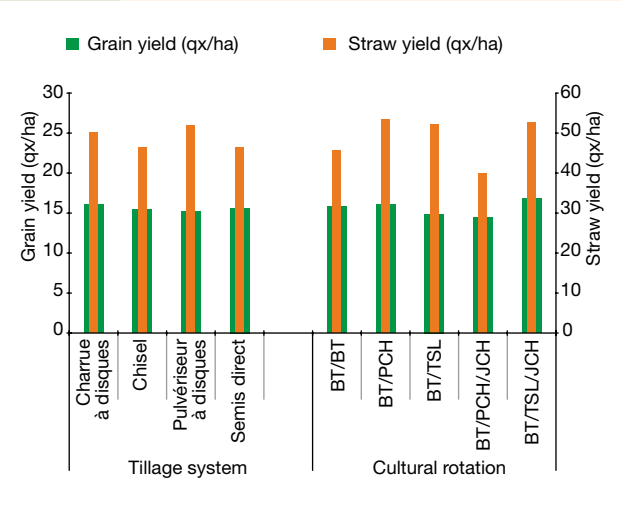


Figure 26: Effect of tillage and crop rotation on bread wheat productivity (Qx/ha) in Douyet experimental field (Fez) during the 2010-2011 crop year.

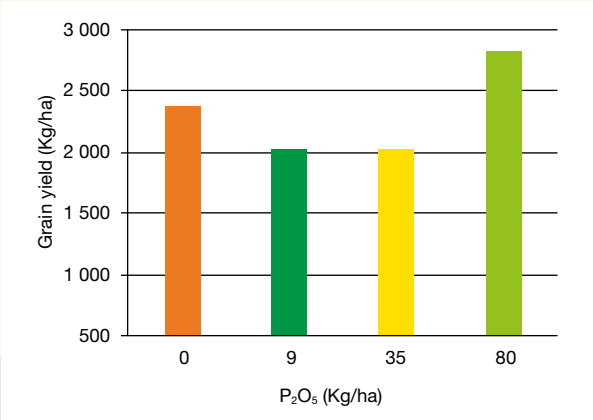


Figure 27: Effect of phosphorus dose on faba bean grain yield at Douyet experimental fiel (Fez) during the crop year 2010-2011

Improvement of irrigation water productivity

Improvement of irrigation water productivity for rosaceous stone fruit

Irrigation by controlled deficit may be a very promising water saving technique. It consists of reducing the water volumes during certain development phases of fruit trees, when growth is slow. These phases generally correspond to the stages of nuclei hardening in rosaceous stone fruits.

A research was conducted to test the response of three fruit trees (peach tree, plum tree and almond tree) to three water regimes (50% ETc, 75% ETc and 100% ETc). Observations on vegetative, physiological, pomological and technological parameters were reported.

Results show that three Rosaceae fruit can resist to higher water stress (75% ETc in peach and 50% ETc in plum and almond) without significant impact on the fruit size but with qualitative parameters deterioration (acidity, ° Brix of fruit).

Improvement of irrigation water productivity for cereals

This research aimed the improvement of irrigation water use efficiency in durum wheat crop (varieties: (1) Toumouh, (2) Marzak (3) Raja and (4) Salama) through an irrigation warning system in the irrigated perimeter of Tadla. Four treatments of irrigation I1, I2, I3 and I4 corresponding to 120%, 100%, 80% and 60% of the crop needs (ETc) were tested. The piloting of the irrigation method was based on soil moisture monitoring and water balance calculation. The water stock is determined every 15 days by the neutron probe. Plots are irrigated when water stock reaches 70% of useful reserve.

Irrigation water use efficiencies proved to be most important for Toumouh variety, between 1.87 and 2.97 (Kg/m^3). Table 5 shows applied treatments and obtained results. Note the low water consumption and the strong irrigation water valorization of INRA varieties.

Table 5 : Irrigation water productivity of four durum wheat varieties in Afourer experimental field (Tadla), for three years of experimentation.

Variety	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Treatment	I1				I2				I3				I4			
Supply quantity (mm)	102,00	102,00	102,00	102,00	86,00	86,00	86,00	86,00	68,00	68,00	68,00	68,00	52,00	52,00	52,00	52,00
Precipitation (mm)	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70	209,70
I+P (mm)	311,70	311,70	311,70	311,70	295,70	295,70	295,70	295,70	277,70	277,70	277,70	277,70	261,70	261,70	261,70	261,70
Yield (Qx/ha)	92,59	63,50	75,00	56,00	73,50	57,00	59,00	42,50	52,00	57,50	50,50	55,00	55,50	53,00	48,50	36,50
Average yield (Qx/ha)	71,75				58,00				53,75				48,38			
Efficiency (kg/m^3)	2,97	2,04	2,41	1,80	2,49	1,93	2,00	1,44	1,87	2,07	1,82	1,98	2,12	2,03	1,85	1,39

Improvement of citrus productivity by rootstocks choice and nitrogen fertilization

The optimization of the combination between rootstocks and nitrogen fertilization is necessary for the production of good quality citrus plants. The objective of this research was to determine the optimal dose of nitrogen and the identification of the most efficient rootstocks in terms of nitrogen use efficiency, to allow a production of good quality citrus plants ready to be grafted.

A trial was conducted under greenhouse in Gharb region to test four nitrogen doses (0, 1, 5 and 10 mM per liter of nutrient solution) on morphological, physiological and biochemical parameters of six rootstocks: *Citrus aurantium,* citrange Carrizo, citrange C35, *Citrus volkameriana* B2 28613, *Citrus macrophylla* and Citrumelo 4475 AB6 A4.

Results show that the use of nitrogen improves morphological, physiological and biochemical tested rootstocks parameters. At the nursery stage, Citrus volkameriana, B2 28613, *Citrus macrophylla* and Citrumelo 4475 AB6 A4 are the most efficient in terms of nitrogen use. The dose of 5 mM/litre of nutrient solution is optimal for the production of good quality plants at the nursery stage. Figures 28, 29 and 30 show the improvement of morphological parameters of citrus by the adequate choice of rootstocks and nitrogen fertilization.

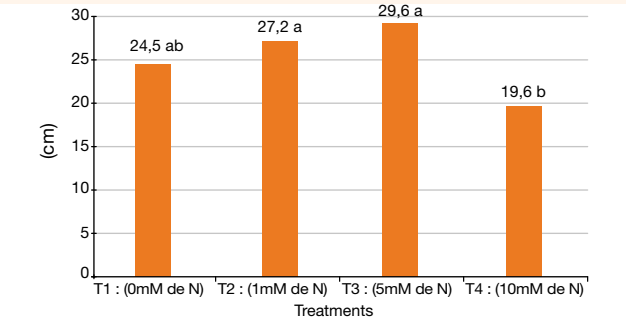


Figure 28: Effect of nitrogen dose on the final height of stem (all rootstocks combined) in Menzeh experimental field (Kenitra).

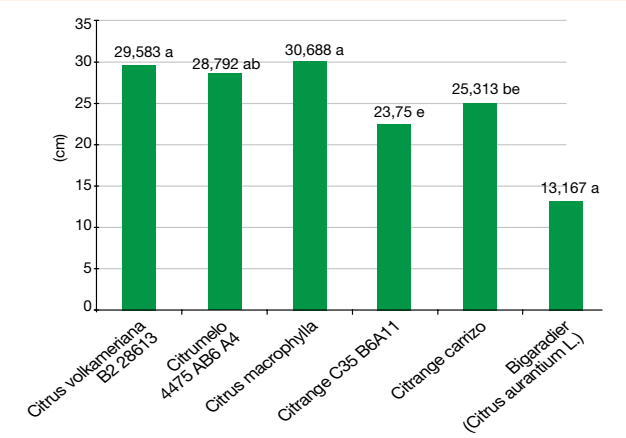


Figure 29: Comparison of the height of stem of different tested rootstocks (all nitrogen treatments combined) in Menzeh experimental field (Kenitra).

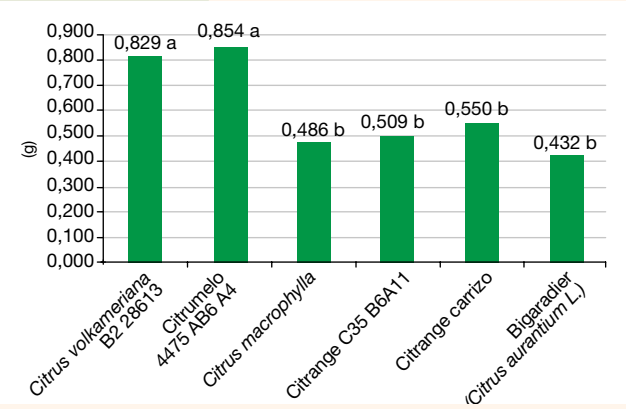


Figure 30: Comparison of the dry weight of roots of different tested rootstocks (all treatments combined) in Menzeh experimental field (Kenitra).

Improvement of the cactus productivity by nitrogen, phosphorus, potassium and magnesium fertilization

A Research achieved on cactus in Souss region (Photo 2) aimed to test productivity and quality improvement of 4 local ecotypes by nitrogen, phosphorus, potassium and magnesium fertilization. Two doses of fertilizer (T1 = 20 N; 20 P; 20 K; 20 Mg and T2 = 30 N; 30 P; 40 K; 20 Mg) were tested by cactus plant and compared to an unfertilized control. Measures focused on all productivity parameters: number of cladodes by plant, fruit maturity, fruit yield, flesh and bark fruit weight, fruit size and sugar content.

Results show that all productivity parameters are improved (Figures 31, 32 and 33).

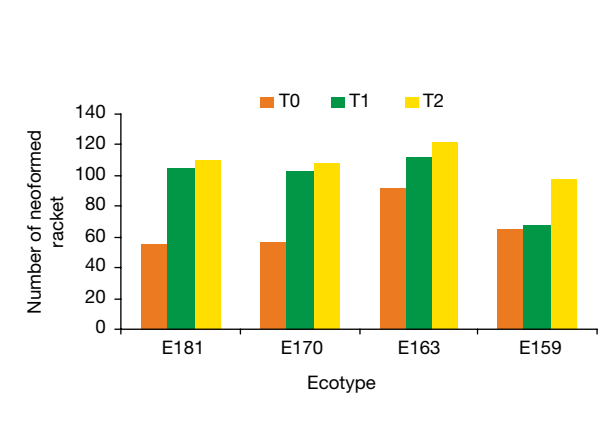


Figure 31: Improvement of cladodes number by mineral fertilization (control T0 and two increasing doses T1 and T2), for four ecotypes in Melk Zhar experimental field (Agadir)

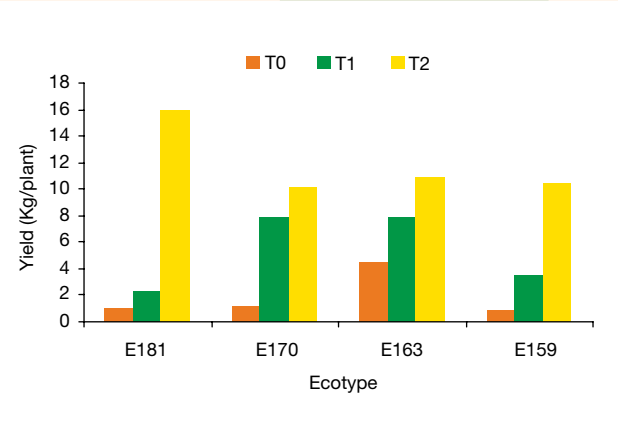


Figure 32: Improvement of cactus fruit yield by mineral fertilization (control T0 and two increasing doses T1 and T2) for four ecotypes in Melk Zhar experimental field (Agadir)

Physico-chemical and organoleptic characterization of main cactus ecotypes in southwestern Morocco

The prickly pear of the Southwest has qualities that make it a much appreciated fruit in Morocco. A better knowledge of various ecotypes quality from this area would facilitate their agro-industrial and commercial valorization. A study was achieved to characterize physico-chemical and organoleptic characters of five ecotypes of three different sites: Howara *(O. mégacantha)* from the region of Ouled Teima, province of Taroudant, Imimkorn *(O. mégacantha)* from the region of Imimkorn province of Chtouka Aït Baha, Achefri *(O. mégacantha)*, Aissa *(O. ficus-indica)* and Moussa *(O. ficus-indica)* from the region of Mesti and Sbouya, province of Sidi Ifni (Photo 3).

Characterization results show that the five ecotypes are similar in terms of size, pulp weight, colour and fruit juice pH (5.98 to 6,37). However, the average rate of soluble solid matter (°Brix)

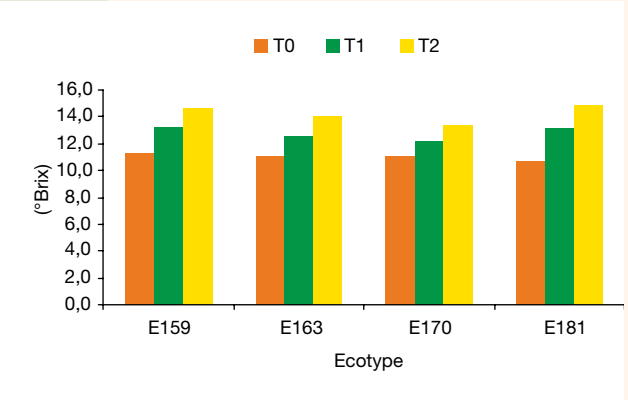


Figure 33: Improvement of sugar content of four ecotypes by mineral fertilization (control T0 and two increasing doses T1 and T2), in Melk Zhar experimental field (Agadir)

Photo 2 : Trial on cactus fertilization in Souss region

Photo 3 : Prickly pear ecotypes from the southwest of Morocco

is significantly higher in Aissa and Moussa ecotypes (14.3 and 13.9%). These values are higher than those of some ecotypes of Morocco central area (from 11 to 12 °Brix) but remain below values observed in some Mexican varieties such as Roja (16.9 °Brix) and C-17 (17.3 °Brix).

These high values of Aissa and Moussa Brix dergree are considered good quality parameter for the agro-industry, especially for fruit jam processing. Moreover, Aissa and Imimkorn ecotypes are the most appropriate for oil extraction used in food and cosmetic industry.

PLANT PROTECTION

Phytosanitary state of cereal and food legumes crops

Exploration was conducted during the physiological stage of flowering - maturity to diagnose pests, diseases and weeds incidence on cereal in the main production regions (Figures 34, 35, 36).This monitoring has revealed the dominance of Septoria, brown rust and root rots on bread wheat with a prevalence of 85, 71 and 59%. In the case of durum wheat, the tree diseases were 95, 73 and 41% of prevalence respectively. Yellow rust has been absent on durum wheat. However, it has been detected at the level of 59% in bread wheat fields. In the case of barley, blight attacks were most dominant (25-45%). The net blotch type spot was of lesser importance. The presence of leaf scald was low with levels of severity of 5-10%.

In General, leaf diseases losses were estimated at 20% on average.

Relating to pest, damage was overall insignificant, despite the infestation levels (20 to 50%). A grain yield loss due to pests was estimated at around 10%.

Relating to weeds, *Asteraceae, Brassicaceae, Papaveraceae* and *Poaceae* were the most dominant. Brome infestations were noted in Saïs, Zaër, Middle Atlas, Doukkala and Chaouia regions. Yield loss due to rigid brome was estimated about 25 q/HA in Saïs region (Figure 37). Ryegrass was also widespread in Doukkala. The presence of this weed is a result of resistance to herbicides. Generally, herbicide treatment has been more successful this year, unlike the previous season. Yield loss due to weeds did not exceed 15%.

Yield losses caused by all cereal enemies were estimated between 10 and 20%.

Characterization of *Mycosphaerella graminicola* population

The first results of *Molecular characterization* of diversity and genetic structure of 96 monospore isolates of M. graminicola from different regions revealed a considerable change in the level of allelic diversity.

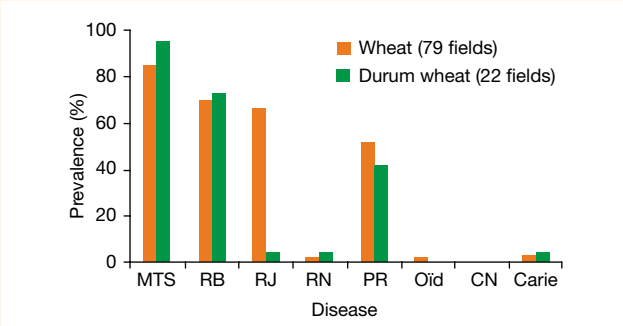


Figure 34: Prevalence of wheat diseases in Morocco during 2010-2011 (TS: disease septoria type, RB: brown rust, RJ: yellow rust, RN: black rust, RR: root rot, Oid.: oidium, CN: naked charbon, Smut

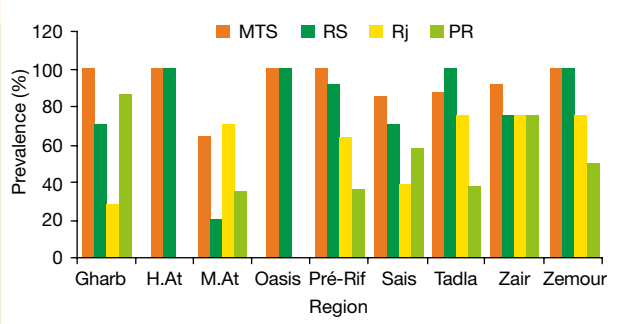


Figure 35: Prevalence of the main durum wheat diseases per region during 2010-2011.

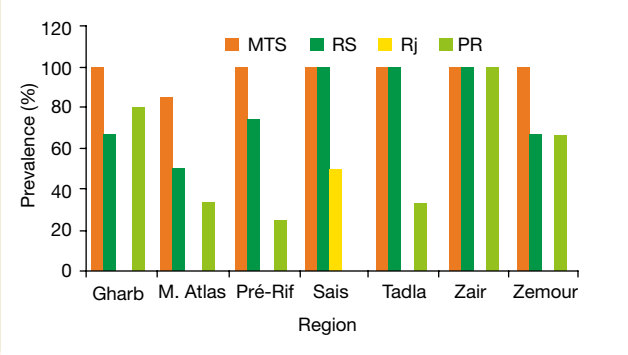


Figure 36: Prevalence of the main bread wheat diseases per region during 2010-2011.

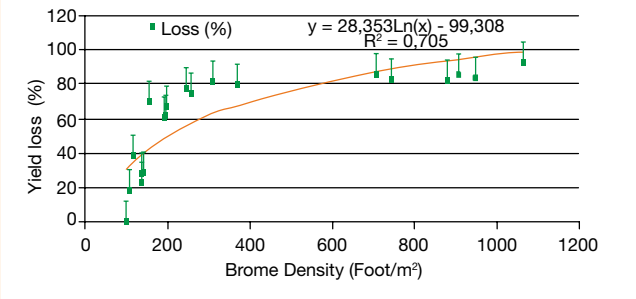


Figure 37 : Effect of rigid bromine density on wheat grain yield loss in cereal fields of Saïs and Moyen Atlas

The study of mating type distribution (sex type) among different isolates of this collection through the multiplex PCR has showed the presence of two mating types MAT1-1 and LS-2 with respective frequencies of 44 and 56%. The two idiomorphs have been identified with a balanced distribution in each of the regions. The two mating types were sometimes identified on the same leaf and even on the same leaf lesion, which confirms the hypothesis of the sexual reproduction achievement of this fungus in Morocco. Regular sexual mixing gives the fungus the ability to avoid varietal resistance and effectiveness of fungicides.

Nine M. graminicola isolates resistant to the strobilurin fungicides class have been detected in a 2010 collection after the screening of G143A substitution and isolates from 2008-2010. However, no resistant isolate was observed in 2008. This suggests the recent appearance of strobilurins resistance in the Moroccan population. Thus, a rational stobulirins use or its substitution by some multi-site fungicides is recommended to avoid more selection pressure on the fungus and consequently to ensure good protection of wheat.

Impact of direct seeding on the phytosanitary state of cereals

The evaluation of root rot impact on cereal in no till system has showed the presence of diseases caused by *Fusarium roseum culmorum* fs *cerealis* and *Bipolaris sorokiniana* (Sacc.) Shoemaker (*Helminthosporium sativum*) which are also common in the conventional system. Optimal conditions under the no- till soil offer a greater capacity for diseases development. Consequently, the direct seeding development could well be limited if the phytosanitary aspect is not taken into account particularly for soil diseases control.

Wheat stem sawfly

The evaluation in field conditions of the wheat stem Sawfly effect *(Cephus spp.)* on different cereal varieties showed different yield loss levels: 10.5, 11.8 and 16.7% respectively for bread wheat, durum wheat and barley (Photo 4). To avoid these losses, it is recommended to incorporate genetic resistance in varieties and to apply insecticide especially in rainy years.

Potential of sexual reproduction of Ascochyta rabiei

The characterization of 41 isolates collected in the main chickpea production areas (Figure 38) has highlighted two sexual types of Ascochyta rabiei (Pass) Larb. In some areas, their distribution frequency was close to the ratio 1:1. This result indicates their random distribution and therefore increased risk of sexual recombination. However, the overall analysis of the whole population shows a dominance of the MAT 1-1, hence a predominance of conidial reproduction (Figure 39). As a result, the potential risk of sexual reproduction must be taken into account in control strategies, particularly varietal resistance.

Photo 4: Wheat stem sawfly attack damage: (from right to left) Ear lodging in wheat field. Circular cutting of straw at the stem base showing empty stems from sensitive varieties and others filled from resistant varieties. Wheat stem Sawfly larva in the stem.

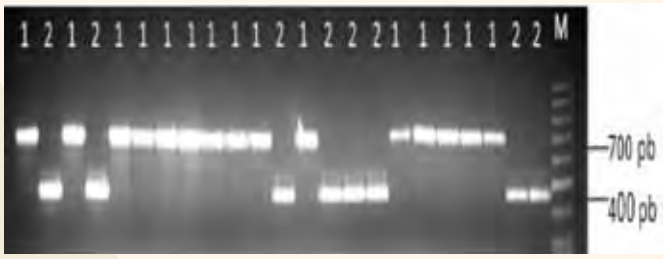


Figure 38: electrophoretic profile on agarose gel 1.5% of the PCR specific -MAT of some isolates of Ascochyta rabiei from different regions of Morocco. Fragments 1 represent MAT1-1 with 700 Pb and fragments 2 represent MAT1-2 400 PB.

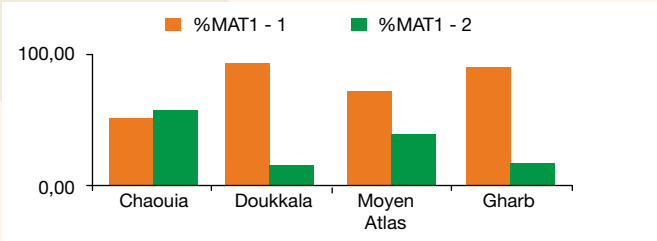


Figure 39: Distribution of polarities groups frequencies (MAT1-1 and MAT1-2) of A. Rabiei in four main regions of chickpea production.

Control of cereal and food legumes enemies

Varietal resistance, a strategic control option

- **Towards the creation of wheat varieties with multiple leaf disease resistance**

The evaluation of 70 wheat lines for resistance to dominant multiple diseases was achieved in Marchouch and Douyet experimental fields. Observations identified 6 and 9 promising lines with very good agronomic performance and combining resistance to Septoria, yellow rust and brown rust in Marchouch and Septoria and yellow rust in Douyet.

- **Effectiveness of yellow rust resistance genes**

The evaluation of isogenic lines resistance possessing the major genes of resistance to yellow rust, in Marchouch, Allal Tazi, Afourar and Annoceur experimental fields, has confirmed the effectiveness of Yr 1, 5, 10, 15, 17 and YrSp genes that confer an absolute resistance. Moreover, these genes have been absent in 10 Moroccan wheat varieties tested in these same conditions. A program of incorporation of these genes in the Moroccan varieties is underway.

- **Development of varieties resistant to Hessian fly**

Screening in nursery conditions of 80 bread wheat lines elite HF F8 2011, selected in previous years for their resistance to the hessian fly (Mayetiola spp.), has showed the high performance of almost half of these lines. Among these latter, some will be proposed to be registered in the official catalogue and enrich the range of Hessian fly resistant varieties in Morocco.

- **Enlargement of the genetic basis of Hessian fly resistance**

167 lines with a homogeneous resistance response against the Hessian fly and 225 others with a heterogeneous reaction have been selected after a triage of 878 synthetic lines of bread wheat. These lines are derived from crosses between cultivated varieties and wild cereals species. These new sources of resistance will be used to enrich the genetic basis for resistance to the Hessian fly in Morocco.

16 mutated lines induced by irradiation have also confirmed their resistance under controlled conditions.

Chemical control of wheat enemies

The development of rigid bromine has been reduced significantly by herbicide with [flucarbozone Na +] and [pyroxsulame (45 g/l) + Cloquintocet-mexyl (90 g/l) + Florasulam (6,25 g/l) + 2, 4 D] and [propoxycarbazone Na^+]. The respective doses are 43 g/ha, 0.5 l/ha and 60 g/ha. This result was obtained after the screening of 8 commercial products in Douyet experimental field. Effectiveness rates of these products have exceeded 94% allowing a substantial improvement of dry matter of 94%.

Development of varietal resistance to Ascochyta Blight in Chickpea

A chickpea genotype resistant to Ascochyta *(Ascochyta rabiei)* and 38 others moderately resistant were selected in field conditions among a collection of 83 cultivars from ICARDA and from the National program (Figure 40). Among these lines, 6 have confirmed their resistance for the third consecutive year.

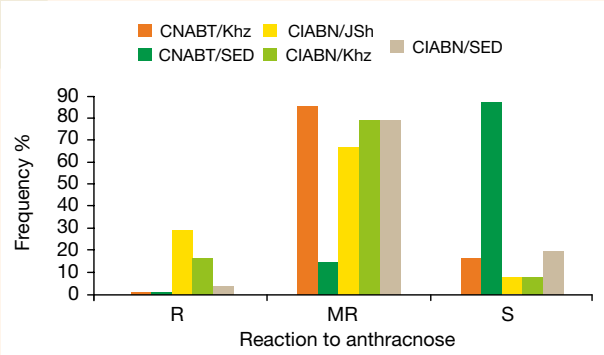


Figure 40: The reaction of national (CNABT) and international (CIABN) chickpea nurseries to anthracnose in Zemamra (KhZ), Sidi El Aidi (SED) and Jemaa Shaim (JSh) experimental fields. R: Resistance; MR: S and Moderately Resistant. S: Sensitive

Chemical weed control of food legumes

The study on chemical weeding in Tadla showed good control of weeds by a pre-emergence treatment based on pendimethalin (1200 g/ha) and metribuzin (300 g/ha). The mixture metribuzin + pendimethalin has also recorded a very good efficiency (90% at 45 days after treatment) and has the advantage of controlling both *Ridolfia segetum* Moris and *Galium verrucosum* Huds, species often associated with food legume crops. Post-emergence treatments based on bentazon, metribuzin and prometryn were sometimes little effective or phytotoxic for crops (Photo 5).

Integrated olive tree protection against diseases and pests

Research on genetic resistance to *Prays oleae*

The Italian variety Americano dofi showed a low level of infestation by *Prays* oleae (Bernards) in sensitivity evaluation trial of seven foreign olive genotypes in Tassaout experimental field. The variety Acebuchera was however more sensitive. Other varieties (Bianchera FIO, Amargoso, real Changlo, salce Fulla, Blanqueta) were moderately sensitive.

Effect of two pyrethrinoides on the olive tree fauna

In a field trial carried out in Marrakech region, the treatment based on Lambda cyhalothrin caused a toxic effect on pests and auxiliary fauna greater than Deltamethrin (Figure 41).

Development of biological control of olive tree enemies

Four bacterial strains of the genus Bacillus were selected among 11 strains evaluated for their antagonistic power toward *Verticillium dahliae* (Kleb), causal agent of verticillium wilt. Among these potential antagonists, two species are well known for their bio control role.

Analysis of regulation factors of olive scale populations

Analysis of regulation factors of *Parlatoria oleae* (Colvée) in Tadla showed a high growth rate despite the regulation factors action. Because of the lack of importance of natural parasitism, it is necessary to make additional entomophagous inputs to reduce pest attacks.

Biodiversity of olive tree tuberculosis in Saïs region

The studies on olive tree tuberculosis (*Pseudomonas savastanoi*) showed a large area distribution of this bacterium. The Moroccan Picholine is the most affected variety followed by the Oleaster. 30 strains of *P. savastanoï* were collected and characterized at molecular and biochemical levels (Photo 6, Figures 42, 43, 44). These strains have shown resistance to antibiotics except streptomycin. This phenomenon would be caused by the introduction of strains of *P. savastanoï* through imported olive plants or the transfer of resistance genes of Saprophytic phyllosphere bacteria or pathogens.

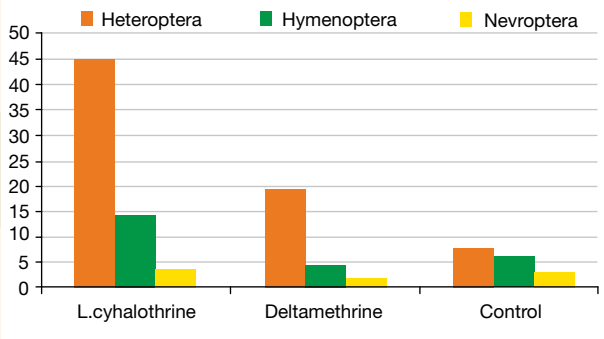
Dodder control in Tadla

The trials of dodder *(Cuscuta monogyna* Vahl.) control showed significant efficacy of products based on glyphosate. Weed development was significantly reduced after 3 applications before flowering with doses ranging from 400 to 500 mg/L and 3 Liters for one tree (Photos 7, 8). In the case of the sugar beet, doses of 50 to 60 g/ha of glyphosate applied at an early stage of Dodder produced good results (Photos 9, 10). For this crop, it is recommended to use cultural techniques such as the early seedtime.

Bayoud control of date palm

Research on bayoud control has concerned the following aspects:

1. The evaluation and the selection of resistant clones with good date quality through the characterization and the selection of efficient and less heat exigent genotypes, the diagnosis and the analysis of samples with symptoms, and the establishment of varietal sheets of 15 genotypes under evaluation;



Figures 41 : *Effect of two pyrethrinoides on olive tree fauna*

Photo 5: Chemical weed control of food legumes in Tadla

Photo 6: Test of reproduction of olive tree tuberculosis symptoms on young plants.

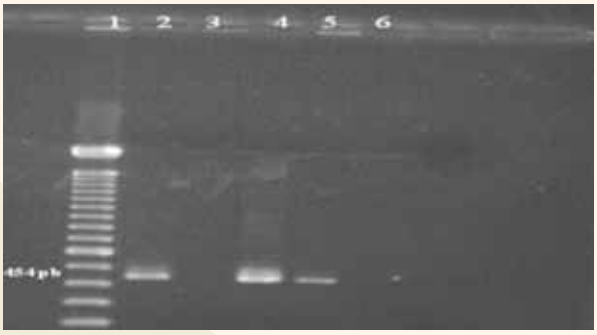


Figure 42: Electrophoretic profil of some Moroccan strains of P. savastanoï on agarose gel after iaaL gene amplification

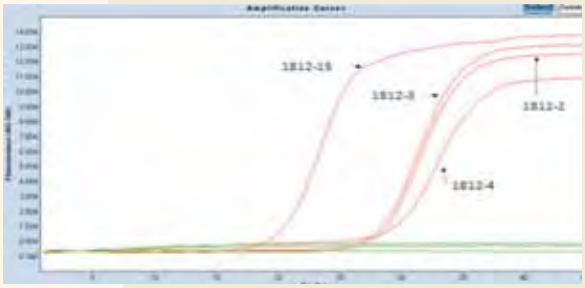


figure 43: Graphical representation of curves amplification of different P. savastanoï. strains

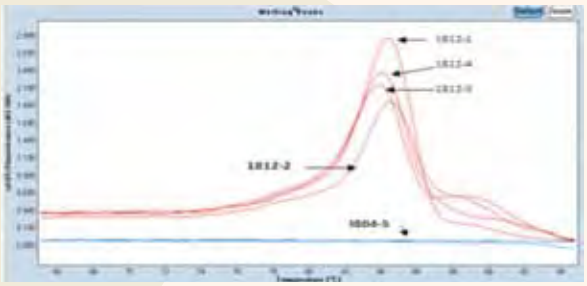


Figure 44: Graphical representation of melting curves of strains 1812 - 1, 1812 - 4, 1812 - 3, 1812-2 of P. savastanoï and 1804-5 (saprophyt).

Photo 7: Olive tree treated with glyphosate

Photo 8: Olive tree untreated

Figure 9: Sugarbeet plot treated with glyphosate

Figure 10 : Sugarbeet plot untreated

2. The analysis of genetic diversity of 28 date palm cultivars, through molecular markers, particularly for sex and bayoud resistance characters. The ISSR and RAPD markers helped the differentiation between each genotypes group of the same sex without discriminating between bayoud resistant and sensitive groups (Figures 45, 46).

3. The research of molecular markers to identify the great diversity among strains of *Fusarium oxysporum f.sp. albedinis* (W.L. Gordon). At the biological level, Fo albedinis strains are distinguished by a typical aspect and their variability for growth and sporulation characters. The molecular study revealed new RAPD and ISSR markers for characterization of the bayoud causal agent. These markers have revealed a significant polymorphism in the special form *albedinis* and consolidate the strains into two distinct groups. At the same time, the genetic distance between strains of *Foa* and *Fo* permitted to hypothesize on their common ancestral origin or derivation of the albedinis form of *Fo* (Figure 47).

Development of good cultural practices of citrus

Biological control of postharvest diseases of citrus fruits

The two antagonists Egm210 (genus *Burkhoderia*) and ZH2 (strain of *Bacillus subtilis* Ehrenberg) have shown an *in vitro* telling inhibitory action in vitro on the development of the trunk gummosis causal agent, *Phytophthora citrophthora* ((R.E. SM. & E.H. Sm.)) (Leonian) and *P. parasitica* (Dast). The effect of Emg210 was more pronounced on *P. parasitica.* However, the two agents have been ineffective in treatments suggesting their use for *in vivo* preventive control.

Selection of new bio-insecticides effective and environment friendly

Research on lethal and sub-lethal effects of biocides of plant origin indicates a high toxicity of the pink oleander, *Nerium oleander* (l.) on the adults of *Aphidius colemani*, with the same effect as the deltametrin.

Snail control in Gharb citrus plantations

Studies to develop an alternative strategy against snails of the genera *Theba* and *Helix* (Photo 11) have been conducted. Conclusive results were obtained by using a yellow plastic barrier around the trunk combined to the action of weeds destruction (Photo 12), the fixing of the plastic bottle top in the case of young plantations (Photo 13) improved by fixing a band induced by salt around the bottle edge (Photo 14).

Development of an integrated strategy of fire blight control

Research on fire blight, *Erwinia amylovora* ((Burrill) Winslow et al., emend.) ((Hauben et al.)) aimed the development of a strategy for effective control and without adverse environment effect. In this framework, prospection studies noted a strong progression of the disease. Molecular characterization showed low diversity in inspected populations, and the determination of the minimum inhibitory concentrations (MICS) found the possibility of this bacterium inhibition by the use of essential oils or hydrolats of some aromatic and medicinal plants. This result, if it is confirmed *in vivo* will give new opportunities for biological control of *E. amylovora,* causal agent of fire blight.

Codling moth pesticide resistance

Toxicological biotests conducted on strains of codling moth, *Cydia pomonella*, show that there is resistance to the deltamethrin in the population from Azrou. This result confirms the field observations. Investigations on the origin of this resistance exclude the genetic and enzymatic hypothesis.

Biological Tuta absoluta control

In a trial of greenhouse tomato culture, extracts of thyme and castor bean showed an obvious toxic effect on larvae in the L3 stage of *Tuta absoluta* (Meyrick). However, extracts of harmal, argan, nettles, henna and the yellow bugrane found no effect on larvae (Figures 48, 49).

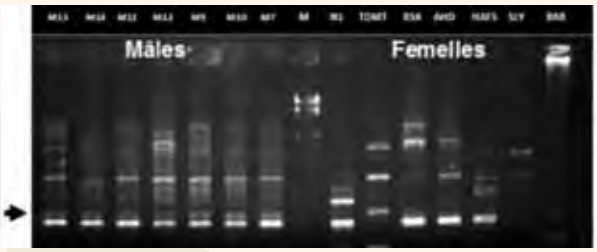


Figure 45 : Example of DNA polymorphism with regard to male sex character detected among date palm male and female genotypes by RAPD-C on aragose gel 1,4% M: marker of molecular weight Eco R1/Hind III, BAP. Arrows: Polymorph molecular markers.

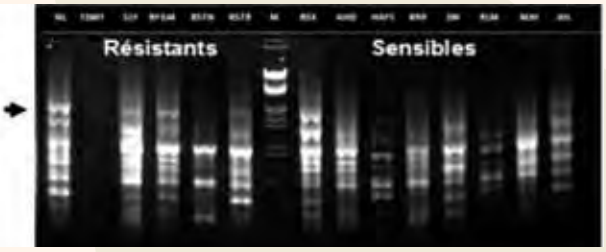


Figure 46 :Example of DNA polymorphism with regard to resistance character detected among sensitive and resistant date palm genotypes revealed by ISSR-Mic B amorce On aragose gel 1,4% M: marker of molecular weight Eco R1/Hind III, BAP. Arrows: Polymorph molecular markers.

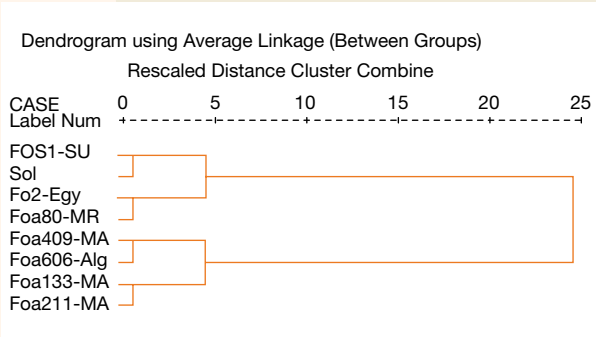


Figure 47: Dendrogram showing the genetic relationships between analysed strains of Fusarium oxysporum by the polymorphic bands combination generated by RAPD and ISSR techniques.

Photo 11

Photo 12

Photo 13

Photo 14

Photo 11: Rise of snails on tree
Photo 12: Yellow barrier against snails (caught snails under the barrier)
Photo 13: snail control test on young plant
Photo 14: Trap with a strip of salt around the trunk

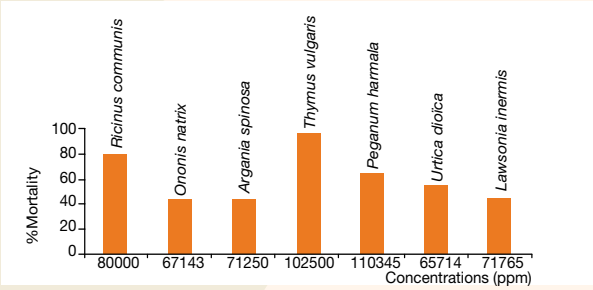


Figure 48 : Death rate of tuta absoluta larvae (72 hours after treatment (methanolic extract)

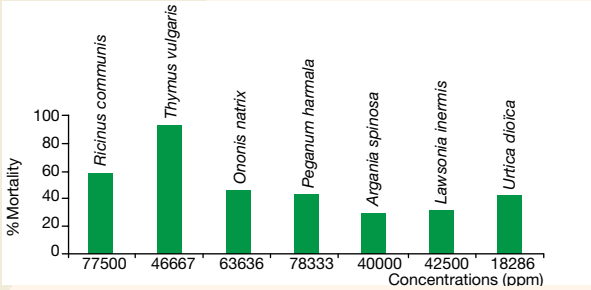


Figure 49 : Death rate of tuta absoluta larvae (72 hours after treatment "Ethanolic extract"

Eucalyptus psyllid in Amizmiz region

Studies on the biology of the Psyllid, *Glycaspis brimblecombei* (Moore), were achieved in Amizmiz after the recent appearance of this pest on a large part of eucalyptus plantations in Morocco. The results showed:

- Psyllid description and characterization in different larval stages,
- Psyllid cycle description: It is characterized by a peak of laying by the end of April and the existence of a second generation during the mid May and mid June period;
- Auxiliary fauna identification: It is characterized by the presence of several orders with dominance of Diptera and Hymenoptera

ANIMAL SCIENCES

New sheep breed "INRA180"

To increase sheep productivity in favorable agricultural zones, the new sheep breed called INRA180 was developed in El Koudia experimental field from a crossbreeding, over several generations, between the founding local breeds D'man and Timahdite, each one with 50% of genes. Today, it is considered as a sheep breed to disseminate for a large number of farmers (Photo 15).

Photo 15: INRA 180 ewe, lambs and ram

Evaluation of live animal carcass quality by ultrasound

Slaughtering was the primary means to objectively determine the carcass quality of animals (Photo 16). Today, the ultrasound technique is used to predict the carcass quality on live animals. For the first time in Morocco, INRA used the ultrasound technique to evaluate the carcass quality from objective measures on lambs of different genotypes fed on pasture and sheepfold.

A study on Timahdite, D'man and INRA180 lambs have shown that feed regime had a highly significant effect on the fat thickness and the *Longissimus Dorsi* muscle thickness and surface measured *in vivo* at the 13th coast of live lambs.

Data generated by ultrasound was verified by post-mortem measures and proved to be very accurate.

Photo 16: Carcass Vs Ultrasons Measures

Command of small ruminant reproduction

The study on the effect of temperature, time and concentration on the fresh semen conservation of Boujad Rams showed that these parameters had a highly significant effect on sperm conservation. The best sperm mobility (72,11%) has been recorded in the concentration 0.8 x 10^9 sperm/mL (Figure 50). Similarly, the interaction is highly significant between time and temperature. Indeed, the temperature 15 ° C ensures better conservation when it is a period from 2 to 8 h. However, for longer conservation (from 24 h) the temperature 5 °C ensures the best sperm mobility. It was concluded that it is possible to conserve the fresh Boujad Rams semen up to 48 h. For the temperature to adopt, it will depend on the desired conservation duration.

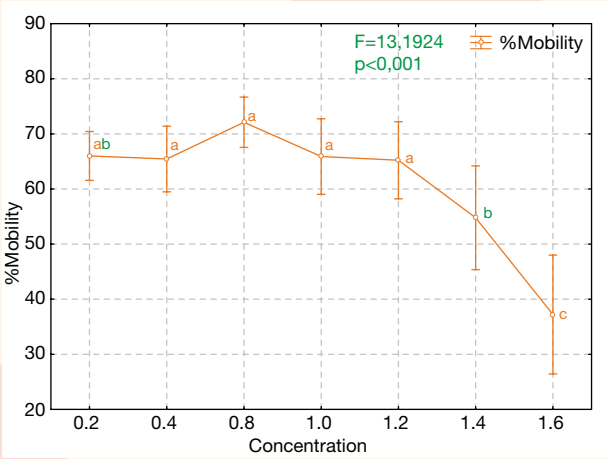


Figure 50: Variation of sperm individual mobility by concentration (109 sperm/ ml)

The study of the cervix anatomy of Boujad ewe taken in the slaughterhouse showed that the lengthier is the cervix, the more numerous are the cervical rings. This indicates that the artificial insemination success will depend on the col anatomy and specifically the folds number.

The study on the development and the validation of different "ELISA Sandwich systems" showed that the PAGs concentration is higher in ewes with multiple birth (double and triple) than those with a single birth. It appears that for the tested sheep, the values obtained by RIA exceed those obtained by ELISA, indicating that the ELISA technique, based on the PAGs measurements, can be an alternative to the RIA technique to diagnose early pregnancy in sheep.

Regarding the goats of the North, the comparison of 7 commercial diluers for goats semen conservation regularly evaluated up to 72 hours after harvest (Figure 51) has to conclude that the diluers "OviPro" and "Ovidill" allow to guarantee the best quality of conservation and sperm survival for artificial insemination.

Moreover, the "billy goat" use for synchronization and stimulation of goats reproduction, added to a female progestagen treatment can induce, during the period of seasonal anoeustrus, heat and ovulation with a good level of synchronization. This synchronization is compatible with two artificial inseminations to realize after 65 and 90 hours of the treatment's end.

Productivity of Draa goat in an accelerated rhythm

The accelerated rhythm production of Draa goat (3 kiddings in 2 years) has allowed average performance (71.8% of fertility and 1.47 kids/goat of prolificity in birth). Variation depending on the fertility season showed a decrease of Draa goat sexual activity in spring due to the heat incidence decline. Thus, the best prolificity is registered in spring which corresponds to October-November coupling period.

In terms of productivity, the Draa goat produces an average of 81 kg of milk by birth for a lactation period of 124 days on average, or an annual productivity of 122 kg of milk/goat. Similarly, the Draa goat weans 13.3 kg of live weight on average by birth, or an annual productivity of 20 kg.

Improvement of small ruminant feeding

The main results of trials on agricultural product valorization by feeding and their effects on animal product quality are:

- Grinding improves the digestive use of lupin grain and therefore the growth of fattening lambs.
- Lupin may be incorporated in kids ration at a rate of 35% of the concentrate ration without affecting meat quality.
- Sorghum grain can be incorporated up to 50% in the kids ration without negatively affecting their performance.
- The incorporation of flax, rich in linolenic fatty acid, in the fattening ration had no impact on meat content and adipose tissue content of fatty acid type Omega 3.

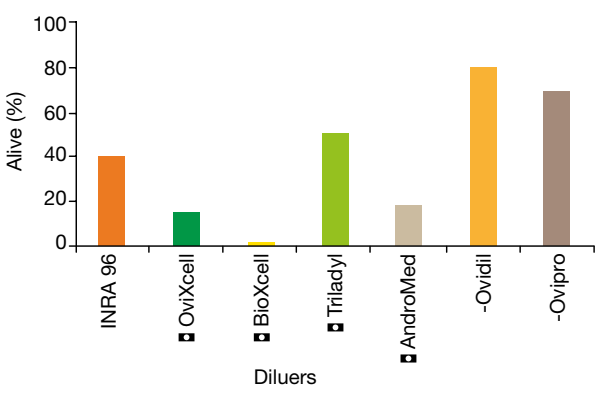


Figure 51: sperm survival after 72 hours in the different diluers

Photo 17: The goat of the North and kids

Photo 18: Draa goat feeding

RESEARCH FOR DEVELOPMENT

Farmer field school, an effective approach to technology transfer

Qualitative evaluation of the «farmer field school» approach (Photo 19, 20) adopted in the realization of the research and development program in Anougal Valley (High Western Atlas) on Apple, showed a gain in added value which was multiplied by 3, an efficiency in farmer capacitiy strengthening and sustainability in adopted learning and advising system.

Display trial, an effective means of technology dissemination

The results of trials on twelve wheat varieties installed in Sidi Allal Tazi experimental field showed a very interesting yield due to the control of production technical conditions.

For bread wheat, Aguilal variety has a very high yield followed by Amal and Arrehane varieties. For durum wheat, Irden and Karim varieties expressed the best performance.

The participatory demonstration in the framework of development projects

The results of the trials on wheat in Ain Sbit commune (Zemmour), under good technical practices produced very good yields of Achtar and Arrihane varieties. These trials were subject of demonstration days for the benefit of farmer communities subject of the integrated rural development project in bour zones (DRI-RPV).

Low pressure drip irrigation system, a promising option for mountain areas

The results of participatory research and development trials for conversion of the surface irrigation system to low pressure drip irrigation system on different crops in Tizi n'test mountain commune (Souss) have shown a water use efficiency about 100% with a doubling yield and a near-total weed reduction (Photo 21). This allowed an extension of areas and rapid adoption of this technology by the community. Note the important role that women have played in this adoption.

Photo 19 : Anougal young farmers training on apple tree pruning

Photo 20 : Young farmer of Anougal training other farmers

Photo 21 : Trial of drip irrigation in mountain areas: Tizi n'Test commune

Introduction of fodder mixtures

The results of participatory research and development trials to introduce in Tizi n'test community (souss region) mixtures of vetch/barley and pea feed/barley instead of barley have shown soil enrichment in mineral nitrogen and an improvement in organic matter rate and total nitrogen. It also improved the corn yield in rotation and leaf nitrogen content (Photo 22).

Photo 22 : Introduction trial of feed mixtures vetch/barley and forage peas / barley in Tizi n'test

Rangeland management improvement

In Khouribga province, the phosphate plateau rangelands based on *Atriplex nummularia* present two problems: the monoculture and the overgrazing. Trial results of three others atriplex species (*A. halimus, A. lentiformis* and *A. ainphibia*) during several years have shown that planting two or three species on the same land may be more appropriate for a sustainable use of improved land. In addition, the atriplex foliage maintains relatively high nitrogen content throughout the year and can be used as nitrogen supplement to poor fodder in case of need.

Photo 23 : Alley Cropping trials at Béni Ikhlef farmers (Khouribgha)

Alley cropping for arid zones

The study on the Alley-cropping introduction with forage shrubs in arid areas showed that fodder shrubs produced a relatively large biomass which results in substantial improvement in animal productivity. Indeed, farmers having accepted these introductions have been very satisfied by the achieved productivity. In addition, the study confirmed the ecological, environmental, agricultural and economic interests of Alley Cropping systems (Photo 23, 24).

Photo 24 :Farmers appreciating the Alley Cropping in Béni Ikhlef (Khouribgha)

Trial plus one: a technique for optimizing farmers technological level

The «Trial plus one» or «Trial + 1» aims to demonstrate the economic and technical effectiveness of each enhancement to a basic technical route. Various improvements are integrated

in a progressive manner allowing each farmer to choose the optimal technological level that suits their financial capabilities.

Trial results on wheat cultivated in Dehs soil in the Gharb plain showed that the simple change of Achtar variety by Arrehane variety can ensure a yield profit of about 3 q/ha, or 891 Dh/ha. Other benefits have been demonstrated by technical route improvements which resulted in earnings accumulation of 7.581 Dh/ha.

Water economy and valorization

The study results of average returns and the water valorization by crops in the Tadla perimeter showed that water valorization and net margin created per hectare are not always in pair. As a result, conciliation between interests of the community and those of farmers can be reached through an adequate incentive policy in accordance with the objectives of the new agricultural strategy, The Green Morocco Plan.

Simulations made by a model developed for the State incentives impact evaluation show that the developed model approximately reflects the reality and the importance attached by the Government to the water economy.

Next to the quantitative approach, stakeholders perceptions analysis confirmed the choice of localized irrigation as a solution to water scarcity. It has highlighted the importance of non-monetary benefits that were underestimated with only quantitative economic analysis.

Effective strategies for climate change adaptation

◆ The direct seeding is a substitution option to conventional till for climate change adaptation. In El Hajeb province, results of financial evaluation of this technique applied to wheat, from a view of project submitter (agricultural cooperative), showed that the internal rate of return (IRR) fluctuates between 17% and 19% for conventional till while this rate varies between 30% and 32% for the direct seedling option. Then, incentives for conversion to direct seeding system are amply justified.

◆ Concerning forms and strategies of adaptation to climate change in Ain Bni Mathar and Mérija rural communes (Eastern Morocco), farmers act as follows(Photo 25):

- the sale of part of their livestock, often at low prices, for buying food, often at high prices;
- Livestock clearance if drought persists;
- The practice of complementation;
- The use of forage crops (barley, oats and alfalfa) developed at the irrigated plots.
- The free farmers movement to other tribes' pastures even if, currently, there are binding limits between tribes.

Photo 25 : focus participatory groups Workshops with different categories of farmers and rural youth

COMMUNICATION & DOCUMENTATION

Main scientific, technical and institutional editions

«The Atlas of date palm in Morocco».

«The Atlas of cactus».

«The Cactus *(Opuntia spp.)*: a practical production techniques Guide».

«The eastern Moroccan steppe pastures.»

Wheat genetic options for climate change adaptation.

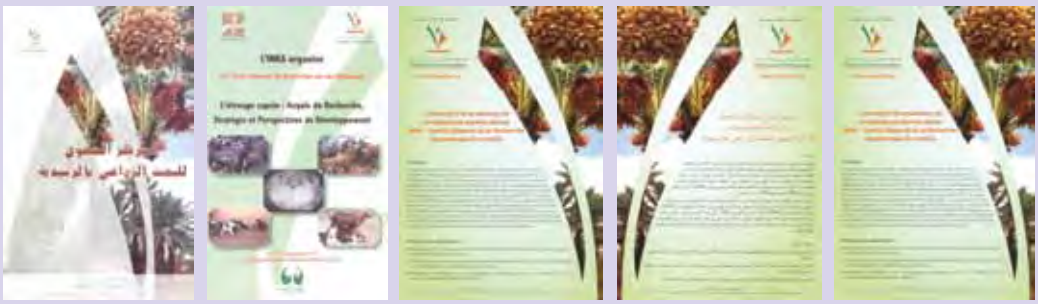
«Apple tree in Morocco».

Morocco Green Plan progress: INRA achievements in the period 2008-2010

Agenda 2012, with citrus as a theme for this year

INRA activity report 2010 in Arabic, French and English

wide range of brochures are designed for different scientific and technical events



Third edition of the cereal yield forecast bulletin published by INRA in partnership with the Joint Research Centre of the European Commission

The posthumous collection of scientific publications in homage to the late Abdelaziz EL HASNAOUI

Main scientific and technical events

INRA has taken part to several forums. The main events are :

Technical Committee of INRA; Board of Directors Meeting; SIAM, 2011; SIDATTES; JMA-FAO; SIFEL; IAVHII student Forum; ENAM student Forum; OLEA 2011; the seminar on Goats; Medinnovation 2011 (R & D Morocco); Surveyor World Congress; International Congress of the Argan tree, open field days and various scientific and technical seminars...

Photo 26 : Different events organised by INRA

Open field days for technology transfer

During the year 2011, INRA organized more than 190 events on more than 50 themes covering different fields that concern INRA achievements. More than 4500 people were present in those events, including managers and technicians of the MAPM, associations and cooperatives, as well as farmers, farmers'sons and rural women.

Press relations and media

INRA has multiplied its close collaboration with media, particularly by drafting and disseminating press releases and the passage on antenna of several interviews with officials and researchers. INRA also signed cooperation agreements with the Magazine PackAgro, Fellah Conseil SARL and Chada FM Radio. Similarly, an electronic journal named "Web Actualié" is diffused weekly to all institutions by mail.

Documentary management

- Subscription to 47 periodicals that are inventoried, treated and compiled to summaries bulletins widely diffused to INRA units.
- Budget endowment for CRRAs to meet needs of scientific documentation.
- Inter-institutional exchange of documentation: acquisition of approximately 30 books in addition to information bulletins and brochures and donation of the number 123-124 of the journal Al Awamia, distributed to 36 national and foreign organizations.

Services of the Central Library and archive

- Diffusion of agriculture web news.
- Preparation of local and international documentary databases and summaries bulletin.
- Assistance and guidance in bibliographic research.
- Management of online consultation of virtual libraries (local resources and AGORA database)
- Referencing and online publication of Al Awamia articles (http://webagris.inra.org.ma:120/agris).
- Referencing and online publication of a collection of technical books (15) (http://webagris.inra.org.ma:120/agris).
- Referencing and online publication of INRA researchers articles published in international journals (http://webagris.inra.org.ma:120/agris)

Network and Internet

- Hosting of scientific web sites relating to the soil fertility maps.
- Maintenance of 3 mailing lists: Staff, ACRA, and ADARA.
- Updating of the central site: particularly "Calls for tender, News, Agenda, Web-news and recently published.
- Websites for the CRRA Meknes, Rabat and Kenitra (Photo 27) : Preparation of functional and technical specification and following the various stages of implementation. The construction of Web sites for the CRRA of Tangier and Agadir are underway.

www.inra.org.ma/meknes

www.inra.org.ma/Rabat

www.inra.org.ma/kenitra

Photo 27 : Regional web sites

COOPERATION AND PARTNERSHIPS

International Cooperation

Organisms	Cooperation fields
ICARDA	- Genetic resources and natural resources
FAO	- SIPAM - MOSAICC
AIEA	Nuclear techniques
COI	- Genetic resources and olive oil
CRDI	- Water management - Climate change
BID	- Scholarships
UE (PCRD)	- Conservation agriculture - Genetics of small ruminants
Collaboration with various organizations ACSAD, OADA, AAAID	
Consortium Agreement on Crop Monitoring as an E-agriculture tool in developing countries ...	

Bilateral cooperation

USA (U. Arizona et U. Texas)	Memorandum of understanding and scientific exchange
France (PRAD)	Protection of plants, breeding, biotechnology, animal production and erosion.
France (CIRAD)	CA2AFRICA (No-tillage system and conservation agriculture).
Brazil	Memorandum of understanding and scientific collaboration in various fields (Botanical Garden, agricultural technology ...)
Belgium / Wallonie	Argan tree; Goat (FRAB)
Japon (JICA)	phytopathology
Algeriea (INRA)	framework agreement cooperation
Others : Mauritania, Tchad, Senegal, Italy and Indonesia.	

National Collaboration

Organisms	Cooperation fields
MAPM (PROFERD)	Various fields of R&D
Agrotech IAV HII CHA U. Ibn Zohr (F. Sciences)	Argan tree
DPA Kelâa des Sraghna	Cactus valorization
DRA Tanger-Tétouan ANOC Chamber of Agriculture Tanger-Tétouan	Goat
ANPVR	Cattle
CNRST National universities	Food Quality IPM (strawberry) bacteriology
National Meteorology Directorate DSS	Moroccan system of vegetation monitoring and agricultural yield forecasting «CGMS_MA»
National Center Mohammed VI for the Disabled	Supervision in agriculture of student with disabilities
National Society of highways	Slope protection Erosion control,
Hassan II Academy of Science and Technology U. Mohammed V Agdal U. Cadi Ayyad U. Ibn Tofail	Olive tree mycorhization
U. Mohammed V Souissi	Fields of common interest
U. Hassan II Mohammedia-Casablanca	Biotechnology, environment…
OCP Group	Various accompanying services
LESAFFRE company	Fertilization by yeasted must
Cali Maroc company	Herbicides
ATMAR company	Direct seedling
NADAR company	Dissemination of knowledge and technology
Fellah Conseil company	Communication and technology transfer

Photo 28 : Memorial photos of collaboration meetings

HUMAN AND FINANCIAL RESOURCE MANAGEMENT

Human resources

- The staff number of the year 2011 is 1.065 agents. (1.100 in 2010)
- The staff promotion concerned 162 officers (15%).
- Five amendments to the staff status
- 43 diploma courses
- 48 training mainly conducted in Europe (63%), funded by cooperation projects
- 93 missions abroad
- Training sessions in various thematic (desk-top computers, foreign languages, Audit, management control, GIS, biotechnology…)

Financial resources

The operating budget for the fiscal year 2011 was 144.333.050,00 Dh (Figure 52):

The budget of investment was 86.273.078,00 Dh. divided as follows:

- Mission support: 30.090.530,00 Dh
- Central administration: 12.138.182,00 Dh
- Regional centres of agricultural research 34.229.386,00 Dh
- Federating research programs 1.214.980, 00 Dh
- Project maps of soil fertility: 8.600.000,00 Dh

These credits were used for the realization of the following:

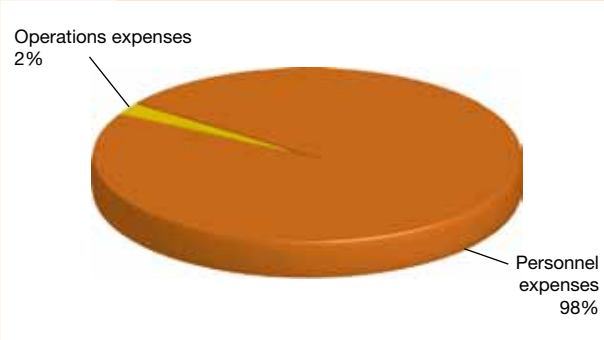


Figure 52 : operating budget

Central administration

- **Buildings:**

- Management: 300.000,00 Dh
- Construction : 64.182,00 Dh

- **Information, training and communication:**

- Purchase of computer equipment 1.530.000,00 Dh
- Purchase of software 620.000,00 Dh
- Subscription and documentation 822.000,00 Dh
- Training 1.794.000,00 Dh

- **Communication**

- Edition, seminars, workshops, membership organizations 7.008.000,00 Dh

Total Central administration:
12 138 182.00 Dh

Regional centers

- **Buildings / Investment**

- Building construction: 3.837.000,00 Dh
- Buildings management: 3.350.000,00 Dh
- Arrangement, construction and installation: 3.890.000,00 Dh

- **Equipments / Facilities**

- Wells construction and equipment: 1.075.000,00 Dh
- Greenhouses construction and equipment: 2.550.000,00 Dh
- Land planning: 900.000,00 Dh
- Irrigation planning: 400.000,00 Dh

- **Equipment**

- Purchase of scientific and laboratory equipment: 1.853.120,00 Dh
- Purchase of agricultural equipment: 1.580.000,00 Dh
- Purchase of irrigation equipment: 1.528.200,00 Dh
- Purchase of meteorological equipment: 351.200,00 Dh
- Office spplies : 985.000,00 Dh
- Purchase of computer equipment: 1.105.000,00 Dh
- Purchase of workshop equipment and other tools: 150.000,00 Dh
- Audiovisual equipment: 210.000,00 Dh

Total regional Centrs :
23.764.520,00 Dh*

** Without CRRA inputs and services*

Federative research programs

- Equipment: 547.900,00 Dh
- Supplies and services: 505.580,00 Dh
- Personnel costs: 161.500,00 Dh

Total :
1.214.980,00 Dh

Soil fertility maps project

Equipment:

- Purchase of scientific and laboratory equipment: 4.000.000,00 Dh

Services:

- Other: 4.600.000,00 Dh

Total :
8.600.000,00 Dh

INPUTS and SERVICES : 40.555.396,00 Dh

TOTAL GENERAL : 86.273.078,00 Dh

ACRONYMS & ABREVIATIONS

AAAID : Arab Authority for Agricultural Investment and Development
ACSAD : Arab Centre for the Studies of Arid Zones and Drylands
AGORA : Access to Global Online Research in Agriculture
AIEA : Agence Internationale de l'Energie Atomique
ANDZOA : Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier
ANOC : Association Nationale des Ovins et Caprins
ANPVR : Association Nationale des Producteurs des Viandes Rouges
BID : Banque Islamique de Développement
CIHEAM : Centre International des Hautes Etudes Agronomiques Méditerranéennes
CIMMYT : Centro Internacional de Mejoramiento de Maíz y Trigo
CIRAD : Centre de coopération internationale en recherche agronomique pour le développement
CMV : Centre de Mise en Valeur Agricole
CNRST : Centre National pour la Recherche Scientifique et Technique
COI : Conseil Oléicole International
COMADER : Confédération Marocaine de l'Agriculture et du Développement Rural
CRDI : Centre de Recherches pour le Développement International
CRRA : Centre Régional de la Recherche Agronomique
CT : Centre de Travaux
DDFP : Direction de Développement des Filière de Production
DEFR : Direction de l'Enseignement de la Formation et de la Recherche
DMN : Direction de la Météorologie Nationale
DPA : Direction Provinciale d'Agriculture
DRA : Direction Régionale d'Agriculture
DRI-MVB : Programme de développement rural intégré de mise en valeur des zones Bour
DSS : Direction de la Stratégie et des Statistiques
ELISA : Enzyme-Linked immunosorbent assay
ENAM : Ecole Nationale de l'Agriculture à Meknès
FAO : Food and Agricultural Organization
FST : Faculté des Sciences et Techniques
IAV : Institut Agronomique et Vétérinaire Hassan II
ICA RDA : International Centre for Agricultural Research in the Dry Areas
IFPRI : International Food Policy Research Institute
INRA : Institut National de la Recherche Agronomique
JAT : Jour après traitement
JICA : Japan International Cooperation Agency
JMA : Journée Mondiale de l'Alimentation
MAPM : Ministère de l'Agriculture et de la Pêche Maritime
MCGP : Moroccan Collaborative Grant Program
MOSAICC : Modelling System for Agricultural Impacts of Climate Change
MS : Matière Sèche
OADA : Organisation Arabe pour le Développement Agricole
OCP : Office Chérifien des Phosphates
ONG : Organisation Non Gouvernementale
ORMVA : Office Régional de Mise en Valeur Agricole
PAG : Protéines Associées à la Gestation
PAM : Plantes aromatiques et médicinales
PCR : Polymerase Chain Reaction
PCRD : Programme-cadre de recherche et de développement
PICCPMV : Projet d'Intégration du Changement Climatique dans la mise en œuvre du Plan Maroc Vert
PMV : Plan Maroc Vert
PRAD : Projets de Recherche Agronomique pour le Développement
PRMT : Programme de Recherche à Moyen Terme
PROFERD : Projets Fédérateurs de Recherche et Développement
RIA : Radioimmunoassay
SAR : Specific absorption rate
SCCF : Fonds Spécial pour les Changements Climatiques
SIAM : Salon International de l'Agriculture du Maroc
SIDATTE : Salon International des dattes à Erfoud
SIFEL : Salon International des Fruits et Légumes
SIG : Système d'Information Géographique
SIPAM : Système Ingénieux du Patrimoine Agricole Mondial
TRI : Taux de rentabilité Interne

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