

Trends in the Moroccan agricultural research: an exploratory bibliometric analysis (2005-2015)

S. ZEBAKH¹, R. ARVANITIS², H. BOUTRACHEH³, M. SADIKI⁴

(Reçu le 09/06/2017; Accepté le 17/06/2017)

Abstract

In Morocco, The national higher education and research system has been rapidly evolving during the last decades with new actors, series of new policies and research funding programs, along with a profound change in the overall economic and political context of the country. In the agricultural sector, since 2008, policy has relied on “Moroccan Green Plan”, a national strategy for sustainable development. Despite the significant efforts to develop the sector, further actions are needed to face the remaining challenges (population growth and rural migration, scarcity of resources and climate change, etc). Adoptions of innovation-driven policies as well as the introduction of modern technologies relying on valorization of research results become therefore a necessity. The objective of the study is to analyze the agricultural research publications in Morocco during 2005-2016 period based on SCOPUS database. It examines the growth of publications and citations, the collaboration patterns through coauthorship, the main productive institution and national and international collaborations. Thematic orientations, through an original classification adapted to the agricultural field, is analyzed and aligned to the priorities set by the national research strategy. This pilot study could be useful for policy makers, researchers and engineers in the country in order to devise indicators that focus on orientations, strengths and weaknesses of the agricultural research system.

Key words: Agricultural research, Publication productivity, R&D trend, Bibliometric study, Research governance.

Résumé

Au Maroc, le système national d'enseignement supérieur et de recherche a évolué rapidement au cours des dernières décennies avec l'apparition de nouveaux acteurs, de nouvelles politiques et programmes de financement de la recherche, accompagnant un profond changement dans le contexte général économique et politique du pays. La politique du secteur agricole repose depuis 2008, sur la stratégie de développement «Plan vert marocain». Malgré les efforts considérables déployés pour développer le secteur, plus d'actions sont nécessaires pour relever les défis croissants (croissance de la population et migration rurale, pénurie de ressources et changements climatiques, etc.). L'adoption de politiques axées sur l'innovation ainsi que l'introduction de technologies modernes reposant sur la valorisation des résultats de recherche deviennent donc une nécessité. L'objectif de cette étude est d'analyser les publications de la recherche agricole au Maroc au cours de la période 2005-2016, selon la base de données SCOPUS. Cet article examine la croissance des publications et des citations, les modèles de collaboration, les auteurs et les institutions les plus productives ainsi que les coopérations nationales et internationales. Les orientations thématiques identifiées selon une classification originale -adaptée au domaine agricole- seront également rapprochées aux priorités soulignées par la stratégie de recherche agricole. Ce travail constitue une étude pilote, tant pour les décideurs que pour les chercheurs et les ingénieurs du pays, afin de concevoir des indicateurs axés sur les orientations, les forces et les faiblesses du système de recherche agricole.

Mots clés: Recherche agricole, Production scientifique, Recherche développement, Étude bibliométrique, Gouvernance.

INTRODUCTION

Agriculture is one of the most important pillars of the Moroccan economy since it contributes to 17 % of GDP and has a major social role employing more than 70% of rural population. In 2008, the Moroccan Ministry of Agriculture and Maritime Fisheries implemented the “Moroccan Green Plan”, an ambitious strategy to develop the agricultural sector. This plan aims to boost economic growth of Moroccan agriculture and reduce rural poverty while ensuring sustainable food security (MAPM, 2014). It has various programs in terms of governance and development which rely on the strengths of the Moroccan agriculture¹ (Akesbi, 2006). However, the Moroccan agriculture is still facing several challenges among which

food security considering the population growth², scarcity of resources, climate impact on agriculture and rural migration (70% of total population in the 60's against 40% nowadays). Therefore, to face these challenges, there is an urgent need for innovation-driven policies as well as the introduction of modern technologies which can rely on valorization of scientific research results.

Moroccan Agricultural Research System (MARS) is characterized by the strong presence of traditional actors called “technical institution” belonging to the Ministry of Agriculture (MAMF) such as INRA, IAV, ENA, and ENFI. For decades, the universities belonging to the Ministry of Higher Education and Scientific Research (MHESR) carried out research in agriculture, resources management and environmental topics as confirmed by

¹ Renewable Water resources, specific microclimate, biodiversity, available agriculture infrastructures, human resources and geographical proximity with Europe.

² Moroccan population increased around 44 % passing from 20 million in 1980 to 34 million in 2016 (HCP website statistics 2017, www.hcp.ma)

¹ Direction de la Coopération, Partenariat et Développement, IAV Hassan II, Rabat, (Morocco). Email : Sanaa.zebakh@yahoo.com

² CEPED-IRD and IFRIS (France)

³ CNRST, IMIST, Hay Ryad, B.P. 8027, Rabat, (Morocco)

⁴ Département de Production Protection et Biotechnologie Végétale, IAV Hassan II, Madinat Al Irfane, Rabat, (Morocco)

their participation in various calls for research projects. The recent national calls for research, funded mainly by the MHESR (2010-2015) and OCP in 2014, funded 90 projects³ in areas related to agriculture for both research communities (universities and technical institution). On the other hand, a new dynamic for the national and Euro-Mediterranean research is observed after the launching of 5 transnational calls by ARIMNET and ERANETMED projects, respectively in the field of agriculture and water/energy. Moroccan funded proposals are 18 for ARIMNET and 15 for ERANETMED⁴. Moroccan participation to the EU framework program in Food, Agriculture and Biotechnology topics is 67 projects in FP6, 48 projects in 7FP and 6 projects in H2020⁵. Finally, the funding opportunities offered by PRAD program, lately named Toubkal, is seen as a pillar of bilateral cooperation with France since more than 86 projects are funded in agriculture between 2007 and 2017⁶.

Regarding the scientific production, few evaluation studies of the research system have been conducted in Morocco (Bouabid and Martin, 2009). The first evaluation of the Moroccan research system was conducted in 2001 with the support of the European Union leading to the definition of a 2025 research strategy by the MHESR. During this exercise, a bibliometric analysis was conducted completing the one presented by Waast and Gaillard (2000) in the study "sciences in Africa". The authors noted that during 1991-1997, the Moroccan scientific production has experienced a remarkable growth rate raking Morocco in 3rd position as African scientific producer after South Africa and Egypt (PASCAL and ISI databases)(Waast and Rossi, 2001).

Bibliometric analysis conducted for the period 1997-2001, using PASCAL database, showed that Moroccan production has almost doubled (1.9 times of the production during 1991-1997) noting the particular participation of young universities (Waast, 2008). Bouabid and Martin (2009) studied the trend of publications for different countries including Morocco from 1997 to 2006 using database of the Science Citation Index (SCI), now known as the Thomson Web of Knowledge. An average rate of growth of 5.3% per year is characterizing global Moroccan publications comparing to 30.0 % for Tunisia and 27.5 % for Algeria. The decrease in scientific production placed Morocco in 6th position in Africa in 2012 (IMIST, 2012).

The bibliometric studies specific to agriculture in Morocco are very rare and it was not possible for us to find any national or international recent publication considering exclusively Moroccan agriculture scientific publication analysis. In 2013, The Ministry of Agriculture conducted an evaluation of the Moroccan Agriculture Research System (MARS). Based on the governance and performance diagnostic of the technical institutions belonging to the Ministry, a strategic vision including actor's organization, guidelines for R&D priorities and programs to implement the strategy are proposed.

Our bibliometric study aims to draw a global picture of Moroccan scientific production in the field of agriculture, to analyze its different aspects, in particular the main "actors" of this scientific production, national and international collaborations and topics.

METHODOLOGY

This study considered all the records between 2005 and 2015, indexed in the address field of Scopus database with a Moroccan affiliation and with a subject matter of agriculture and veterinary sciences. The choice of Scopus was considered adequate since it provides a wide array of journals (Sánchez, et al., 2016). This corpus could be complemented with Web of Science as it is often suggested (Escalona Fernández et al., 2010). However, considering the results of various studies comparing Scopus and WoS in non-hegemonic countries like Slovenia or others (Bartol et al., 2014; Sánchez et al., 2016), and the fact that Scopus coverage is higher than WoS for the Middle-East and North Africa region (Hanafi and Arvanitis, 2016; Scopus Content Coverage Guide, 2016), we decided to base our work on this database.

The research fields of our interest are agriculture, biological sciences related to agriculture, as well as veterinary sciences. It is very difficult to define the scope of agriculture using keywords and combination of keywords which may not always cover the entire gamut of literature on agriculture and there is always a possibility of missing some publications (Sagar et al., 2014).

The corpus was identified using selective search on Moroccan affiliations, SCOPUS classification fields, specific journals related to agriculture, and combination of keywords for agricultural and veterinary (A&V) fields⁷. Publications dealing with medicine and other basic sciences (Chemistry or Physics and Astronomy) are removed and combined filters (disciplinary fields and keywords) were applied to improve the quality of the final corpus. We used the Sci2 for data preparation and Gephi for analysis and visualization of different collaboration networks (Yifan Hu algorithm).

RESULTS AND DISCUSSION

Production and citations of Moroccan scientific production in agriculture and veterinary sciences (A&V)

Table 1 shows the overall production of articles in SCOPUS with at least one Moroccan affiliation address. It also shows the scientific production in the Agricultural and Veterinary (A&V) fields according to the identified corpus. The share of A&V sciences in the Moroccan publications varies between 16.8 % and 8.7% (Table 1). The average share for the studied period was 10.5 % which is the same range of the one reported by the evaluation study carried in 2001⁸ (9% and 12% for the period from 1997-2001) (MESRSFC, 2003).

³ Sources: www.cnrst.ac.ma

⁴ Sources: www.arimnet2.net and www.eranetmed.eu

⁵ Sources: List of Moroccan projects communicated to SZ author in 2016.MHESR. .

⁶ Sources: : <http://www.campusfrance.org> and list of Toubkal project communicated to SZ author in 2016. CNRST

⁷ Such as agricultur * OR biotechno * OR irrigat * OR fertiliz * OR pesticid * OR forestr * OR crop * OR wheat OR fungi

⁸ The first evaluation of the national research system has been conducted in 2003 in the framework of Moroccan- European Commission (DG-Research) collaboration (agreement signed in 2000).

Figure 1 shows the growth of published documents in a ten year period (2005 to 2015), by major fields of science according to SCOPUS classification. The highest increase in number of publications concerned medicine (+234 %), which represents 30 % of the total Moroccan publications. Agriculture and veterinary sciences grew at a steady rate from 233 publications in 2005 to 411 publications in 2015. From previous evaluation in Morocco, agricultural sciences are a low-producing field, and its rate of growth has always been slower than the basic sciences (Rossi and Waast, 2007; MESRSFC, 2003). Nonetheless, we observe that A&V sciences as a whole have been overtaken by environmental sciences since 2013, supported by numerous national calls dedicated to environment.

Although the production in the last decade (2005-2015) grew less in A&V than other disciplines, we observe a rather steady growth since 2010 with less yearly fluctuations (Table 1). A total of 3 282 publications were published in A&V during 2005-2015 by Moroccan scientists.

Moroccan publications received 30 191 cumulative citations during the last decade. The publications and citations per year are given in table 2.

We note a large number of citations for two publications in toxicology in 2007 and 2008 that are considered as a reference material for a great number of natural objects. Thus, 2007 and 2008 appears to have a very high total number of citations; one single publication was cited 452 and 1906 times, respectively since their publication year.

Table 1: Moroccan scientific production in SCOPUS (2005-2015)

YEARS	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
All disciplines	1385	1529	1650	1893	2252	2530	3045	3601	3978	4783	4633	31279
Agriculture & Veterinary (A&V)	233	224	237	283	249	239	293	329	368	416	411	3282
% of total records	16.8	14.6	14.3	14.9	11.0	9.4	9.6	9.1	9.2	8.7	8.8	10.5

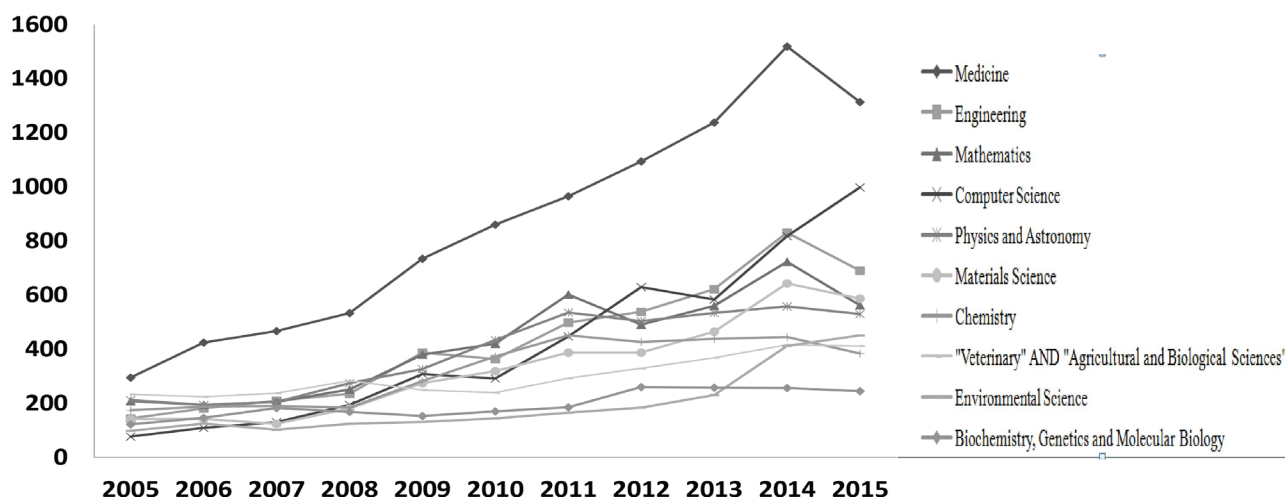


Figure 1: Moroccan publication according to SCOPUS classification (2005-2015)

Table 2: Number of publication and citations (2005-2015)

Years	Publications P	Citations / year
2005	233	40
2006	224	241
2007*	237	546
2008*	283	993
2009	249	1540
2010	239	2083
2011	293	2653
2012	329	3373
2013	368	3998
2014	416	4987
2015	411	5381
Total	3282	25835

* 2 publications considered as outliers are removed in 2008 (1906) and 2007 (452).

Most prolific institutions

During the period of the study, the most prolific institutions are UCA and UM5 contributing to 34% of total production, followed by technical A&V institutions IAV and INRA contributing by 18.8 % (Table 3).

Universities contribute to 78 % of the total scientific publications in agricultural and veterinary fields, research institutions (INRA, INRH, CRF, INH..) by 16.6 and engineering schools (IAV, ENAM and ENFI) by 13.2 % (Table 4).

Regarding the participation of technical institutions of the Ministry of agriculture (MAPM), we note that IAV contribution was highest with 331 articles (46%) followed by INRA with 285 records (40%). The total contribution of technical agricultural institutions in this corpus is 716 publications corresponding to 21.8 % of total Moroccan scientific production (Figure 2).

Language and sources of publication

Articles written in english account for 86.9 % of total records and french papers represent 12.1 % of articles (Table 5). The predominance of english can be explained by both the international prominence of this language in scientific publications, but also it is a bias of Scopus that does not include many local journals (Vargas et al., 2011) or journals in Arabic. Arabic is less present in the promotion system, in the publication and circulation of knowledge and in the way policy is conducted in Arab countries as mentioned by Hanafi and Arvanitis (2016). In the case of Morocco, a very important particularity is that A&V research published locally is often published in french, but Scopus does not yet include these local

journals in Agricultural and Veterinary sciences (Revue Marocaine des Sciences Agronomiques et Vétérinaires produced by IAV, Al Awamia journal produced by INRA and Alternatives Agricoles by ENAM).

Table 5: languages of publication

Langue	Number of publication	(%)
English	2904	86.9
French	405	12.1
Spanish	23	0.69
Arabic	1	0.0002
Others (Italian, German,..)	8	0.06

The corpus we gathered was published in 907 journals and some journals are more frequently used than others. 98 records were published in *Acta Horticulturae*, 75 in *PLOS One*, many articles were published in the highly prestigious *Compte-rendus de l'Académie des sciences* in geology (56) and biology (28). We found some “predatory journals” (classified in the defunct Beall listing) also to be present in the listing, though not so many (Table 6).

In total, 156 source journals have more than 5 publications in the last decade. We observe that 435 journals present only one article (48%) and 167 journals 2 publications (18% of total journals). This relatively high variety seems to indicate also a diversity in subject fields. Some quasi-internal journals such as CIRAD's (French Agronomic Institute present in Morocco) are still present (41 articles) but losing ground. Some regional journals are also men-

Table 4: Type of most productive national institution in A&V

Type of institutions	Number of institutions	Number of publications	% of total Publications
Universities	15	2564	78.1
Research centers	6	545	16.6
Engineering schools	4	433	13.2
Private university	1	20	0.6
Others	5	48	2.0

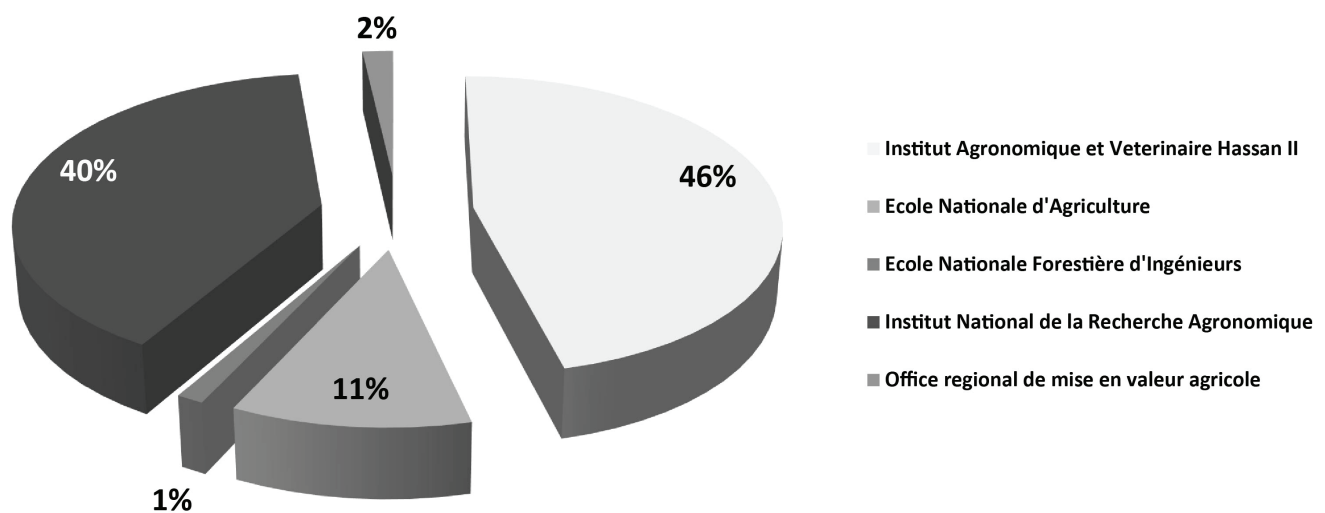


Figure 2: Contribution of agricultural technical institution

Table 3: List of most prolific institutions regarding the number of publication in A&V

AFFILIATION	A&V Publications (P)	% of total P (3282)
Université Cadi Ayyad, Marrakech (UCA)	599	18.3
Université Mohammed V, Rabat (UM5)	514	15.7
Institut Agronomique et Vétérinaire Hassan II (IAV)	331	10.1
Institut National de la Recherche Agronomique (INRA)	285	8.7
Université Abdelmalek Essaadi, Tétouan (UAE)	227	6.9
Université Ibn Tofail Kénitra (UIT)	178	5.4
Université Sidi Mohamed Ben Abdellah (USMBA)	157	4.9
Université Ibn Zohr ,Agadir (UIZ)	138	4.2
Université Moulay Ismail, Meknès (UMI)	135	4.1
Université Hassan II, Casablanca (UHII)	126	3.8
Université Chouaïb Doukkali, El Jadida (UCD)	121	3.7
Université Ain Chock, Casablanca (UAC)	119	3.6
Université Mohammed Premier, Oujda (UM1)	95	2.9
École Nationale d'Agriculture de Meknès (ENAM)	78	2.4
Université Hassan 1 ^{er} , Settat (UH1)	78	2.4
Institut National de Recherche Halieutique (INRH)	71	2.2
Université Sultan Moulay Slimane (UMS)	59	1.8
Institut Pasteur du Maroc (IP)	57	1.7
Centre de Recherche Forestière (CRF)	51	1.5
Institut National d'Hygiène (INH)	50	1.5
CNESTEN	31	0.9
Al Akhawayn University (AUI)	20	0.6
Ministry of Health, Morocco	19	0.6
Centre Hospitalier Universitaire Ibn-Rochd	18	0.6
INSAP	15	0.5
Ibn Sina Hospital, Agdal Rabat	13	0.4
Office Régional de Mise en Valeur Agricole	13	0.4
Centre Minier de Khouribga	12	0.4
Faculté des Sciences (NI)	10	0.3
École Nationale Forestière d'Ingénieurs	9	0.3

Table 6: List of 45 journals with Moroccan publication in agriculture recording more than 13 publications (2005-2015)

Sources	H Index	SJR	Publication (P)	% total (P)	Citation (C)	Non cited (P)	Average (C)
<i>Bioresource Technology</i>	2.33	193	16	0.49	460	0	28.8
<i>Food Chemistry</i>	1.62	169	27	0.82	550	0	20.4
<i>Agricultural Water Management</i>	1.55	71	16	0.49	625	1	39.1
<i>Food Control</i>	1.52	75	16	0.49	464	0	29.0
<i>Palaeogeography, Palaeoclimatology</i>	1.50	112	19	0.58	284	0	15.0
<i>PLoS ONE</i>	1.40	181	75	2.29	749	2	10.0
<i>Journal of Agricultural and Food Chemistry</i>	1.25	216	19	0.58	408	0	21.5
<i>Industrial Crops and Products</i>	1.06	76	23	0.70	125	1	5.4
<i>Hydrobiologia</i>	1.04	100	14	0.43	223	1	15.9
<i>Comptes Rendus - Geoscience</i>	0.94	54	56	1.71	670	7	12.0
<i>Environmental Earth Sciences</i>	0.76	76	26	0.79	122	4	4.7
<i>Scientia Horticulturae</i>	0.73	68	19	0.58	206	1	10.8
<i>Euphytica</i>	0.69	75	13	0.40	178	2	13.7
<i>Small Ruminant Research</i>	0.61	57	15	0.46	126	2	8.4
<i>Comptes Rendus - Biologies</i>	0.55	64	28	0.85	278	3	9.9
<i>Journal of North African Studies</i>	0.53	15	25	0.76	40	16	1.6
<i>Phytopathologia Mediterranea</i>	0.49	31	13	0.4	36	2	2.8
<i>Grasas y Aceites</i>	0.46	32	13	0.4	104	1	8.0
<i>International Journal of Agriculture and Biology</i>	0.42	21	19	0.58	213	1	11.2
<i>Acta Biotheoretica</i>	0.42	25	15	0.46	20	6	1.3
<i>Arabian Journal of Geosciences</i>	0.42	16	21	0.64	161	9	7.7
<i>Irrigation and Drainage</i>	0.41	27	21	0.64	161	2	7.7
<i>Desalination and Water Treatment</i>	0.39	26	40	1.22	107	8	2.7
<i>EPPO Bulletin</i>	0.38	22	14	0.43	27	3	1.9
<i>Quaternaire</i>	0.37	22	14	0.43	54	5	3.9
<i>Acta Botanica Gallica</i>	0.36	23	33	1.01	75	8	2.3
<i>Natural Product Research</i>	0.35	34	28	0.85	150	6	5.4
<i>Natural Product Communications</i>	0.35	26	43	1.31	240	5	5.6
<i>Arabian Journal for Science and Engineering</i>	0.35	20	26	0.79	57	14	2.2
<i>African Journal of Biotechnology</i>	0.30	56	48	1.46	1165	12	24.3
<i>Estudios Geologicos</i>	0.29	18	14	0.43	40	1	2.9
<i>Water Quality Research Journal of Canada</i>	0.26	35	13	0.40	31	0	2.4
<i>Biotechnology, Agronomy and Society</i>	0.25	22	24	0.73	126	8	5.3
<i>Procedia Engineering</i>	0.24	23	27	0.82	40	17	1.5
<i>Revue de Médecine Vétérinaire</i>	0.23	25	17	0.52	36	9	2.1
<i>Cahiers Agricultures</i>	0.21	12	41	1.25	127	7	3.1
<i>Journal of Mobile Multimedia</i>	0.21	5	13	0.4	110	11	8.5
<i>Fresenius Environmental Bulletin</i>	0.20	30	15	0.46	49	5	3.3
<i>Livestock Research for Rural Development</i>	0.20	18	19	0.58	15	14	0.8
<i>Alauda</i>	0.18	12	16	0.49	31	6	1.9
<i>Scien. Study and Res.: Chem. and Chem. Eng, Biotech, Food Industry</i>	0.18	3	13	0.4	14	8	1.1
<i>Acta Horticulturae</i>	0.17	42	98	2.99	129	49	1.3
<i>Annales de Biologie Clinique</i>	0.16	23	13	0.4	40	14	3.1
<i>Revue des Sciences de l'Eau</i>	0.14	18	16	0.49	32	4	2.0
<i>European Journal of Scientific Research</i>	0.13	30	63	1.92	121	36	1.9
<i>BioTechnology: An Indian Journal</i>	0.10	3	13	0.4	3	11	0.2
Sub-Total	-	-	1170	35.6	9022	322	-
866 remaining journals	-	-	2112	64.4	23522	425	-
Total	-	-	3282	100.0	32555	747	-

tioned, such as the *African Journal of Biotechnology* or the *Arabian Journal for Science and Engineering*. Some also long standing older journals, such as *Acta Botanica Gallica* and similar, are also mentioned. Interestingly, the more cited papers appear not only in these old or among the famous journals (such as *PLOS*) but also mainly in some fields such as Toxicology. We notice that 747 publications are never cited (22.7% of the total records), not even as self-citations. The ranking of journals differs when considering the number of citations, and also according to two different indicators, like the SJR⁹ or H index.¹⁰ *Food and Chemical Toxicology Journal* is ranked 99 with only 7 publications during 2005-2015.

However, taking into account the total citations for these 7 papers, the journal is ranked first of the sources list with 2461 citations highlighted by 2 publications cited respectively in 2008, 1906 times and a second paper in 2007 cited 452 times. Those 2 publications are of a review type. *The African Journal of Biotechnology* received the second larger number of average publication followed by *Plos One* in the third position with 749 citations.

Authorship patterns

The analysis revealed that 96.2 % of the publications are multi authored and 124 contributions (3.7%) are signed by one author at national level. Collaboration between

⁹ SJR indicator is a measure of scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where such citations come from

¹⁰ The h-index is an author-level metric that attempts to measure both the productivity and citation impact of the publications of a scientist or scholar. The index is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications.

authors, examined through authorship, is increasing since 2010. It is confirming the tendency of scientists toward increasing institutional collaboration such as creation of networks through public incentives, international collaboration through calls, national grants to universities encouraging partnership. The degree of collaboration¹¹ (C) is ranged between 0.92 and 0.98 at the highest (Table 7). Coauthorship papers increased by 44% from 2010-2015 (Figure 3).

Most productive authors were ranked in terms of their productivity based on the cumulative number of publications during 2005-2015. The top position was occupied by M. Kupper (CIRAD-IAV), a french researcher based in a Moroccan institute of agriculture and veterinary sciences (IAV), with 46 publications. M. Hafidi (UCAM-URAC32), professor at the University of Marrakech collaborating with a French associated research unit, was second ranked with 43 publications followed by professor Z. Charrouf from the University of (UM5) with 31 contributions. We note that international collaboration through joints research units or resident experts could be a support to increase scientific production in indexed journals as it is the case with french institution (Table 8).

Considering the 25 most productive authors, 36% are affiliated to foreign institutions (French and Spanish). The close linkages of french and Moroccan scientists is thus very visible, as well as the predominance, today, of the universities in scientific production.

¹¹ C: The degree of collaboration is defined as the ratio of the number of collaborative research papers to the total number of research papers in the discipline during a certain period of time.

Table 7: Evolution of collaboration between agricultural sciences researchers

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Coauthored papers	224	214	232	276	244	221	283	317	353	406	399	3169
Single authors	9	10	5	7	5	18	10	12	15	10	12	113
Total	233	224	237	283	249	239	293	329	368	416	411	3282
Degree of collaboration (C)	0.96	0.96	0.98	0.98	0.98	0.92	0.97	0.96	0.96	0.98	0.97	-

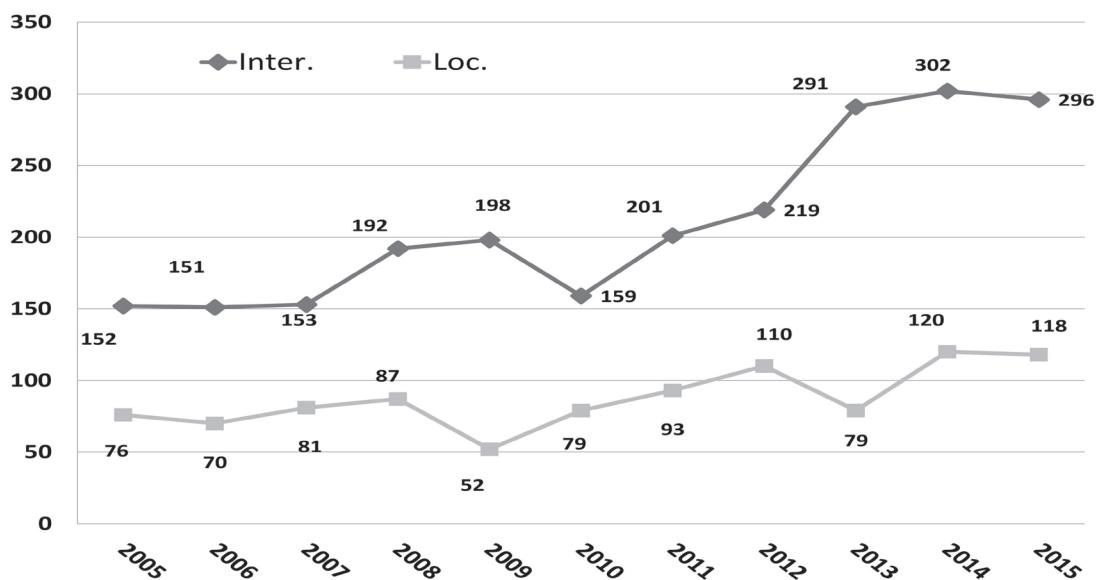


Figure 3: National and international collaborations

Table 8: Affiliation of 25 most productive authors (2005-2015)

Auteur	Publications	% of total	Affiliation 1	Affiliation 2
Kuper, M.	46	1.4	CIRAD, UMR G-Eau	IAV Hassan II
Hafidi, M.	43	1.3	UCA	CNRST, URAC32
Charrouf, Z.	31	0.9	UM5	
Guillaume, D.	29	0.9	Université de Reims-C-A	
Khadari, B.	28	0.9	INRA, UMR 1334 France;	
Rhazi, L.	26	0.8	UHII	
Boujenane, I.	25	0.8	UHII	
Er-Raki, S.	24	0.7	UCA	IRD
Chehbouni, A.	23	0.7	CESB, U.Toulouse, CNRS, IRD, CNES	
Zinedine, A.	23	0.7	INH	
Fahd, S.	22	0.7	UAE	
Satrani, B.	22	0.7	CRF	
Abbad, A.	21	0.6	UCA	
Abrini, J.	21	0.6	UAE	
Duponnois, R.	21	0.6	LSTM, IRD, France,	CNRST, URAC 32, UCA
El Hadrami, I.	21	0.6	UCA	
Hanane, S.	21	0.6	CRF	
Slimani, T.	21	0.6	UCA	
Duchemin, B.	20	0.6	CESBIO, U.Toulouse, CNRS, CNES, IRD	
Faysse, N.	20	0.6	CIRAD, G-EAU, France,	ENA, Meknès, Morocco
Khabba, S.	20	0.6	UCA	
Kodad, O.	20	0.6	CITA Aragón, Spain	INRA, Morocco
Chaouch, A.	19	0.6	UIT	
ChoukrAllah, R.	19	0.6	IAV Hassan II- CHA	
Gharby, S.	19	0.6	UM5	

Table 9: International co-authorship by countries in Moroccan A&V publications

Country	Co-authorship	%	Country	Co-authorship	%
France	1117	34.0	Netherlands	55	1.7
Spain	531	16.2	Australia	47	1.4
United States	196	6.0	Switzerland	47	1.4
Italy	179	5.5	Turkey	45	1.4
Tunisia	161	4.9	India	44	1.3
United Kingdom	140	4.3	Senegal	37	1.1
Belgium	138	4.2	Syrian Arab Rep.	36	1.1
Germany	133	4.1	Austria	34	1.0
Algeria	116	3.5	Egypt	32	1.0
Portugal	114	3.5	Greece	32	1.0
Canada	110	3.4	Denmark	29	0.9
Others (110 countries +18 undefined)	698	21.3	UAE	26	0.8

International collaboration

Table 10 shows that 71 % of the publications are coauthored with scientists affiliated to foreign countries and 29% submitted by a local Moroccan affiliation. The rate of international collaboration is growing since 2007 (Figure 3) which could be attributed to the increasing Moroccan participations in international projects, in particular in EU-funded projects (FP6 and FP7) in Food, agriculture and biotechnology projects (67 projects within FP6, and 48 projects in 7FP) (Zebakh and Finance, 2017).

Table 10: Co-authorship and citations

	% Articles	H-Index	Cit/Pub.
International co-authorship	71%	62	12,5
Only national affiliations	29%	28	4,6
Total A&V	100%	63	10.0

A large increase of coauthored papers occurred in the last years. Moroccan scientists cooperate more frequently with French counterparts (Figure 4). 1117 papers involved

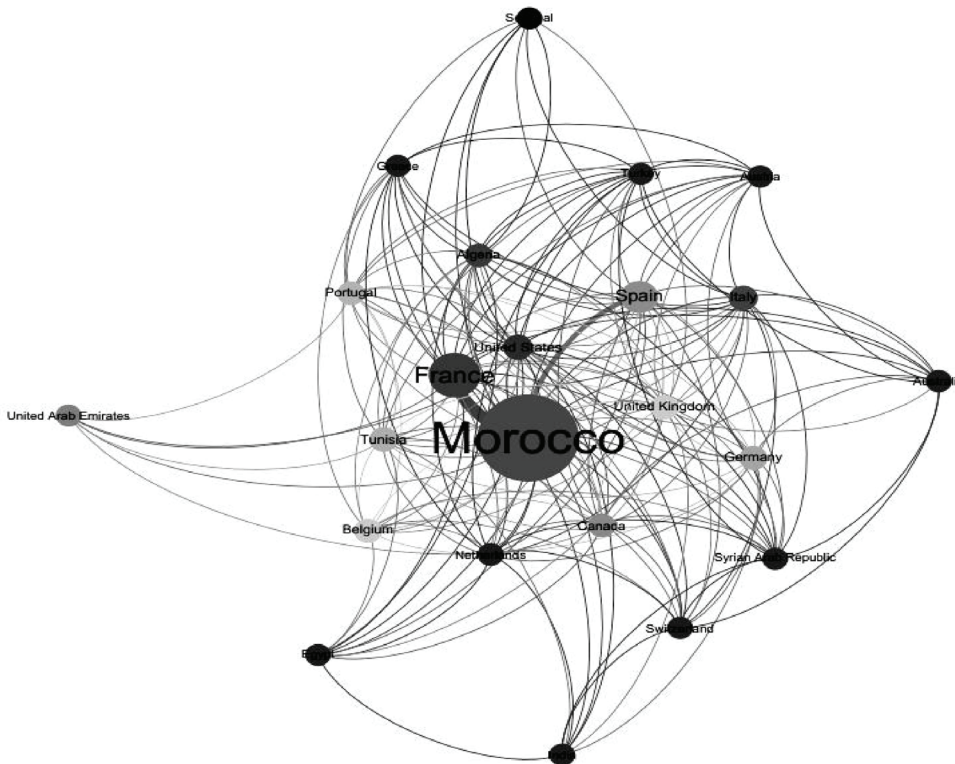


Figure 4: Morocco’s main partner countries in agricultural sciences coauthored publications indexed in Scopus (2005-2015)

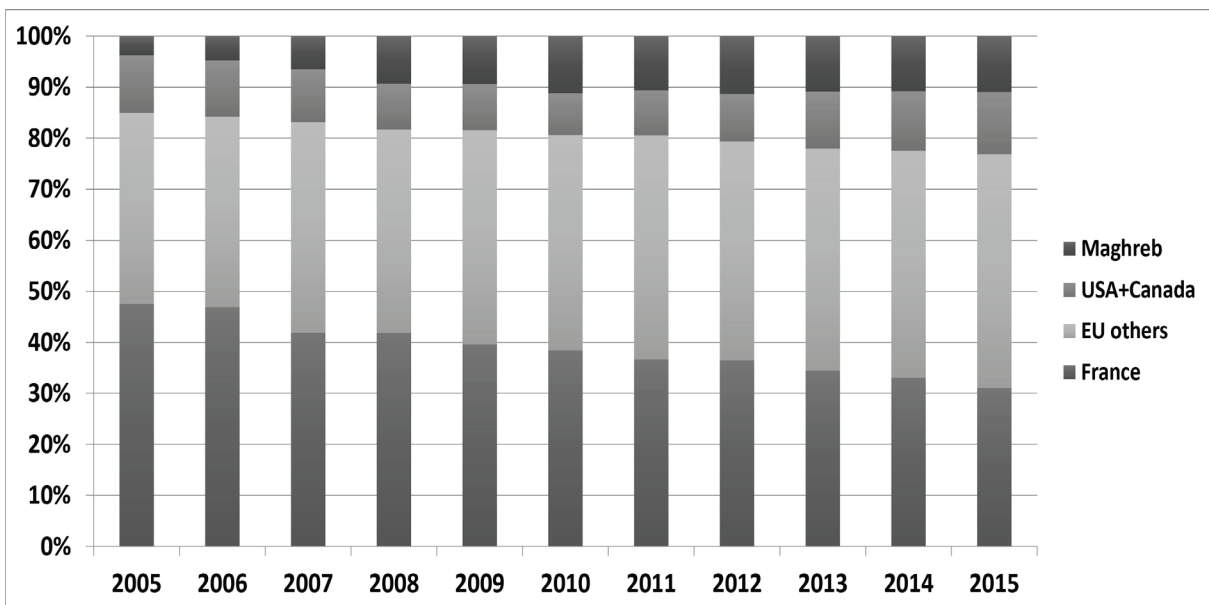


Figure 5: Evolution of publication partnership

French scientists (34%) followed by Spanish researchers contributing in 531 records (16%). United States and Italy collaboration represent 5% approximately of the coauthored articles. Other countries such as Tunisia, UK, Belgium and Germany are present in smaller proportions (4%) and Algeria, Portugal and Canada (3%) (Table 9).

The remarkably high numbers of coauthored papers with French is the conjunction of at least three different phenomena. First, France has devised a large number of cooperation agreements and funding instruments with Maghreb countries, and in particular with Moroccan institutions. There are 73 funded projects for the Moroccan-French bilateral program called PRAD, dedicated to Agriculture and Development, followed by 14 projects in Toubkal. Second, France has been promoting joint projects with Morocco in various European projects, making France the first partner of Morocco in FP6 and FP7 participation. Third, language plays a very important part, and is not captured by these statistics.

The second ranked country is Spain with 16% of total co-authorships due to historical collaboration and the bilateral program PCI between MHESR and Spain agency for international cooperation and development.

We also find that international co-authored articles receive substantially more citations than articles with authors solely with national affiliations (Table 10). A more precise analysis is needed to identify the reasons for this result that has also been reported in many publications (for a review, see chapter 1 of Gaillard and Arvanitis, 2013). In our case, we believe that articles are the product of collaborative projects either funded by bilateral cooperation or by international and EU programmes. They also indicated a much more active international scientific community, mainly based in national universities.

The relative weight of collaborations, measured through co-authorships, are steadily decreasing with France while increasing for other EU countries, mainly Spain (Figure 5). Maghreb (Tunisia and Algeria, in that order) and North America (US & Canada) co-authorships remain constant in relative terms, although co-authorships is growing in absolute terms. A survey conducted by the Moroccan CNRST in 1996 showed that out of 1071 scientific collaborations identified by the survey, more than 80% were engaged with a French partner, out of which 50% were in agricultural sciences (Kleiche, 2002). A study carried out in 2014 (Zebakh and Finance, 2017) on the Moroccan participation to the EU FP7, confirmed the same tendency.

National collaborations

The national collaboration networks reveal a dense central nucleus. Figure 6 reveals the major scientific players in the field (the most significant / visible of this corpus) as well as the importance of the scientific collaborations that they maintain in this field. We observe the importance of certain institutions in the national scientific production and the higher collaboration between technical A&V institutions (IAV and INRA) and universities (UCAM, UM5, UH2, UAE, USMBA, UIT, UIZ ...). This last trend reveals a very significant

change in the way research in A&V is done in Morocco. Universities (UCAM and UMV) are the main sites of research production in A&V fields. Nevertheless, important collaborations with technical institutions such as IAV and INRA are created as displayed in figure 6.

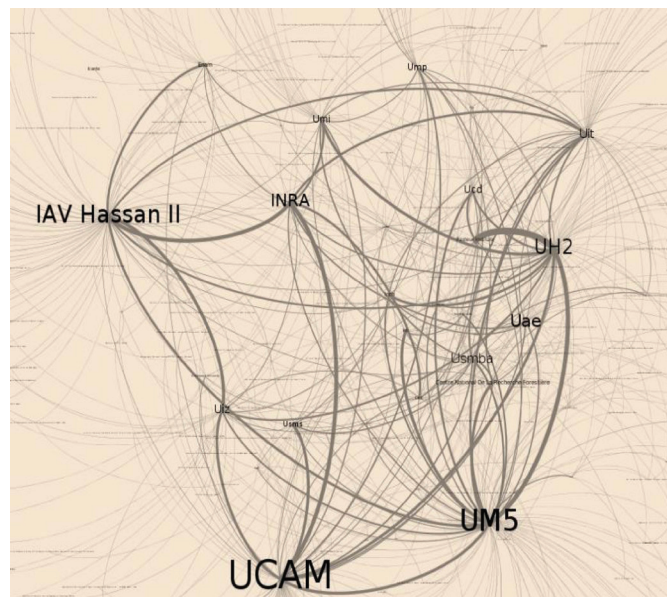


Figure 6: Collaboration network between national actors of agriculture and veterinary sciences

Publication by topic

SCOPUS content is classified under four broad subject categories namely life sciences, physical sciences, health sciences and social sciences & humanities, which are further divided into 27 major subject areas and 300+ minor subject areas (Scopus, 2016). Table 11 presents the Moroccan A&V production under this classification for the period 2005-2015. In this manner, we can see various basic orientations that exist in the A&V literature. First, the two main subject areas are environmental sciences which correspond also to the main subject areas of international research projects with the EU, and molecular biology, genetics and other topics which have been a national priorities. Second, we find many articles also classified in various other disciplines from basic sciences and engineering. The predominance of earth and planetary sciences is related to research on the climate change impacts; medicine and immunology relate to diseases in animals and research in veterinary sciences. Third, we were interested by the presence of social sciences which indicates some strong interest in societal challenges and closer analysis of social and human impact on research.

However, we tried to classify the 3282 publications according to main topics of interest in agriculture and animal sciences (Table 12). According to this coding, the greatest interest of research is oriented towards water (845 publication), biotechnology (842) and soils (723), followed by plant health and food industry. Veterinary sciences and dairy represents 16 % of total publications. The social sciences topics rank just after veterinary sciences, a high position considering that we have practically no social science journals in the sample. Also, topics of traditional agronomic studies (cultivation practices, Plant health, Tree culture, Horticulture, Farming techniques, fertigation, Cereals, ...)

Table 11: Main topics in Moroccan publications in agricultural and veterinary sciences

SCOPUS disciplinary (“subject”) areas	Number of publication	%
Agricultural and Biological Sciences	2462	75.0
Environmental Sciences	719	21.9
Biochemistry, Genetics and Molecular Biology	650	19.8
Earth and Planetary Sciences	439	13.4
Medicine	362	11.0
Immunology and Microbiology	238	7.2
Engineering	219	6.7
Chemistry	152	4.6
Veterinary	145	4.4
Social Sciences	138	4.2
Pharmacology, Toxicology and Pharmaceutics	98	2.9
Multidisciplinary	93	2.8
Mathematics	84	2.5
Chemical Engineering	72	2.2
Materials Science	55	1.7
Computer Science	45	1.4
Neuroscience	41	1.3
Nursing	28	0.8
Arts and Humanities	26	0.8
Economics, Econometrics and Finance	15	0.5
Energy	13	0.4
Business, Management and Accounting	8	0.2
Decision Sciences	6	0.2
Physics and Astronomy	4	0.1
Health Professions	1	0.03
Psychology	1	0.03

Table 12: Areas of main interest of the corpus (2005-2015)

Thematic	Publications (P)	Cumulative Citations (CC)	(CC/P)	H-index
Water	845	9552	11.30	43
Biotechnology	842	8727	10.36	40
Soil	723	7666	10.60	40
Plant health	690	7026	10.18	38
Food industry	582	5447	9.36	32
Veterinary sciences and animal production	525	5274	10.05	34
Social sciences	513	4498	8.77	31
Tree culture	343	2943	8.58	29
Horticulture	268	2346	8.75	27
Farming techniques	249	2923	11.74	28
Local endemic products	222	1979	8.91	24
Fertigation	201	1802	8.97	23
Cereals	160	1867	11.67	23
Forestry	136	899	6.61	18
Fish	111	1024	9.23	17
Landscape	99	1344	13.58	19
Entomology	93	735	7.90	14
Post harvest	35	285	8.14	8

represent 58.2% of the production in this sample and 80.2% if soils are included under this category. We have thus some indications here of the fact that local research interests might be different from those promoted by internationally very highly cited articles. In line with this observation Rafols, Chavarro and Ciarli (2016) are mentioning that publications identified in CAB database (which gives more importance to local publications) are focusing different research orientations than the ones internationally recognized by high-impact journals, this corroborating our preliminary results.

Considering Moroccan priorities in term of research, it is important to note that we couldn't find an official document listing clearly the national research priorities for A&V. Nevertheless, in 2005, during the exercise of defining the 2025 strategy for research, the Ministry of Higher education and scientific research identified 3 topics in connection with A&V: agriculture in stress conditions, biotechnology and environment. In addition, in 2014, the inter-ministerial committee for research and technological development had approved a list of 6 priorities including agriculture, fisheries, water and natural resources and renewable energies (MESRSFC, 2014).

In the absence of official data on national agricultural

research priorities¹², we have based our study on the recommendations of the Moroccan Agricultural Research System (MARS) evaluation study carried in 2013 by the Department of Agriculture. In fact, the new strategy highlighted eleven plant production sector, five for animal production and eight transverse topics: Climate change, soil fertility, biotechnology, water, range management, technology transfer and socio-economic aspects, soil degradation (MAPM, 2016).

In order to prioritize the sectors and the part of the value chain they address (genetic material, production, and commercialization) for R&D investment, the Ministry relied on two sets of criteria. The first one concerns the importance of the sector as measured by turnover, employment, exports, etc; the second one concerned the appreciation of the role of the government to invest in a particular sector (in R&D, private investments, etc). As a result, three levels of priorities (high, medium and low) regarding the R&D investments were defined in 16 sectors. Following this approach, the channels were prioritized for the three components of the value chains (genetic material, produc-

¹²Except of INRA internal research strategy which is identifying since 2005 a 4 year PRMT (mid-term research program)

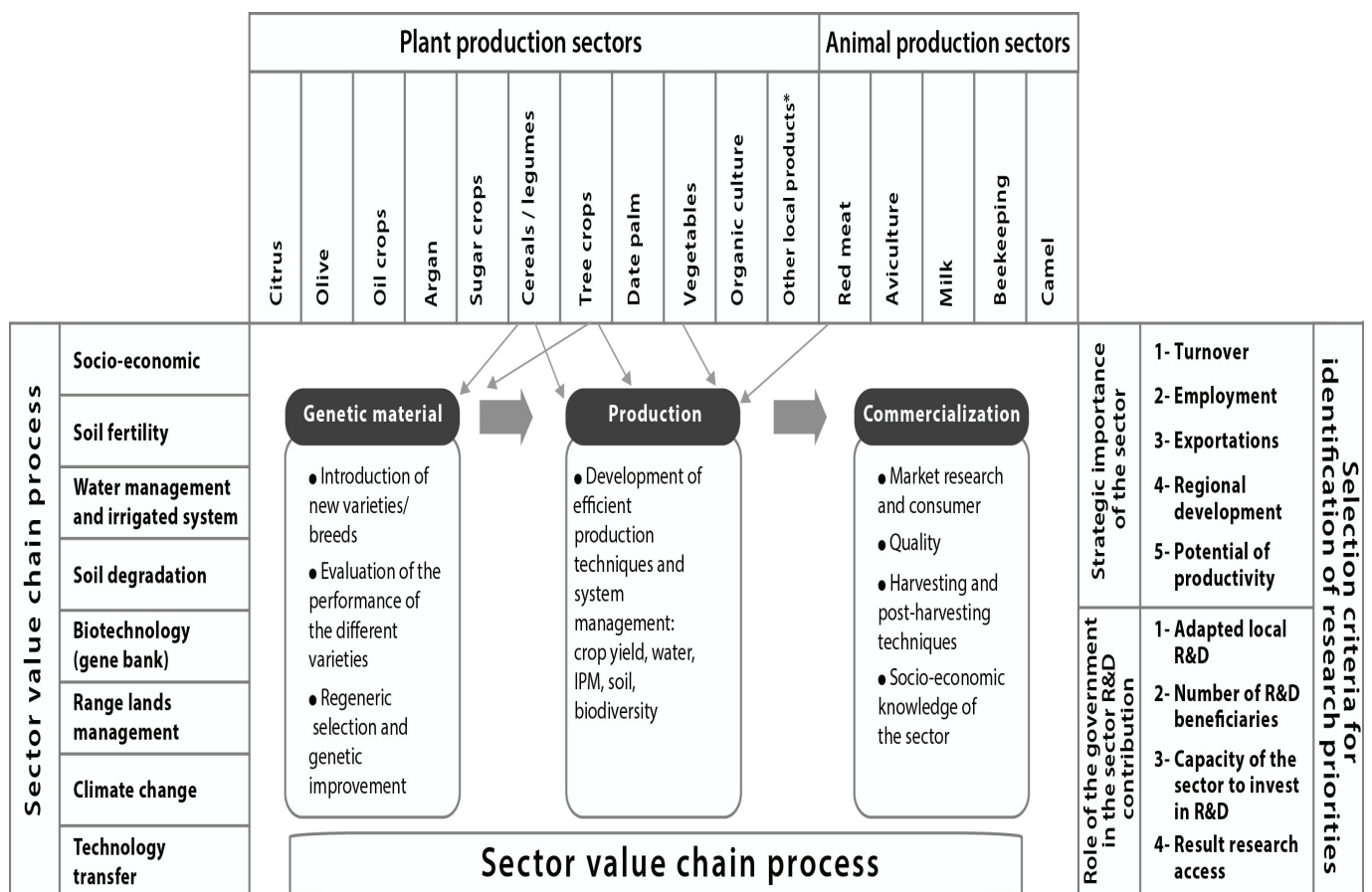


Figure 7 : Identification of R&D agriculture national priorities¹³ (source: Ministry of Agriculture-MAPM)

—————> High RD priorities by sector and segment of the chain as identified by the Ministry of Agriculture

* Safran, Rose perfume and Cactus

¹³ The official recognition of sectors by the law (03.12 regarding the agricultural and fisheries inter-trade, promulgated by dahir n ° 1-12-14 of 17 July 2012): actually the number of organized professional sector actors is 19: Rice, seed, Safran, Rose perfume, Olive, Oil crop, Vegetables, Citrus, Sugar crops, Cereals (legumes), tree crops, Date palm, Argan, Organic cultures, Milk, aviculture, Red meat, Beekeeping, Camel.

tion and marketing). As results, the following high priorities are identified by the Ministry of Agriculture for R&D: genetic material and production for cereals including leguminous and fruit trees; research on genetic material of the date palm, vegetable production and finally production of red meats (Figure 7).

When comparing the topics that have been dominant in this bibliometric study and the research priorities, we observe a loose but nonetheless real connection between these priorities and scientific production of last decade. Our corpus of scientific production is mainly concentrated on water resources management (irrigation, water efficiency, etc...), biotechnology including genetic material of cereals, legume production, and soil aspects such as fertility, degradation, research on tree crops, horticulture and post harvest. We also find research on Argan and aromatic and medicinal plants under the agro-food industry.

The large variation of topics in bibliometric study could find explanation in the fact that, except for INRA, research strategy for agriculture are officially communicated by the Ministry of Agriculture late 2013. In addition, the dynamism created by funding mechanisms at national level (PROFERD and Competitive Mechanism for R&D) are not enough visible due to the low funding, size of projects, and partnership limited to agricultural technical institutions.

CONCLUSION

The results of this study can be used in a research policy perspective. They give an overview of the scientific knowledge system in agriculture field in Morocco and produced indicators can be used as a policy decision tools to take correct decisions at institutional, national or international levels.

During 2005-2015, Moroccan researchers produced 3282 publications 10.5 % of total Moroccan scientific production (variation during 1997-2001 was between 9% and 12%). It confirms that agricultural sciences are a low-producing field, as its rate of growth has always been slower than basic sciences (Rossi & Waast, 2007; MESRSFC, 2003)

Citations are very much concentrated in a very small number of journals, They focus partly on a variety of topics, much wider than A&V, mainly in domains that are highly cited in general such as toxicology or genetic.

At national level 29 % of publications are issued through collaboration between universities (UCAM, UMED V which are the most productive) and technical institution such as IAV and INRA. Although losing weight, they are still strong players and give orientations to agricultural research. We note that internal collaborations increased last five years in response to the R&D nationals calls requiring national cooperation (calls funded by the Ministry of Higher education, ARIMNET and ERANETMED, and the Competitive Mechanism by The Ministry of Agriculture).

International collaborations measured through co-authorship vary between 65% and 80 %. France contributed by 34% of the publications. We note a progressive decreasing tendency since 2006 in favor of other EU countries. Moroccan participation to FP7 with other UE partners could be the main reason.

Water and irrigation used in agricultural production are identified as the main interests of local researchers. Followed by biotechnology applied to vegetal material (mainly cereals), production techniques (soil, plant health), agro-food industry including valorization of aromatic and medicinal plants, animal health and production and social studies represents more than 70% of the corpus topics. Those topics meet a large part of the agreed highly priorities identified by the national strategy of research (plant biotechnology, plant production and animal production).

The Moroccan agricultural research relies on an important institutional capacity and well-established international networks. We believe that today's research can contribute to the enhancement of the country's agricultural production (see "Moroccan Green Plan" objectives). A strategic research vision and specific research programs and incentives could be an important lever for Moroccan agricultural research.

The results of this study can be used in a research policy perspective by providing an overview of the scientific knowledge system in the agricultural field in Morocco and by producing indicators that can serve as a basis for policy decision tools.

REFERENCES

- Akesbi N. (2006). Évolution du secteur agricole et perspectives de développement rural. In 50 ans de développement humain au Maroc, perspectives 2025: rapports thématiques. Maroc: Cinquante ans de Développement Humain au Maroc, pp. 426-445.
- Bartol T., Budimir G., Dekleva-Smrekar D., Pusnik M., Juznic P. (2014). Assessment of research fields in Scopus and Web of Science from the viewpoint of national research evaluation in Slovenia. *Scientometrics*, 98: 1491-1504. <https://doi.org/10.1007/s11192-013-1148-8>
- Bouabid H., Martin B.R. (2009). Evaluation of moroccan research using a bibliometric-based approach: Investigation of the validity of the h-index. *Scientometrics*, 78(2), 203-217.
- Escalona Fernández M.I., Lagar Barbosa P., Pulgarín Guerrero A. (2017). Web of Science Vs. Scopus: Un Estudio Cuantitativo en Ingeniería Química. *Anales de Documentación* 13: 159-175.
- Gaillard A.M., Canesse A-A., Gaillard J., Arvanitis R. (2013). Euro-Mediterranean Science and Technology Collaborations: a Questionnaire Survey. In C. Morini, R. Rodriguez, R. Arvanitis end R. Chaabouni (Eds.), *Moving to the future in the Euro-Mediterranean Research and Innovation partnership - The experience of the MIRA project*. Bari & Paris: Options Méditerranéennes, CIHEAM, pp. 79-102.

- Gaillard J., Gaillard A.M., Arvanitis R. (2013). Determining factors of international collaboration in science & technology: results of a questionnaire survey. In J. Gaillard and R. Arvanitis (Eds.), *Research collaborations between Europe and Latin America. Mapping and Understanding partnership*. Paris: Editions des Archives Contemporaines, pp. 101-150.
- Hanafi S., Arvanitis R. (2016). *Knowledge production in the Arab World: the impossible promise*. London: Routledge.
- IMIST (2012). *La production scientifique en Afrique, Maroc Bibliométrie 6: 1-8*.
- Kleiche M., Waast R. (Eds.) (2008). *Le Maroc scientifique*. Paris: Publisud, 1-29. An English version has been published as: Waast, Roland and Kleiche-Dray, Mina (Eds.). (2009). *Evaluating of a national research system: Morocco*. Luxembourg: European Commission. http://ec.europa.eu/research/iscp/pdf/morocco_evaluation.pdf
- MAPM (2016). *Stratégie de la Recherche Agricole au Maroc Livrable de l'Etude sur la Stratégie de la Formation et de la Recherche Agricoles au Maroc*.
- MESRSFC (2003). *Rapport d'évaluation de la recherche. Atelier National sur l'évaluation du système de la recherche scientifique dans les domaines des sciences exactes, sciences de la vie et sciences de l'ingénieur-Rapport d'évaluation*. Rabat.
- MESRSFC (2014). *Décisions et recommandations du Comité Permanent de RDI, 2014*.
- Ministère de l'Agriculture (2014). *Agriculture en chiffres*, Rabat.
- Rafols I., Chavarro D., Ciarli T. (2016). *Under-representation of research in the global south: Biases in mainstream journal indexing systems*. In proceedings of International Research Conference on Scientometrics, STI Policy and Science Communication, Stellenbosch University, Stellenbosch, November 2016.
- Sagar A., Kademani B. S., Bhanumurthy K. (2014). *Agriculture research in India: A scientometric mapping of publications*. *DESIDOC Journal of Library and Information Technology*, 34: 206-222.
- Sánchez A. D., de la Cruz Del Río Rama M., Álvarez García J. (2017). *Bibliometric analysis of publications on wine tourism in the databases Scopus and WoS*. *European Research on Management and Business Economics*, 23: 8-15.
- Scopus (2016). *Scopus Content Coverage Guide*.
- Vargas R. A. (2011). *Brazilian agricultural research in the Web of Science: a bibliometric study of scientific output and collaboration (2000-2011)*, *Scientometrics*, 296-318.
- Vargas R. A., de Souza Vanz S.A., Chittó Stumpf I.R. (2011). *Brazilian agricultural research in the Web of Science: a bibliometric study of scientific output and collaboration (2000-2011)*, *Em Questao (Porto Alegre)*, 21: 296-318.
- Waast R., Gaillard J. (2001). *L'état des sciences en Afrique*. Paris: IRD & Ministère des Affaires Etrangères, France (Aide N° ERBIC 18 CT 98 9164).
- Waast R., P.L. Rossi (2001). *Les sciences en Afrique, Synthèse bibliométrique*. Paris: IRD, 172 P
- Waast R., Rossi P.L. (2008). *La production scientifique du Maroc. Données récentes*. Publié dans Actes de conférence: Communication faite en séance plénière à l'Académie Hassan II des Sciences et des Techniques, Rabat, 21 février 2008.
- Waast R., Rossi P. L. (2009). *A scoreboard and beyond: The experience of ESTIME for Morocco and other Mediterranean Countries*. Publié dans Actes de conférence: MIRA indicators Workshop, IRD, 16-17 March 2009, Bondy (France).
- Waast R., Rossi P. L. (2008). *Bibliométrie fine: méthode et résultats*. In : Kleiche Dray Mina (ed.), Waast Roland (ed.), Fassi Fehri O. (préf.) *Le Maroc scientifique*. Paris: Publisud, 89-118.
- Zebakh S., Finance J.P. (2017). *La coopération scientifique avec l'Europe: la participation du Maroc aux programmes européens*. In Gaillard J. and H. Bouabid (eds), *La recherche scientifique au Maroc et son internationalisation*, Saarbrücken, De.: Editions Universitaires Européennes, 121-156.