

A review on

# **Muslim Contribution to Agriculture**

**Compiled by:** Salah Zaimeche BA, MA, PhD  
**Chief Editor:** Professor Salim Al-Hassani  
**Editor:** Professor Talip Alp  
**Production:** Ahmed Salem BSc

**Release Date:** December 2001  
**Publication ID:** 4018  
**Print Copy Price:** £45.00 UK  
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9 Conyngham Road, Victoria Park, Manchester, M14 5DX, United Kingdom

Web: <http://www.fstc.co.uk> Email: [info@fstc.co.uk](mailto:info@fstc.co.uk)

## A REVIEW ON

**MUSLIM CONTRIBUTION TO AGRICULTURE****Introduction**

History usually conveys the notion that the agricultural revolution took place in recent times in the form of rotation of crops, advanced irrigation techniques, plant improvements, etc... some such changes only taking place in the last couple of centuries in Europe, and some even taking place nowadays. It is explained that such revolutionary changes fed the increasing European population, released vast numbers from the land and allowed agriculture to produce a capital surplus, which was invested in industry, thus leading to the industrial revolution of the 18<sup>th</sup>-19<sup>th</sup> century. This is the accepted wisdom until one comes across works on Muslim agriculture and discovers that such changes took place over ten centuries ago in the Muslim world, some such changes being the foundations of much of what we have today. Watson, Glick and Bolens,<sup>1</sup> in particular, indeed, show that the major breakthroughs were achieved by Muslim farmers on the land, and by Muslim scholars with their treatises on the subject. Thus, as with other subjects, prejudice distorts history, Muslim achievements of ten centuries ago covered up; a point raised by the French scholar, Cherbonneau, who holds: `it is admitted with difficulty that a nation in majority of nomads could have had known any form of agricultural techniques other than sowing wheat and barley. The misconceptions come from the rarity of works on the subject... If we took the bother to open up and consult the old manuscripts, so many views will be changed, so many prejudices will be destroyed.'<sup>2</sup>

**The Agricultural Revolution**

As early as the ninth century, a modern agricultural system became central to economic life and organization in the Muslim land. The great Islamic cities of the Near East, North Africa and Spain, Artz explains, were supported by an elaborate agricultural system that included extensive irrigation and an expert knowledge of the most advanced agricultural methods in the world. The Muslims reared the finest horses and sheep and cultivated the best orchards and vegetable gardens. They knew how to fight insect pests, how to use fertilizers, and they were experts at grafting trees and crossing plants to produce new varieties.<sup>3</sup> Glick defines the Muslim agricultural revolution in the introduction of new crops, which, combined with extension and intensification of irrigation, created a complex and varied agricultural system, whereby a greater variety of soil types were put to efficient use; where fields that had been yielding one crop yearly at most prior to the Muslims were now capable of yielding three or more crops, in rotation; and where agricultural production responded to the demands of an increasingly sophisticated and cosmopolitan urban population by providing the towns with a variety of products unknown in Northern Europe.<sup>4</sup> Whilst for Scott, the agricultural system of the Spanish Muslims, in particular, was `the most complex, the most scientific, the most perfect, ever devised by the ingenuity of man.'<sup>5</sup>

Such advancement of Muslim farming, according to Bolens, was owed to the adaptation of agrarian techniques to local needs, and to `a spectacular cultural union of scientific knowledge from the past and the present, from the Near East, the Maghreb, and Andalusia. A culmination subtler than a simple accumulation of techniques, it has been an enduring ecological success, proven by the course of human history.'<sup>6</sup> Fertilisers, in their variety, were used according to a well-advanced methodology; whilst a maximum amount of moisture in the soil was preserved.<sup>7</sup> Soil rehabilitation was constantly cared for, and

preserving the deep beds of cropped land from erosion was, according to Bolens, again, 'the golden rule of ecology,' and was 'subject to laws of scrupulous careful ecology.'<sup>8</sup> For Scott, the success of Islamic farming also lay in hard enterprise. No natural obstacle was sufficiently formidable to check the enterprise and industry of the Muslim farmer. He tunneled through the mountains; his aqueducts went through deep ravines, and he leveled with infinite patience and labor the rocky slopes of the sierra (in Spain).<sup>9</sup> Watson sums up.<sup>10</sup> To him, the rise of productivity of agricultural land and sometimes of agricultural labour owe to the introduction of higher yielding new crops and better varieties of old crops, through more specialised land use which often centred on the new crops, through more intensive rotations which the new crops allowed, through the concomitant extension and improvement of irrigation, through the spread of cultivation into new or abandoned areas, and through the development of more labour intensive techniques of farming. These changes, themselves, were positively affected by changes in other sectors of the economy: growth of trade, enlargement of the money economy, increasing specialisation of factors of production in all sectors, and with the growth of population and its increasing urbanisation.

Irrigation, from Andalusia to the far East, from the Sudan to Afghanistan, remained central, 'the basis of all agriculture and the source of all life.'<sup>11</sup> The ancient systems of irrigation the Muslims became heirs to were in an advanced state of decay, and ruins.<sup>12</sup> The Muslims repaired them and constructed new ones; besides devising new techniques to catch, channel, store and lift the water, and making ingenious combinations of available devices.<sup>13</sup> All of the *Kitab al-Filahat* (book of agriculture), whether Maghribi, Andalusian; Egyptian, Iraqi; Persian or Yemenite, Bolens points out, insist meticulously on the deployment of equipment and on the control of water.<sup>14</sup>

### **Agricultural Machines and Construction**

Water that was captured through a variety of ways was then successively channelled, stored and lifted using the different techniques and varied devices for each operation. Irrigation became cheap, affecting lands previously impossible or uneconomic to irrigate.<sup>15</sup> Irrigated fields yielded as many as four harvests yearly,<sup>16</sup> which, as in Spain, laid the foundations for the country's prosperity.<sup>17</sup> Damming of rivers to provide households, mills with power, and for irrigation, was also widespread.<sup>18</sup> The introduction of the noria (a water lifting device) in any district has always had revolutionary consequences upon agricultural productivity, too. And because it was relatively inexpensive to build and simple to maintain, the noria enabled the development of entire huertas that were intensively irrigated.<sup>19</sup>

In Cordoba, al-Shaqundi (thirteenth century) speaks of 5000 norias (possibly including both lifting and milling devices) on the Guadalquivir.<sup>20</sup> Some are still in use, as at La Nora, six km from the Murcia city centre, where although the original wheel has been replaced by a steel one, the Muslim system is otherwise virtually unchanged.<sup>21</sup> In general, these Islamic irrigation techniques that were transferred to Spain were adapted to specific natural conditions.<sup>22</sup> The Muslims, Forbes holds, should be credited with important developments of irrigation in the Western Mediterranean. And they did not just extend the irrigated area in Spain and Sicily, but also knew how to drain rivers and how to irrigate their fields by systems of branch channels with an efficient distribution of the available water.<sup>23</sup> Other than that, they also captured rainwater in trenches on the sides of hills or as it ran down mountain gorges or into valleys; surface water was taken from springs, brooks, rivers and oases, whilst underground water was tapped by creating new springs, or digging wells.<sup>24</sup>

## Water Management

Water, so precious commodity in a more Islamic aware age, was managed according to stringent rules, any waste of the resource banned, and the most severe economy enforced. Thus, in the Algerian Sahara various water management techniques were used to make the most effective use of the resource. The Foggaras, a network of underground galleries, conducted water from one place to the other over very long distances so as to avoid evaporation. Although the system is still in use today, the tendency at present is for over-use and waste of water. Still in Algeria, in the Beni Abbes region, in the Sahara, south of Oran, farmers used a clepsydra to determine the duration of water use for every user in the area.<sup>25</sup> This clepsydra regulates with precision, and night and day, the amount going to each farmer, timed by the minute, throughout the year, and taking into account seasonal variations. Each farmer is informed of the timing of his turn, and summoned to undertake necessary action to ensure effective supply to his plot.<sup>26</sup> In Spain, the same strict management was in operation. The water conducted from one canal to the other was used more than once, the quantity supplied accurately graduated; distributing outlets were adapted to each soil variety, two hundred and twenty four of these, each with a specific name.<sup>27</sup> All disputes and violations of laws on water were dealt with by a court-whose judges were chosen by the farmers themselves, this court named The Tribunal of the Waters, which sat on Thursdays at the door of the principal mosque. Ten centuries later, the same tribunal still sits in Valencia, but at the door of the cathedral.<sup>28</sup>

## Globalisation Crops

Elaborating on the Islamic agricultural revolution, Watson holds<sup>29</sup> that the picture that emerges is that of 'a large unified region which for three or four centuries, and in places still longer, was unusually receptive to all that was new. It was also unusually able to diffuse novelties: both to effect the initial transfer which introduced an element into a region and to carry out the secondary diffusion which changed rarities into commonplaces. Attitudes, social structure, institutions, infrastructure, scientific progress and economic development all played a part in the making of this medium of diffusion. And not only agriculture but also other spheres of the economy-and many areas of life that lay outside the economy- were touched by this capacity to absorb and to transmit.' Indeed, as the Muslims advanced, Forbes explains, they introduced methods and machinery of the Ancient Near East, and also certain crops which could not have been grown with the typically classical agricultural methods. The Romans had imported rice but had never grown it on a large scale. The Muslims started to grow it on irrigated fields in Sicily and Spain, whence it came to the Pisan plain (1468) and Lombardy (1475).<sup>30</sup> In the words of Wickens, Spain received (apart from a legendary high culture), and what she in turn transmitted to most Europe, all manner of agricultural and fruit-growing processes, together with a vast number of new plants, fruit and vegetables that we all now take for granted.<sup>31</sup> These new crops included sugar cane, rice, citrus fruit, apricots, cotton, artichokes, aubergines, saffron... Others, previously known, were developed further.<sup>32</sup> Muslims also brought to that country rice, oranges, sugar cane and cotton,<sup>33</sup> and sub-tropical crops such as bananas and sugar cane were grown on the coastal parts of the country,<sup>34</sup> many to be taken later to the Spanish colonies in the Americas. Also owing to the Muslim influence, a silk industry flourished, flax was cultivated and linen exported, and esparto grass, which grew wild in the more arid parts, was collected and turned into various types of articles.<sup>35</sup> In Sicily, crops and techniques introduced by the Muslims still constitute up till now the foundations of the economy.<sup>36</sup> Much of the transfer of such crops often owes to the enthusiasm of individual persons. Hence, Abd al-Rahman I, out of nostalgia for the Syrian landscape was personally responsible for the introduction of several species, including the date palm.<sup>37</sup> A variety of pomegranate was introduced from Damascus by

the chief judge of Cordoba, Mu`awiya b Salih, and a Jordanian soldier named Safar took a fig cutting and planted it on his estate in the Malaga region. This species, called *safri* after the soldier, subsequently became widely diffused.<sup>38</sup> It was also the Muslims who had introduced sugar cane into Ethiopia, and who made the East African island of Zanzibar famous for its high quality sugar.<sup>39</sup> In general, "it would make a whole book," Baron Carra de Vaux observes, "and not the least interesting, on the history of flowers, plants and animals that had come from the Orient, and which are used in agriculture, pharmacy, gardens, luxury trade, and arts."<sup>40</sup> He lists tulips, hyacinths, narcissi, Lilacs, jasmine, roses, peaches, prunes, sheep of 'barbary' lands, goats, Angora cats, Persian coqs, silk, cotton, plants and products used for dyeing, etc.<sup>41</sup>

## Farming Manuals

Muslim farming manuals conveyed much of the expertise that was available.<sup>42</sup> Ways and methods for increasing production and productivity, and maintaining soil fertility were explained alongside detailed descriptions of soils, and their requirements. Soils were classified, and so was water according to its quality. It was explained how to enrich the soil by various methods, and methods of ploughing (normal and deep), hoeing, digging and harrowing.<sup>43</sup> Ibn Bassal's treatise distinguished between ten classes of soil, each assigned with a different life sustaining capability, according to the season of the year. He was insistent that fallow land be ploughed four times between January and May and, in certain cases (for example, cotton, when planted in the thick soils of the Mediterranean coast), he recommended as many as ten ploughings.<sup>44</sup> Ibn al-Awwam's treatise was published in a Spanish translation and a French version between the end of the eighteenth and the middle of the nineteenth as its contents were of particular interest in both Spain and Algeria.<sup>45</sup> This *Kitab al-Filaha* (the book of agriculture),<sup>46</sup> has 34 chapters dealing with agriculture and animal husbandry. It covers 585 plants, explains the cultivation of more than fifty fruit trees, makes observations on grafting, soil properties, manure, and plant diseases and their treatments. Ibn al-Awwam studies gardening, irrigation, affinities between trees, grafting, animal husbandry and bee keeping. Al Ichbili's *Kitab al-Filaha* goes in the same direction in giving precise instructions to farmers about nearly every matter of concern. Extracts from it<sup>47</sup> show in minute detail how to grow olive trees, the treatment of diseases, grafting, harvesting olives, properties of olives, refining olive oil, conditioning of olives... And the same with respect to other crops, including cotton, the required soil properties, the tasks preceding the planting, soil preparation, use of manure, and what sort; ploughing techniques, their frequency, the time for sowing and the manner it is done, watering after sowing, and during growth, maintenance of plants, harvesting etc. A wealth of information is also found in the 'Calendar of Cordova of 961.'<sup>48</sup> Its technical accuracy is 'remarkable,' and much of what it contains was to be found in subsequent geography books and farming treatises. Each month of the year had its tasks and time table, March, for instance, was when fig trees are grafted; and early cereals begin to rise. It was the time to plant sugar cane, and when pre-season roses and lilacs begin to come out. Quails appear; silk worms hatch; from the sea, mullets journey up rivers. That is also the time to plant cucumbers, and saw cotton, saffron, and aubergines. During this month are sent to provincial tax officials mail orders to purchase horses for the government; locusts begin to appear and their destruction is ordered; time to plant lime and marjoram, too. It is also the mating season of many birds.<sup>49</sup>

To illustrate the wide interest of a variety of writers regarding one single crop, one takes the example of rice.<sup>50</sup> Ibn Bassal, for instance, advises on the choice of terrain, plots that face to the rising sun. The thorough preparation of the soil is well recommended as well as the addition of manure, and how it is to be done. Sowing is advised between February and March. Al-Ichbilli gives the specific amount of rice that

needs to be sown on any given surface, and how that should be carried out. Ibn al-Awwam speaks at length of the watering process, that land should be submerged with water up to a given height, then sowing the rice. Once the soil had absorbed the water, the seeds are covered with earth, and the land submerged with water again. All details on irrigation and ways of drainage once the plants grow are given. Fighting parasites, clearing weeds, and the means used for that also attract much attention from the writers. Ways of harvesting and for safe storage are explained, too. Use of rice as a food commodity takes many forms. Ibn al-Awwam specifies that the best way of cooking and eating rice is with butter, oil, fat and milk. An anonymous author of the Almohad dynasty<sup>51</sup> also wrote a recipe book called *Kitab al-Tabkh fi-l Maghrib wal Andalus*, which includes many recipes, five of them with rice, all sounding most appetising.

### **The loss of Ecological Balance**

'With a deep love for nature, and a relaxed way of life, classical Islamic society,' Bolens concludes, 'achieved ecological balance, a successful average economy of operation, based not on theory but on the acquired knowledge of many civilized traditions.'<sup>52</sup> It was colonialism, she recognises, which subsequently and seriously upset the traditional agricultural balance in order to increase profitability for the colonizers.<sup>53</sup> The decline of agriculture as the destruction of other aspects of Islamic civilisation had, however, begun with the various invaders, from the Crusaders to the Mongols, from the Banu Hillal to the Normans and Spain's conquistadors in the West. Such invasions caused the ruin of irrigation works, destroyed permanent crops, closed down trade routes, and caused farmers to take flight.<sup>54</sup> The Muslim farmers also became over taxed by their new masters in Christian Spain and Sicily, and were exterminated in those countries; their system perishing with them.<sup>55</sup> The later colonisers, the French, only finished off whatever was left. No better place to see that than in Algeria, where the French on arrival in 1830 found a much greener country than the one they left 130 years later, and a population living more or less in harmony with its environment. In their wars of devastation against Algerian resistance, the French destroyed the garden rings that surrounded towns and cities, cutting trees and orchards. After that, they deforested whole regions to exploit timber, and took all fertile lands from their Muslim owners, forcing them to subside on arid lands, and in the vicinity of forests causing their degradation. Later, during the war of independence 1954-62, the French set ablaze millions of acres of forest lands; and then departed, leaving a legacy of bareness and hostility to greenery from which the Algerians have not recovered yet.<sup>56</sup>

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References:

- <sup>1</sup> -A.M Watson: *Agricultural Innovation in the Early Islamic World*, Cambridge University Press, 1983.
- A.M Watson: 'The Arab agricultural revolution and its diffusion,' in *The Journal of Economic History* 34 (1974).
- T.Glick: *Islamic and Christian Spain in the early Middle Ages*, Princeton University Press, New Jersey, 1979.
- T.Glick: *Irrigation and hydraulic technology: Medieval Spain and its legacy*, Varorium, Aldershot, 1996.
- L.Bolens: *Les methodes culturales au moyen age d'apres les traites d'agronomie andalous: traditions et techniques*. Geneva, 1974.
- L. Bolens, *Agronomes Andalous du Moyen Age*, Geneva/Paris, 1981.
- L.Bolens: L'Eau et l'Irrigation d'apres les traites d'agronomie Andalous au Moyen Age (XI-XIIem siecles), *Options Mediterraneees*, 16 (Dec, 1972).
- <sup>2</sup> A. Cherbonneau: *Kitab al-Filaha* of Abu Khayr al-Ichbili, in *Bulletin d'Etudes Arabes*, pp 130-44; at p. 130.
- <sup>3</sup> Frederick. B.Artz: *The Mind of the Middle Ages*; Third edition revised; The University of Chicago Press, 1980, p, 150.
- <sup>4</sup> T.Glick: islamic, op cit, p. 78.
- <sup>5</sup> S.P. Scott: *History of the Moorish Empire in Europe*. 3 Vols, Vol 3; J.B. Lippincott Company, London, 1904; p. 598.
- <sup>6</sup> L.Bolens: 'Agriculture' in *Encyclopedia of the history of Science, technology, and Medicine in Non Western Cultures*, Editor: Helaine Selin; Kluwer Academic Publishers. Dordrecht/Boston/London, 1997. pp 20-2, at p. 20.
- <sup>7</sup> T. Glick: Islamic, op cit, p. 75.
- <sup>8</sup> L.Bolens: Agriculture, in Encyclopedia, op cit, p. 22.
- <sup>9</sup> S.P. Scott: History, op cit, p.604.
- <sup>10</sup> A.Watson: Agricultural innovation, op cit, pp 2-3.
- <sup>11</sup> Lucie Bolens: Irrigation: in Encyclopedia, op cit, pp 450-2; at p. 451.
- <sup>12</sup> A.M. Watson: Agricultural innovation, op cit, p. 104.
- <sup>13</sup> Ibid, pp. 109-10.
- <sup>14</sup> L. Bolens, Irrigation, op cit, p. 451.
- <sup>15</sup> A.M. Watson: Agricultural innovation, op cit, p. 104.
- <sup>16</sup> T.Glick: Islamic, op cit. P. 75.
- <sup>17</sup> D.R. Hill: *Islamic science and Engineering*, Edimburgh University Press, 1993; p. 161.
- <sup>18</sup> Ibid, pp 159-69.
- <sup>19</sup> T.Glick: islamic, op cit, p. 74.
- <sup>20</sup> Al-Saundi, Elogio del Islam espanol, p. 105; in T.Glick: Islamic, op cit, p.75.
- <sup>21</sup> D.R. Hill: Islamic Science, op cit, pp. 97.
- <sup>22</sup> E. Levi Provencal: *Histoire de l'Espagne Musulmane*; 3 vols; Maisonneuve, Paris, 1953; vol iii, p. 279.
- <sup>23</sup> R.J. Forbes: *Studies in Ancient technology*, vol II, second revised edition, Leiden, E.J Brill, 1965, p. 49.
- <sup>24</sup> A.M. Watson: Agricultural innovation, op cit p. 107.
- <sup>25</sup> L. Goonalons: La Clepsydre de Beni Abbes, in *Bulletin d'Etudes Arabes*, vol 3, 1943, pp 35-7:
- <sup>26</sup> Ibid, p. 37.
- <sup>27</sup> S.P. Scott: History, pp 602-3.

<sup>28</sup> Ibid, pp 602-3.

<sup>29</sup> A.Watson: Agricultural innovation, op cit, p.2

<sup>30</sup> R.J. Forbes: Studies, op cit, p. 49.

<sup>31</sup> G.M. Wickens: What the West borrowed from the Middle east, in *Introduction to Islamic Civilisation*, edited by R.M. Savory, Cambridge University Press, Cambridge, 1976, pp 120-5; at p. 125.

<sup>32</sup> M. Watt: *The Influence of Islam on Medieval Europe*, Edimburgh University Press, 1972; pp 22-23.

<sup>33</sup> A. Pacey: *Technology in World Civilization, a thousand year history*, The MIT Press, Cambridge, Massachusetts, 1990, p. 15.

<sup>34</sup> E.Levi Provençal: Histoire, op cit, p.283.

<sup>35</sup> W.Montgomery Watt: The influence, op cit, pp 22-3.

<sup>36</sup> Francesco Gabrieli: "Islam in the Mediterranean World", in *The Legacy of Islam*, edited by J.Schacht with C.E. Bosworth, 2nd edition. Oxford Clarendon Press, 1974. pp 63-104, at p. 75.

<sup>37</sup> T.Glick: Islamic, op cit, p. 76.

<sup>38</sup> Ibid.

<sup>39</sup> A. Pacey: Technology, op cit, p. 15.

<sup>40</sup> Baron Carra de Vaux: *Les Penseurs de l'Islam*, vol 2, Paris, Librairie Paul Geuthner, 1921, vol 2, Chapter x: Les Sciences Naturelles, Histoires Naturelles. at p. 306.

<sup>41</sup> Ibid, pp 309-19.

<sup>42</sup> Most particularly:

-Ibn Al-Awwam: *Le Livre de l'Agriculture* d'In al-Awwam, tr. from Arabic by J.J. Clement-Mullet, Vol. I, Paris 1864.

-Ibn Bassal: *Libro de agricultura*, Jose M.Millas Vallicrosa and Mohammed Azinan eds, Tetuan: instituto Muley al-hasan, 1953.

<sup>43</sup> Derived from A.M. Watson: Agricultural, op cit, chapter 23.

<sup>44</sup> Millas Vallicrosa, 'Sobre la obra de agricultura de Ibn Bassal,' in *Nuevos estudios sobre historia de la ciencia espanola* (Barcelona: Consejo Superior de Investigaciones Cientificas, 1960), pp 139-40.

<sup>45</sup> J. Vernet and J. Samsó: Development of Arabic Science in Andalusia, in *The Encyclopedia of the History of Arabic Sciences*, ed. Roshdi Rashed, Routledge, London, 1996, Vol 1, pp 243-76; at p 263.

<sup>46</sup> Ibn Al-Awwam: *Le Livre de l'Agriculture*, op cit,.

<sup>47</sup> In A Charbonneau: *Kitab al-Filaha* of Al-Ichbili, in *Bulletin d'Etudes Arabes*, vol 6 (1946); pp 130-144;

<sup>48</sup> Details of which in E.L. Provençal: History, op cit, pp. 289-90.

<sup>49</sup> Ibid.

<sup>50</sup> Derived from V. Lagardere: La Riziculture en Al Andalus (VIIIem-Xvem siecles), in *Studia Islamica*, vol 83, 1996, pp 71-87.

<sup>51</sup> A Berber dynasty that went into Spain from Morocco, defeated the invading Christian forces and preserved the Islamic status of the Peninsula for over a century. When the Almohads were defeated, eventually, it was the end of Muslim Spain, the Muslims losing within a few years from each other (in the 1240s): Seville, Cordova, Valencia, and other territories, only retaining Grenada which would fall in 1492.

<sup>52</sup> L.Bolens: Agriculture, in *Encyclopaedia*, op cit, p. 22.

<sup>53</sup> Ibid.

<sup>54</sup> See final Chapter by A. Watson: 'Agriculture in retreat,' in A. Watson: Agricultural.... Op cit.

<sup>55</sup> See Charles H. Lea: *A History of the Inquisition in Spain*, in four volumes, The MacMillan Company, New York, 1907, volume three, pp 317-410.

<sup>56</sup> Good accounts of such French devastation can be found in the following:



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- Charles.R. Ageron: *Histoire de l'Algerie contemporaine*, 3 vols, Presses Universitaires de France, 1979.
  - Charles.A. Julien: *Histoire de l'Algerie Contemporaine*, Presses Universitaires de France, 1964.
  - Henry Aleg et all: *La Guerre d'Algerie*, Temps Actuels, Paris, 1981.

## Bibliography

- Charles.R. Ageron: *Histoire de l'Algerie contemporaine*, 3 vols, Presses Universitaires de France, 1979.
- Henry Aleg et all: *La Guerre d'Algerie*, Temps Actuels, Paris, 1981.
- Frederick. B.Artz: *The Mind of the Middle Ages*; 3rd edition revised; The University of Chicago Press, 1980.
- L.Bolens: *Les methodes culturales au moyen age d'apres les traites d'agronomie andalous: traditions et techniques*. Geneva, 1974.
- L. Bolens, *Agronomes Andalous du Moyen Age*, Geneva/Paris, 1981.
- L.Bolens: L'Eau et l'Irrigation d'apres les traites d'agronomie Andalous au Moyen Age (XI-XIIem siecles), *Options Mediterraneees*, 16 (Dec, 1972).
- L.Bolens: 'Agriculture' in *Encyclopedia of the history of Science, technology, and Medicine in Non Western Cultures*, Editor: Helaine Selin; Kluwer Academic Publishers. Dordrecht/Boston/London, 1997. pp 20-2.
- Baron Carra de Vaux: *Les Penseurs de l'Islam*, vol 2, Paris, Librairie Paul Geuthner, 1921, vol 2, Chapter x: Les Sciences Naturelles, Histoires Naturelles.
- A.Charbonneau: *Kitab al-Filaha* of Abu Khayr al-Ichbili, in *Bulletin d'Etudes Arabes*, pp 130-44.
- R.J. Forbes: *Studies in Ancient technology*; vol II, second revised edition, Leiden, E.J Brill, 1965.
- Francesco Gabrieli: "Islam in the Mediterranean World", in *The Legacy of Islam*, edited by J.Schacht with C.E. Bosworth, 2nd edition. Oxford Clarendon Press, 1974. pp 63-104.
- T.Glick: *Islamic and Christian Spain in the early Middle Ages*, Princeton University Press, New Jerzey, 1979.
- T.Glick: *Irrigation and hydraulic technology: Medieval Spain and its legacy*, Varorium, Aldershot, 1996.
- L. Goonalons: La Clepsydre de Beni Abbes, in *Bulletin d'Etudes Arabes*, vol 3, 1943, pp 35-7.
- D.R. Hill: *Islamic science and Engineering*, Edimburgh University Press, 1993.
- Ibn Al-Awwam: *Le Livre de l'Agriculture* d'In al-Awwam, tr. from Arabic by J.J. Clement-Mullet, Vol. I, Paris 1864.
- Ibn Bassal: *Libro de agricultura*, Jose M.Millas Vallicrosa and Mohammed Azinan eds, Tetuan: Instituto Muley al-Hasan, 1953.
- C..A. Julien: *Histoire de l'Algerie Contemporaine*, Presses Universitaires de France, 1964.
- V. Lagardere: La Riziculture en Al Andalus (VIIIem-Xvem siecles), in *Studia Islamica*, vol 83, 1996, pp 71-87.
- Charles H. Lea: *A History of the Inquisition in Spain*, in four volumes, The MacMillan Company, New York, 1907, volume three.
- E. Levi Provençal: *Histoire de l'Espagne Musulmane*; 3 vols; Maisonneuve, Paris, 1953; vol iii.
- Millas Vallicrosa, 'Sobre la obra de agricultura de Ibn Bassal,' in *Nuevos estudios sobre historia de la ciencia espanola* (Barcelona: Consejo Superior de Investigaciones Cientificas, 1960).
- A.Pacey: *Technology in World Civilization, a thousand year history*, The MIT Press, Cambridge, Massachusetts, 1990.
- S.P. Scott: *History of the Moorish Empire in Europe*. 3 Vols, Vol 3; J.B. Lippincott Company, London, 1904.
- J. Vernet and J. Samsó: Development of Arabic Science in Andalusia, in *The Encyclopedia of the History of Arabic Sciences*, edt Roshdi rashed, Routledge, London, 1996, Vol 1, pp 243-76.
- M. Watt: *The Influence of Islam on Medieval Europe*, Edimburgh University Press, 1972.

- 
- A.M Watson: *Agricultural Innovation in the Early Islamic World*, Cambridge University Press, 1983.
  - A.M Watson: 'The Arab agricultural revolution and its diffusion,' in *The Journal of Economic History* 34 (1974).
  - G.M. Wickens: What the West borrowed from the Middle east, in *Introduction to Islamic Civilisation*, edited by R.M. Savory, Cambridge University Press, Cambridge, 1976, pp 120-5.