Malaysian Journal of Library & Information Science, Vol.14, no.1 April 2009: 83-103

A bibliometric analysis of the *Punica grantum* L. literature

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ABSTRACT

The purpose of this study was to identify and analyze the intellectual structure of the Punica granatum L (pomegranate) literature and to determine trends and patterns. Specific areas addressed were growth of the literature, publication type, author productivity and patterns, subject focus, language dispersion, and characteristics of the journal literature. Thirty-one related databases and the online catalogs of two United States national libraries were searched to identify publications. The final data set consisted of 3,306 items. All publications were reviewed through 2006. Data were sorted and manipulated using the software package ProCite. For analysis of the data, bibliometric techniques were applied. The results show that the literature has grown consistently from 1970 onwards exploding to significant proportions beginning in 2000. Most of the publications are the result of author collaboration (7l.82%) and written in the English language (69.57%). India and the United States are the leading contributors to the literature and educational institutions make-up more than fifty percent of the authors' affiliation. The literature is multi- and inter-disciplinary in nature. The major subject areas are plant diseases, growth (plants), botanical chemistry, pharmacognosy, and plant products. Journal articles (75.53%) constitute the largest single type of publication. There are 1,045 unique journal titles containing 2,497 publications. According to Bradford's Law a core of 38 journal titles form the nucleus of this literature. This study provides future direction for researchers, facilitates discussion within multiple disciplines, and assists information providers in formulating policy guidelines for the selection and acquisition of information resources.

Keywords: *Punica granatum* L.; Pomegranate; Bibliometrics; Scholarly communication; Medicinal plants; Nutritional plants

INTRODUCTION

In the age of busy lifestyles, stress, and imposing environmental factors, individuals are becoming more and more conscientious about their health. With natural remedies, natural products, diet and nutrition and alternative medical treatments as part of an ever-increasing phenomenon to promote physical and mental well-being, few would doubt the fundamental importance of plant nutrition in their daily lives. The use of plants as a source of nourishment and in the treatment of medical conditions can be

dated back centuries. Hippocrates (460-377 B.C.), the Greek scholar and physician believed that medicines made from plants could treat human illnesses. Theophratus (371-297 B.C.), considered to be the first botanist, wrote exhaustively on plant subjects, and Dioscorides (first century, A.D.) "assembled a comprehensive treatment of the properties, uses, cultivations, and selection of six-hundred medicinal plants" (Sumner 2000). From the Middle Ages down through the centuries and across continents, writings about the characteristics and uses of plants have been documented (Chadwick and Craker 1988).

Despite the interest from ancient to modern times in ethnobotany, it was not until the mid-1970s that the World Health Assembly formally recommended that traditional medicine be incorporated into conventional health care systems. In 1978 the Assembly highlighted the importance of medicinal plants in the treatment and prevention of illnesses. These developments lead to the establishment of World Health Organization (WHO) Collaborating Centres for Traditional Medicine (WHO 1988). Under the umbrella of the U.S. National Institutes of Health (2008), the National Center for Complementary and Alternative Medicine (NCCAM) was formed in 1998. Their primary responsibility is to conduct and support basic and clinical research in several areas including biologically based practices. Finally, in 2002, the WHO launched a global strategy called TM/CAM that aims, among other things, to assist governments in the cultivation and conservation of medicinal plants to ensure their sustainable use and to regulate and set policies on herbal medicines (WHO 2008). As a result of these events, the scientific output on the medicinal properties of plants, their growth, remedies, and the therapeutic uses they provide has grown consistently worldwide. One of these plants with significant nutritional and medicinal potential is the pomegranate.

The pomegranate, scientifically named *Punica granatum* L. is one of the oldest fruits known to man and can be traced back to Persia, Greek mythology, ancient Egypt, Babylonia, the Roman Empire, as well as being symbolized in religious holy books (Morton 1999). Today, the pomegranate is cultivated in Iran, Mediterranean countries, Afghanistan, India, China, Pakistan, and some parts of the United States. The pomegranate's antioxidant polyphenols and anti-inflammatory properties, as well as its richness in Vitamin C and folic acid, make it one of the most sought after plants. According to Abelson (2006), farmers cannot grow the fruit fast enough, companies cannot produce enough pomegranate-based items, and stores are unable to maintain a sufficient supply.

The literature on the *Punica granatum* L. is very scattered, multi- and inter-disciplinary in nature covering most geographic regions. Additionally, when considering the scientific, commercial, and popular appeal of this plant gives rise for the need to better understand the publication patterns of its literature. A widely used research method for analyzing the scientific activities of a literature is to apply bibliometric techniques, that is, to quantitatively evaluate its scientific productivity. Any attempt to systematically collect data on the global scientific production of the *Punica granatum* L. literature has yet to be done. Such a study will contribute to the cognitive, social, and organizational development of the *Punica granatum* L. literature. The study will provide future direction for researchers, facilitate discussion within multiple disciplines, and assist

information providers in formulating policy guidelines for the selection and acquisition of information resources.

RESEARCH OBJECTIVES

The purpose of this study is to identify and analyze the intellectual structure of the *Punica granatum* L. literature and to determine trends and patterns. The study specifically addresses the following questions:

1) What has been the periodic growth of the *Punica granatum* L. literature?
2) Where do *Punica granatum* L. authors publish?
3) Who has been conducting research and how much? What are the indicators of author collaboration?
4) What is the geographic distribution of scientific production?
5) What are the first author affiliations?
6) What are the primary research interests of the authors?
7) What languages are used to communicate the scientific literature?
8) In which journals do *Punica granatum* L. authors publish? What are the core journals? Which countries publish the most journals? From which disciplines?

REVIEW OF LITERATURE

There have been a number of bibliometric studies on plants, herbs, and agricultural crops. Bhat (1995) examined two decades of records, 1973-1993 in *CAB Abstracts*. Some 50,000 citations covered such topics as medicinal plants (52.5%), pesticidal and poisonous plants (24.2%), and herbs and spices (12.0%). One of the conclusions of the study was that the volume of literature published annually had at least tripled over this period. Subbaiah (1984) reported on 80 years of grape research in India with the primary focus on the cultivation of grape crops. Using bibliographic data from 158 publications, Adelowo and Agbonlahor (2003) developed a taxonomic information system on medicinal plants of South-Western Nigeria where they collected and analyzed 118 indigenous species. Chadwick and Craker (1988) reviewed and evaluated the literature on herbs for the purpose of providing a list of information sources that would assist librarians in building scientific and technical collections. They found that the herbal literature was limited and widely scattered resulting in a lack of accessibility for libraries.

Several studies explored the content of a specific journal (Lal 1993; Sarala 1995). Most recently, Biswas, Roy, and Sen (2007) studied the content and characteristics of the journal *Economic Botany* from 1994-2003. They found that certain subject clusters such as ethnobotany, traditional and folk medicine, plant products, and phytochemistry dominated the literature. The majority of the papers were co-authored; most primary authors were affiliated with academic institutions, and the articles originated from 45 countries with the United States leading, followed by the United Kingdom.

Other studies focused specifically on the subject of Chinese medicine. To describe a few, Haiqi (1994) examined the references of 343 articles listed under the MeSH topic medicine-Chinese-traditional in the Medline database, covering the years 1974 to 1992. The data showed most items originated from China and the United States. Chinese and English were the preferred languages used and there was a high concentration of articles in a relatively small number of journal titles. Similarly, Leung, Chan, and Song (2006) examined publishing trends in Chinese medicine, Chinese pharmacy, and acupuncture as documented in WorldCat. Their findings showed that there were 45 languages found in the database, with English constituting the largest share (53%). For obvious reasons, monographs constituted the major format and understandably most of the records were from the twentieth-century.

Two studies similar in nature to the present study were conducted by Anwar (2005; 2006). In the first study, Anwar (2005) studied the periodic growth, author patterns, subject focus, and geographic origin of the *Nigella sativa* literature, commonly known as the Black seed. He analyzed 530 citations and found that most of the literature came from medical sciences and chemistry; India and Egypt were the leading contributors; most publications were co-authored; and English was the main language. In another study, Anwar (2006) examined the *Phoenix dactylifera* L., date palm literature. Using bibliometric analysis, he identified 2,465 citations and found that most of the literature originated from Iraq and Egypt; English was also the most used language; and a small core of authors were responsible for one-third of the publications. This literature was also interdisciplinary primarily covering the fields of agriculture, biological sciences, and chemistry.

The present study represents the first research using bibliometric techniques to evaluate and quantify the scientific activity on the *Punica granatum* L. literature. The pandemic affect that the *Puncia granatum* L. has had on the common populace supports the need to study the structure and development of its communication patterns. The results from this study should make an important contribution to the continuing research on the *Punica granatum* L.

METHODOLOGY

The literature on *Punica granatum* L. is multi-disciplinary in nature and therefore distributed across a variety of sources. Thirty-one relevant databases, including *Agricola, AGRIS International, BIOSIS, CAB Abstracts, Cambridge Scientific Abstracts, Chemical Abstracts, Food Science & Technology Abstracts, MEDLINE and SciSearch* were searched to identify relevant citations. In addition, the National Library of Medicine (NLM) and the National Agricultural Library (NAL) online catalogs were also examined for potential citations. All publications were reviewed through 2006. The total number of citations retrieved was 5,309. The data were sorted and manipulated using the software package ProCite. Care was exercised to ensure the relevancy and accuracy of each record. Duplications, 1,794 records in all, were removed as each new group of records was loaded into the ProCite file. Furthermore, 209 records were incomplete and their information would have led to inconsistencies in the data analysis, therefore, these

records were also removed. The final data set consisted of 3,306 records. For the analysis of the data, bibliometric techniques were applied including Bradford's Law.

RESULTS AND DISCUSSION

Growth of the Literature

The periodic growth of the *Punica Granatum* L. literature is shown in Figure 1. The timeline is divided into periods of 5-years each with the exception of the first and last periods. Prior to 1970, very few items were published. Similarly, Anwar (2005, 2006) in his studies on the *Nigella sativa* and the *Pheonix dactylifera* L. literature also reported very limited research interest during this period. From 1970 onwards, there has been a steady and consistently increasing interest in *Punica granatum* L. related research. Analysis suggests that the literature exploded to remarkable proportions during the period 2000 to 2004 (n=901; 27.25%). The dotted line shown in Figure 1 is to indicate that the final value of 537 publications covers only two years (2005-2006). The data shows that the average number of publications for this two year period is approximately 268 per year. If the rate of growth follows a similar average per year, then one might see that the number of publications through 2009 could grow in access of 1300 publications. Findings from this study support the premise that the scientific output of the *Punica granatum* L. literature is growing and that there is an avid research interest in the pursuit of related topics.

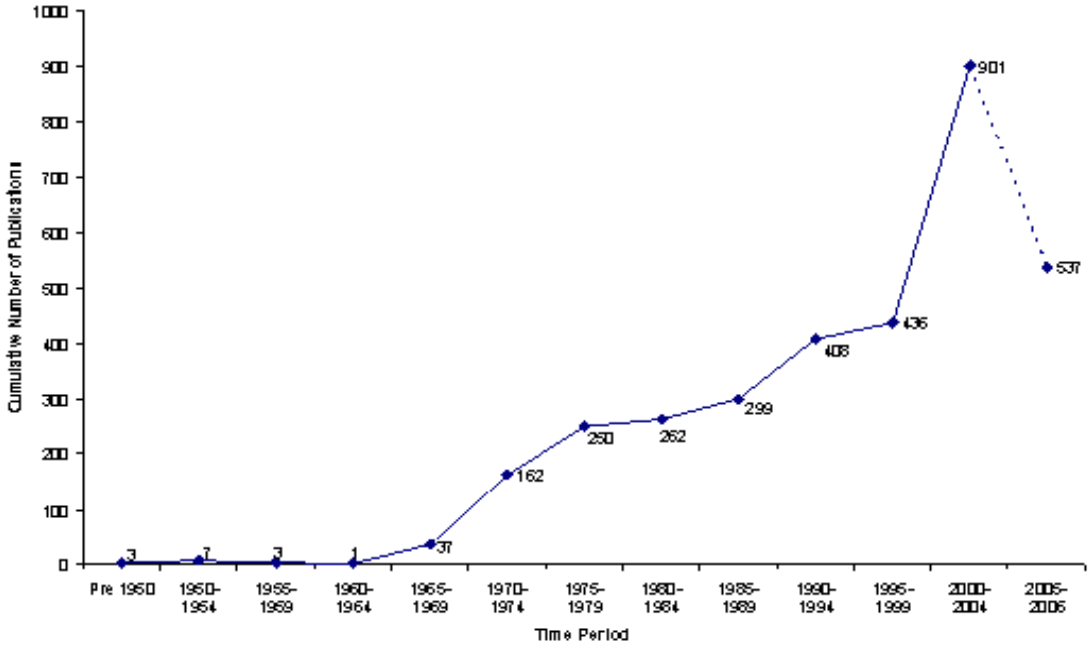

Figure 1: Periodic growth of the *Punica granatum* L. literature

Scientific Output by Document Type

This section provides findings on the type of publications produced. It is clear that journal articles constitute the largest single category, 75.53 percent (n=2,497) followed by conference papers at 9.50 percent (n=314). Patents, the third most frequent document type, account for 8.22 percent (n=272) of the total literature. Books and book chapters contribute 4.81 percent (n=159), while reports and dissertations make-up the remaining 1.94 percent (n=64). The high percentage of journal articles found in the *Punica granatum* L. literature is consistent with established theory that the majority of scholarly communication in the sciences follows this path (Osareh 1996; Glanzel and Schoepflin 1999).

Studies by Moed and Hesselink (1996), Alfaraz and Calvino (2004) and Anwar (2005) indicated that normally patents have not figured widely in a scientific literature, that is less than two percent. In this literature, patents have played a more important role (8.22 percent). According to Koenig and Beauchemin (2002) patents are becoming more strategically important because approximately "25% of all scientific and technical publications produced each year originate in patent offices around the world." Since 1963, patent applications in the United States have quadrupled and applications worldwide have increased tenfold (Pike 2007). The break down of patents for the *Punica granaum* L. literature is as follows: 130 patents are from Eastern Asian countries, 70 from the United States, 54 from European countries, and the remaining 18 from four other countries. Consistent with the number of patents increasing significantly over time, the majority of the patents in this literature (216) were issued between the years of 2000 to 2006.

Author Characteristics

(a) Scientific Output of the Authors

For the period under study, there were 5,670 unique authors consisting of single authors as well as co-authors (56 corporate bodies are excluded from this analysis). The vast majority of authors, 76.46 percent (n=4,335), contributed only one item each while the most prolific author had 43 publications.

Table 1 lists the most productive authors of the *Puncia granatum* L. literature, the number of their publications, the period during which they have been contributing to the literature, and the yearly mean of author productivity. There are 34 top producing authors who contributed between 12 and 43 publications each. These 34 scholars can be considered the core writers on the *Punica granatum* L. literature. A closer look at Table 1 reveals that 29 of these authors have publications from the year 2000 to 2006. In addition, by examining the ranking by yearly mean, the top seven ranked authors have produced all of their publications during the same time span. This is consistent with an earlier statement that the production of literature from 2000 and beyond experienced a significant growth trend.

(b) Author Collaboration

Bibliometric indicators are widely used in the analysis of scientific collaboration to study productivity, visibility and quality of research (Bordons and Gomez 2000). Two aspects of the collaboration process examined in this paper are the quantitative analyses of author collaboration and how such collaboration has evolved over time. The distribution

of author collaboration in the *Punica granatum* L. literature is shown in Table 2 (56 corporate bodies are excluded from this analysis). The rate of collaboration has grown significantly from 55.6 percent during the period 1970 to 1974, to 78.3 percent in 2005 to 2006, an increase of 361.8 percent. Consequently, co-authored contributions have the largest share of the publications**,** 71.82 percent (n= 2,334). This growth, indicative of the high occurrence of multiple authorship, is consistent with findings reported in other bibliometric studies that scientists predominately work in teams (Satyanarayana and Ratnakar 1989; Steynberg and Rossouw 1995; Bordons and Gomez 2000; Karlsson et al. 2007).

Table 1: Authors Producing 12 or More Publications

SN	Name of the Author	Contribution Period	Total No. of Publications	Rank by Number	Yearly Mean	Rank by Yearly Mean
1	Levin, G. M.	1976-1996	43	1	2.1	10
2	Melgarejo, P.	1991-2006	30	2	1.9	12
3	Aviram, M.	2000-2006	26	3	3.7	5
4	Lansky, E. P.	1998-2006	24	4	2.7	7
5	Artes, F.	1995-2005	23	5	0.3	25
6	Mars, M.	1994-2004	22	6	2.0	11
7	Seeram, N. P.	2004-2006	21	7	7.0	1
8	Desai, U. T.	1989-2000	19	8	1.6	14
9	Benk, E.	1969-1987	18	9	0.9	19
10	Tomas-Barberan, F. A.	1995-2006	18	9	1.5	15
11	Krishnamoorthy, A.	1990-2005	17	10	1.0	18
12	Mani, M.	1990-2005	17	10	1.0	18
13	Singh, R.	1974-2006	17	10	0.5	23
14	Mukhtar, H.	2003-2006	16	11	4.0	4
15	El-Kassas, S. E.	1984-2002	15	12	0.8	20
16	Gil, M. I.	1995-2000	15	12	2.5	8
17	Llacer, G.	1995-2001	15	12	2.1	10
18	Prasad, P. N.	1990-2004	15	12	1.1	17
19	Aksoy, U.	1995-2000	14	13	2.3	9
20	Heber, D.	2004-2006	14	13	4.7	2
21	Hernandez, F.	1999-2006	14	13	1.8	13
22	Luedders, P.	1979-1996	14	13	0.8	20
23	Martinez, J. J.	2000-2006	14	13	2.0	11
24	Pareek, O. P.	1974-2006	14	13	0.4	24
25	Afaq, F.	2003-2006	13	14	3.3	6
26	Kucherova, T. P.	1974-1989	13	14	0.8	20
27	Shiraishi, T.	2000-2002	13	14	4.3	3
28	Tanaka, T.	1985-2004	13	14	0.7	21
29	Abe, M.	2000-2002	12	15	4.0	4
30	Karale. A. R.	1979-2000	12	15	0.6	22
31	Mote, U. N.	1990-2003	12	15	0.9	19
32	Patil. V. K.	1980-1996	12	15	0.7	21
33	Sharma, R. C.	1992-2005	12	15	0.9	19
34	Zhang, Y.	1991-2000	12	15	1.2	16

Table 2: Distribution of Author Collaboration (N=3,250)

Number of Authors	No. of Publications	Percentage of Publications
1	916	28.18
2	905	27.84
3	671	20.65
4	390	12.00
5	166	5.11
6	100	3.08
>6	102	3.14
Total	3,250	100.00

The data used to calculate the average number of authors per document is presented in Table 3. Due to the scarcity of publications before 1970, statistics from pre-1950 to 1969 were ignored. As can be seen in Table 3, the average number of authors per publication during each five-year period has gradually increased over time. The cumulation average for the first five-year period is 1.9 whereas in the last period, the cumulation average has risen to 3.4. One needs to keep in mind that the last time period contains only two years worth of data; therefore, it can be assumed that if such an upward trend continues then the average number of authors per publication may be greater than 3.4 by the completion of the 2005-2009 period.

Table 3: Average Number of Authors per Publication

Time Period	1970 to 1974	1975 to 1979	1980 to 1984	1985 to 1989	1990 to 1994	1995 to 1999	2000 to 2004	2005 to 2006
Total Source Items	160	246	252	287	402	435	892	525
Total Number of Source Authors	307	470	532	662	961	1,128	2,648	1,766
Average	1.9	1.9	2.1	2.3	2.4	2.6	3.0	3.4

Further examination of the data shows that the average number of authors per publication in the *Punica granatum* L. literature is lower than the average associated with science disciplines. According to Science Citation Index (SCI 2006), the average number of authors per source item in 2005 is 4.5, whereas in this study the average is 3.5. The average, however, can vary widely among science and technology fields. Bordons and Gomez (2000) report, a field like physics can have an average of 9.3 while fields such as mathematics and clinical medicine will have extremely low values. So, it can be argued that the average of 3.5 authors per publication is still safely within the science disciplines.

(c) Geographic Origin of the First Author

The geographic origin of the first author was determined for 3,162 publications (data for 144 publications was not available). Contributors to the *Punica granatum* L. literature

came from 87 countries. Due to this large number, countries were categorized according to geographic regions based on a document prepared by the United Nations Statistics Division (2008). All continents were represented with the exception of Antarctica. An examination of the geographic origin of first authors (Table 4) reveals that Southern Asian countries, 33.21 percent (n=1,050), figured strongly, followed by authors originating from Eastern Asian countries, 13.28 percent (n=420). In fact, all Asian countries combined make-up a substantial portion of the literature, 64.20 percent (n=2,030). African countries with the exception of Northern Africa account for less than one percent of all items.

Table 4: Geographic Origin of the First Author (N=3,162)

Geographic Region	No. of Countries	No. of Publications	Percentage of Publications
Southern Asia	6	1,050	33.21
Eastern Asia	5	420	13.28
Northern America	2	321	10.15
Central Asia	4	269	8.51
Western Asia	14	257	8.13
Southern Europe	6	223	7.05
Northern Africa	5	187	5.91
Western Europe	6	138	4.36
Northern Europe	5	96	3.03
South America	6	72	2.28
Eastern Europe	8	41	1.30
South-Eastern Asia	4	34	1.08
Oceania	2	18	0.57
Central America	1	11	0.35
Caribbean	3	7	0.22
Eastern Africa	6	7	0.22
Southern Africa	1	6	0.19
Western Africa	3	5	0.16
Total	87	3,162	100.00

Table 5 shows that ten countries produced 75.11 percent (n=2,375) of all the publications, while the remaining 24.89 percent (n=787) originated from 77 countries. When addressing specific countries, India had the largest share of publications, 28.72 percent (n=908), followed by the United States, 9.33 percent with 295 items, the former U.S.S.R. (n=248; 7.84%), and China (n=207; 6.55%). Collectively, these four countries account for more than half, 52.44 percent (n=1,658) of the publications on the *Punica granatum* L. literature.

The country of origin of the first author was cross-tabulated with date of publication to establish which countries published most frequently during which periods of time. It was found that the former Soviet Republic was very active during the 1970s and 1980s publishing 240 items, however, after the dissolution of the Republic in 1991, research

scholarship decreased significantly. From 1991 to 2006, eight of the 15 independent republics have published only 55 items, a 74.3 percent decrease. Maddox (1994) writes that former socialist countries in Eastern and Central Europe still suffer from a tradition of self-sufficiency and shortage of international journals and Vizi (1993) notes that despite the new freedom, a shortage of financial means has caused a massive brain drain. Similar to the former Soviet Union, Egypt is the only other country where the number of publications has decreased. Authors from Egypt have steadily published since the 1960s, yet there has been a 79.13 percent decline in publications covering the years 2000 to 2006.

Table 5: Top Ten Most Productive Countries

Rank	Name of Country	No. of Countries	Percentage of Countries
1	India	908	28.72
2	U.S.	295	9.33
3	Former U.S.S.R.	248	7.84
4	China	207	6.55
5	Japan	165	5.22
6	Egypt	139	4.40
7	Spain	127	4.02
8	Germany	103	3.26
9	Turkey	101	3.20
10	U.K.	82	2.60

Examination of the literature shows that the research output from India has been steadily growing since the 1970s, and the number of publications covering the years 2000 to 2006 account for 39.65 percent (n=360) of the items. The United States first published on the *Punica granatum* L. in 1917 but like other countries has published most of its research from 1980 onwards with more than half (n=189) appearing in the years 2000-2006. China did not start producing research until the 1980s with only a few items (n=11), followed by 54 publications in the 1990s and increasing to 142 from 2000 to 2006. Likewise, Japan produced the majority of its items (n=115) from 2000 to 2006. Finally, almost all of the publications by authors originating from Spain (n=115), Turkey (n=90), and from the United Kingdom (n=68) were published from 1990 onwards.

(d) Institutional Affiliation of the First Author

A final demographic variable studied was the institutional affiliation of the first author. The publications indexed in the databases provided first author affiliation addresses for 3,162 publications only (data for 144 publications was not available). Institutional categories included educational institutions, research institutes, corporate bodies, government agencies, health care facilities, professional associations, botanical gardens, and museums (Table 6). In agreement with world distribution, educational institutions, 56.20 percent (n=1,777), make up more than fifty percent of the author's affiliation, with universities bearing the largest portion. Research centres are the second highest category of author affiliation 27.32 percent (n=864). The ranking of the 34 institutions producing ten or more publications is shown in Table 7. Thirty-three on the list are affiliated with academic and research organizations, with Mahatma Phule Agricultural

University (India) ranking first with 107 publications. The remaining one is an industrial institution, Kanegafuchi Chemical Industry located in Japan with 12 contributions.

Table 6: Institutional Affiliation of First Author (N=3,162)

Type of Institution	No. of Authors	Percentage of Publications
Educational Institution		
University	1,527	48.30
College	131	4.14
Academy	100	3.16
Other	19	0.60
Subtotal	1,777	56.20
Research Institute/Station	864	27.33
Corporate Body	322	10.18
Government Agency	151	4.78
Health Care Facility	24	0.76
Professional Association	15	0.47
Botanical Garden	7	0.22
Museum	2	0.06
Total	3,162	100.00

Subject Dispersion of the Literature

The macro-analysis of the 3,306 publications, based on subject distribution, provides a disciplinary profile of the *Punica granatum* L. literature. Due to the different indexing structures used to assign descriptors within the database, the volume of descriptors assigned to the citations, and the multi-disciplinary nature of the literature, subjects were assigned using *Library of Congress Subject Headings* (*LCSH*). Primary subjects of the publications were identified by selecting a major descriptor assigned to the database citation. These descriptors were categorized into 30 terms according to *LCSH* to establish the preferred subject term.

Table 8 shows the degree to which the *Punica granatum* L. literature is dispersed among many subjects. The top ten subjects, plant diseases, growth (plants), botanical chemistry, pharmacognosy, plant products, agricultural processing, agricultural chemicals, plant breeding, pests--control, and botany account for more than two-thirds of all the publications, 74.02 percent (n=2,447), while the remaining 20 categories are represented by 25.98 percent (n=859).

As with other studies of a similar nature (Anwar 2005; Anwar 2006), this study also found that the pomegranate literature supports a strong inter-disciplinary approach to the research being conducted. To highlight a few examples, alternative medicine is shared by biology, pharmacology, and botanical chemistry; beverages and food--composition is shared by botanical chemistry, medicine, and pharmacology; growth (plants), plant diseases, and plant contamination is shared by biology and agriculture; agricultural chemicals is shared by pests--control and soil management. Such overlap attests to the strong inter-disciplinary nature of not only the *Punica granatum* L.

literature but the literature on nutritional plants. Despite the overlap, if these publications are grouped into broader disciplines, biology (n=1,453; 43.95%), agriculture (n=827; 25.01%), and pharmacology (n=396; 11.98%) comprise the largest portion of the citations (n=2,676; 80.94%). This empirical evidence offers sound support for the view that the *Punica granatum* L. literature is not only multidisciplinary in scope and character but interdisciplinary as well.

Table 7: Institutions Producing Ten or More Publications

SN	Name of Institution	Rank	No. of Publications	Name of Country
1	Mahatma Phule Agricultural University	1	107	India
2	Indian Institute of Horticultural Research	2	41	India
3	Punjab Agricultural University	3	40	India
4	Haryana Agricultural University	4	38	India
5	Assiut University	5	37	Egypt
6	Central Arid Zone Research Institute	6	35	India
7	Centre of Edafology and Applied Biology of the Segura High Council of Scientific Research (CEBAS-CSIC)	7	28	Spain
8	Technion – Israel Institute Technology	8	25	Israel
9	University of California, Davis(David Geffen School of Medicine)	9	24	USA
10	Indian Agricultural Research Institute, New Delhi	10	23	India
11	Universidad Miguel Hernandez	11	22	Spain
12	University of California, Los Angeles	12	21	USA
13	University of Horticulture & Forestry	12	21	India
14	Technische Universitat, Berlin	13	19	Germany
15	Aligarh Muslim University	13	19	India
16	University of Wisconsin, Madison	14	18	USA
17	Plant Pests and Diseases Research Institute	15	16	Italy
18	Cairo University	15	16	Egypt
19	University of Tehran	15	16	Iran
20	National Research Centre	15	16	Egypt
21	Environmental Protection Agency, Washington, D. C.	16	15	USA
22	Ankara University	16	15	Turkey
23	Ministry of Agriculture, Egypt	16	15	Egypt
24	Alexandria University	17	14	Egypt
25	Kasetsart University	17	14	Thailand
26	King Saud University	17	14	Saudi Arabia
27	Anhui Agricultural University	17	14	China
28	Central Food Technology Research Institute	17	14	India
29	Chemische Landesuntersuchungsanstalt, Sigmaringen (Chemical Investigation Institute Sigmaringen)	18	12	Germany
30	Kanegafuchi Chemical Industry Co. Ltd.	18	12	Japan
31	The Agricultural Research Organization of Israel (ARO)	19	11	Israel
32	Akdeniz University	20	10	Turkey
33	Ege University	20	10	Turkey
34	University of Agriculture (Faisalabad)	20	10	Pakistan

Table 8: Subject Dispersion of the Literature (N=3,306)

SN	Subject	Rank	No. of Publications	Percentage of Publications
1	Plant Diseases	1	505	15.28
2	Growth (Plants)	2	371	11.22
3	Botanical Chemistry	3	314	9.50
4	Pharmacognosy	4	255	7.71
5	Plant Products	5	216	6.53
6	Agricultural Processing	6	192	5.81
7	Agricultural Chemicals	7	163	4.93
8	Plant Breeding	8	158	4.78
9	Pests--Control	9	151	4.57
10	Botany	10	122	3.69
11	Food--Composition	11	110	3.33
12	Beverages	12	94	2.84
13	Plant Anatomy	13	76	2.30
14	Dermatopharmacology	14	64	1.94
15	Ethnopharmacology	15	63	1.91
16	Food--Analysis	16	62	1.88
17	Laboratory Animals	17	59	1.79
18	Soil Management	18	47	1.42
19	Nutrition	19	46	1.39
20	Produce Trade	20	42	1.27
21	Food Contamination	21	34	1.03
22	Alternative Medicine	22	30	0.91
23	Horticulture	23	21	0.64
24	Botany--History	24	19	0.57
25	Plant Conservation	24	19	0.57
26	Diseases	25	18	0.54
27	Ecology	26	17	0.51
28	Allergy	27	14	0.42
29	Drugs	27	14	0.42
30	Botany--Study and Teaching	28	10	0.30
--	Total	--	3,306	100.00

Language Dispersion of the Literature

Table 9 shows that English language publications constitute a significant portion of the literature in this study, 69.57 percent (n=2,300). The remaining items, 30.43 percent (n=1,006), are written in 30 other languages. The next six languages, Russian, Chinese, Japanese, German, French, and Spanish, although having much lower percentages, collectively contribute 23.32 percent (n=771). The other 24 languages are responsible for only 7.11 percent (n=235) of the publications. Twelve of those languages account for less than one percent with seven having only one publication each.

Table 9: Language of Publication (N=3,306)

Language	No. of Publications	Percentage of Publications
English	2300	69.57
Russian	287	8.68
Chinese	190	5.75
Japanese	102	3.09
German	91	2.75
French	52	1.57
Spanish	49	1.48
Slavic languages (6 languages)	36	1.09
Portuguese	33	1.00
Turkish	32	0.96
Korean	31	0.94
Italian	30	0.91
Persian	28	0.85
Arabic	13	0.39
Others (12 languages)	32	0.97
Total	3,306	100.00

When language was cross-tabulated with country of origin, it was found that all the researchers residing in India published only in English and 97.12 percent of authors from Egypt published in English as well. Other authors who published more than half of their publications in English rather than the official language of the country were Spain (77.17%), Turkey (66.34%), Iran (58.11%), France (57.14%), and Italy (52.63%). These findings are strong indications that authors choose to publish in English rather than their native language, perhaps because of the higher visibility or use of English language publications within the scientific community. In general, English is the dominant language for international scientific communication. This fact is further mirrored in the many bibliometric studies that can be found in all fields of the literature.

Journal Literature

Given that the journal literature comprises 75.53 percent (n=2,497) of all *Punica granatum* L. publications and since the scientific journal is the main mode of scholarly communication, it was warranted to take a closer look at this characteristic. The subject distribution of the journals, identification of the core journals as determined by Bradford's Law, and the geographic origin of the journals are presented in this section. The online version of *Ulrich's* (2008) was used to determine the geographic distribution and the subject category of the journal literature. There are 1,045 unique journal titles containing 2,497 publications. Table 10 illustrates that *Punica granatum* L. researchers publish in journals that cover a broad spectrum of subject categories, 27 in this study. The five most common categories were biology, agriculture, medical sciences, food and food industries, and pharmacy and pharmacology collectively comprise 72.44 percent (n=757) of the journal titles. Further representation of the categories shows a wide-range of business, industry, and social sciences disciplines as well.

Table 10: Subject Distribution of the Journal Literature

SN	Subject Category	Rank	No. of Journals N=1,045	Cumulative Percentage of Journals	No. of Articles N=2,497	Cumulative Percentage of Articles
1	Biology	1	304	29.09	692	27.71
2	Agriculture	2	212	49.38	663	54.26
3	Medical Sciences	3	97	58.66	139	59.83
4	Food and Food Industries	4	74	65.74	191	67.48
5	Pharmacy and Pharmacology	5	70	72.44	147	73.37
6	Chemistry	6	59	78.09	117	78.06
7	Science: Comprehensive Works	7	54	83.26	109	82.43
8	Gardening and Horticulture	8	39	87.00	198	90.36
9	Nutrition and Dietetics	9	35	90.35	66	93.00
10	Environmental Studies	10	17	91.98	21	93.84
11	Forests and Forestry	10	17	93.61	30	95.04
12	Beverages	11	11	94.66	25	96.04
13	Alternative Medicine	12	10	95.62	17	96.72
14	Textile Industries and Fabrics	13	9	96.48	23	97.64
15	Physics	14	5	96.96	5	97.84
16	Veterinary Sciences	14	5	97.44	7	98.12
17	Business and Economics	15	4	97.82	4	98.28
18	Earth Sciences	15	4	98.20	6	98.52
19	Energy	15	4	98.58	7	98.80
20	Archaeology	16	3	98.87	3	98.92
21	Engineering	16	3	99.16	3	99.04
22	Public Health and Safety	16	3	99.45	4	99.20
23	Metallurgy	17	2	99.64	2	99.28
24	Anthropology	18	1	99.73	1	99.32
25	General Interest Periodicals	18	1	99.82	1	99.36
26	Geography	18	1	99.91	1	99.40
27	Law	18	1	100.00	15	100.00

To test the distribution of journal articles over journal titles Bradford's Law of Scattering was applied (Bradford 1934). The journal titles are ranked based on the number of articles they contribute to the *Punica granatum* L. literature. The ranked list is then divided into three or more zones with each zone having decreasing journal productivity while containing approximately the same number of journal articles. In the case of this study, four zones were formed (Table 11). From Table 11, it can be seen that the progression from the first to the fourth zone shows increasing scatter or dispersion of the *Punica granatum* L. literature. Table 11 also shows that zone 1 consists of 38 journal titles that form the core (nucleus) of this literature. Their contribution is 638 journal articles (25.55%) while in zone 4, there are 637 titles that have a similar contribution of 25.51 percent. The graphical representation of the distribution of this data is illustrated in Figure 2. It is observed that the curve follows closely the well-known shape of the Bradford curve. Table 12 lists in descending order the most productive journals in the literature. *Journal of Maharashtra Agricultural Universities* ranked first with 57 (2.28%)

published papers, *Indian Journal of Horticulture* ranked second with 33 (1.32%) research articles, and *Assiut Journal of Agricultural Sciences* ranked third with 32 (1.28%) papers.

Table 11: Bradford Distribution of Journals and Articles

Bradford Zone	Number of Journals		Number of Articles		Multiplier
	Number	(%)	Number	(%)	
Zone 1	38	(3.64)	638	(25.55)	-----
Zone 2	116	(11.10)	645	(25.83)	3.05
Zone 3	254	(24.31)	577	(23.11)	2.19
Zone 4	637	(60.95)	637	(25.51)	2.51
All Zones	1,045	100.00	2,497	100.00	2.58 (Mean Value)

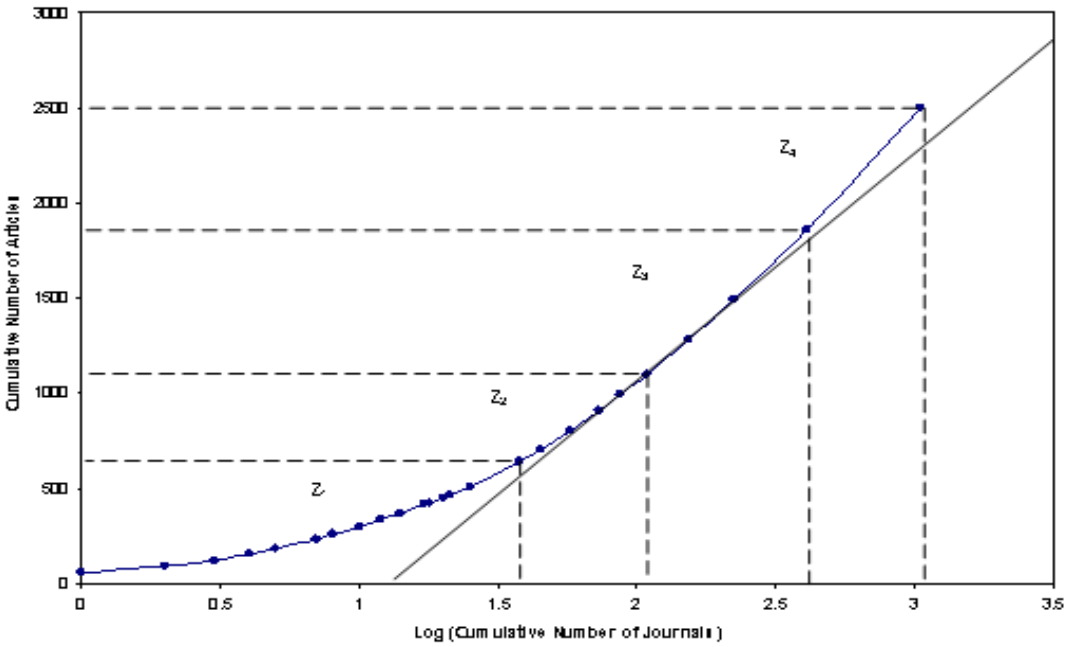

Figure 2: Graphical Distribution of Journal and Articles

Table 12: Most Productive Journals (Zone 1 titles)

SN	Journal Title	Number of Articles	Percentage of Articles	Cumulative Percentage
1	Journal of Maharashtra Agricultural Universities	57	2.28	2.28
2	Indian Journal of Horticulture	33	1.32	3.60
3	Assiut Journal of Agricultural Sciences	32	1.28	4.88
4	Journal of Ethnopharmacology	30	1.20	6.08
5	Subtropicheskie Kul'tury	28	1.12	7.20
6	China Fruits	27	1.08	8.28
7	Journal of Agricultural and Food Chemistry	27	1.08	9.36
8	Annals of Arid Zone	25	1.00	10.36
9	Indian Phytopathology	20	0.80	11.16
10	Izvestiya Akademii Nauk Turkmenskoi SSR Seriya Biologicheskikh Nauk	20	0.80	11.96
11	Chemistry of Natural Compounds	18	0.72	12.68
12	Indian Journal of Agricultural Sciences	18	0.72	13.40
13	Haryana Journal of Horticultural Sciences	16	0.64	14.04
14	Phytochemistry	16	0.64	14.68
15	Journal of Fruit Science	15	0.60	15.28
16	Federal Register	15	0.60	15.88
17	South Indian Horticulture	15	0.60	16.48
18	Entomology	14	0.56	17.04
19	Medicinal and Aromatic Plants--Industrial Profiles	13	0.52	17.56
20	Sadovodstvo i Vinogradarstvo	13	0.52	18.08
21	Brazilian Journal of Pharmaceutical Sciences	12	0.48	18.56
22	Current Science	11	0.44	19.00
23	Indian Food Packer	11	0.44	19.44
24	Indian Journal of Entomology	11	0.44	19.88
25	Iranian Journal of Agricultural Sciences	11	0.44	20.32
26-38	Others	130	5.21	25.53*

*The cumulative percentage is 25.53 due to rounding of figures

Finally, the results of the geographic distribution of the journal publishers are summarized in Table 13. An examination of the data reveals that the journals originate from six continents. The geographic regions of Southern Asia, Northern America, and Eastern Asia cover the largest share, 50.62 percent (n=529). Within these groups, India and the United States are the leading countries in publishing the *Punica granatum* L. literature. They contribute 17.70 percent (n=185) and 15.60 percent (n=163) respectively. All of the European regions combined account for 30.72 percent (n=321) of the total publications. Regions such as Central America, Eastern Africa, and the Caribbean are home to less than one percent of the journal titles.

Table 13: Country of Origin of Journals (N=1045)

Geographic Region	No. of Countries	No. of Publications	Percentage of Publications
Southern Asia	7	230	22.01
Northern America	2	169	16.17
Eastern Asia	3	130	12.44
Western Europe	6	127	12.15
Northern Europe	6	100	9.57
Central Asia	1	69	6.60
Southern Europe	6	63	6.03
Western Asia	10	34	3.25
South America	5	31	2.97
Eastern Europe	8	31	2.97
Northern Africa	3	30	2.87
Oceania	2	12	1.15
South-Eastern Asia	5	11	1.05
Central America	1	3	0.29
Eastern Africa	3	3	0.29
Caribbean	1	2	0.19
Total	69	1,045	100.00

CONCLUSION

The literature on *Puncia granatum* L. has emerged from a peripheral position within the scientific community to become a well-defined, well-recognized area that has research channels drawing from the botanical, agricultural, medical, chemical, and pharmacology disciplines. The wide diversity of the research topics, including 30 distinct subject categories, attests to the inter- and multi-disciplinary nature of the literature. The scientific output has grown exponentially and this growth of knowledge is continuing to produce at a feverish rate. The literature is indexed in a multitude of databases, covers a wide variety of disciplines, and is being published in a large variety of journals. The literature is clearly being noticed and is generating high interest within the scientific community.

Like in other scientific areas, the contributors to the *Punica granatum* L. literature emanate from academic institutions, especially universities, they like to collaborate, and they mainly publish in English. The distribution of authors, however, shows a major concentration of authors with a low publication rate, that is primarily only one publication and very few highly productive authors. In all, the literature originates from 87 countries with India leading, followed by the United States. The former U.S.S.R., an important producer of the literature during the 1970s and 1980s is now being replaced by China as the third highest provider. The journal literature is the major venue of choice for this scientific community, however, a large number of journals (n=1,045) are required to produce the 2,497 items. Applying Bradford's distribution, a nucleus of 38 titles forms the core of the journal literature for *Puncia granatum* L.

The WHO (2008) estimates that 25 percent of all modern medicines are descended from plants, that higher percentages of the populations of wealthier countries are turning more and more to alternative medicine, and that the global market for medicinal plants stands at about 60 billion US$ a year industry. Furthermore, Sumner (2000) writes that there are more than 250,000 species of flowering plants and fewer than five percent have been explored for their medicinal potential. Bearing these statistics in mind, along with the increasing popularity of this plant as well as the intense academic interest evidenced in this study is a strong indication that the *Punica granatum* L. literature will continue to grow. The outcome of this study is a positive, encouraging sign to the scientific community to pursue research endeavors related to the *Puncia granatum* L. as well as other nutritional and medicinal plants.

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