Application

Pragmatic Approach to Subject Indexing: A New Concept

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In 1982 it was decided to computerize the indexing activities of SMIC—the Sorghum and Millets Information Center—located in the Library of ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). The previously used manual indexing procedure was found to be unsuitable for computer manipulation, and it was decided to replace it by some other system which would be computer-manipulative and could represent subject contents of the documents accurately and precisely. A survey of the existing systems was made and none of them was found entirely satisfactory for SMIC. A simple indexing system has been developed which is free from any classification system and which is not limited by cumbersome postulates. In this system, keywords chosen by the indexer (who is expected to have some subject knowledge) are arranged in a meaningful sequence (a logical string). The keywords are connected by punctuation marks depicting various types of associations. The keywords are rotated to provide access through each significant keyword. The system, which is computer-manipulative, can also be used manually.

Introduction

An index is the most important tool in an information retrieval (IR) system. It has been described as a condensed key to the information contained in a document, book, or collection, or a bridge between the contents of an information store and the user. Indexing consists of indicating the subject content of an item of information by assigning one or more terms to the document so as to characterize it unequivocally. The steps involved in indexing are:

(1) conceptual analysis of the significant content of a document;

(2) expressing the analysis by a set of words or phrases to represent the subject;

(3) translating the relevant subject descriptions into standard language;

(4) arranging the standardized subject descriptions according to the syntax of the indexing language used in the information system.

Of these, the first two steps are intellectual and subjective, dependent to a great extent on the understanding and environment of the indexer. Depending on knowledge and experience, the same document will be analyzed differently by different indexers. On the other hand, because of different environments, different aspects of the same document may not be considered equally significant from the point of view of indexing. Hence, this is beyond the realm of standardization and control. Basic problems in indexing concern the other two steps—the terminological control and the sequencing of terms. The present article deals with the last problem—the syntax.

Problems in Indexing

The efficiency and effectiveness of the retrieval function is often measured in terms of its specificity, exhaustivity, speed, ease, and the degree of satisfaction felt by the user. All these factors call for a mechanism having a highly generalized, hospitable, versatile, and therefore adaptable intellectual foundation for the hierarchical formulation of specific purpose-oriented or need-based procedures for all manifestations of information retrieval. According to Bhattacharyya [1], the only mechanism capable of meeting all these requirements for information retrieval is the artificial language, technically known as Subject Indexing Language (SIL).

A SIL consists of elements which constitute its vocabulary, and rules for admissible expressions. It is artificial in the sense that it may depend upon the vocabulary of a natural language, though not always, but its grammar especially its syntax is altogether different from that of any natural language. Although SIL is supposed to have the mechanism to cope with all the problems of indexing, in practice it is not found to be so. In the words of Bhattacharyya [2] again "No standard Subject Indexing Language has yet been found to be suitable and adequate to meet the specific requirements of depth indexing in an

Received September 6, 1983; revised February 13, 1984; accepted March 16, 1984

 CCC 0002-8231/84/060325-07$04.00

area of micro-subjects." For tackling the indexing problem of SMIC, various available indexing procedures were considered, and none was found suitable. That led to the concept of "Pragmatic Approach to Subject Indexing" (PASI), which is the theme of this article. It is necessary at this stage to describe the operation in SMIC to appreciate the environment in which PASI developed.

About SMIC

The Sorghum and Millets Information Center (SMIC) was established in the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Library in December 1976, with the objective of collecting, collating, and disseminating information to research workers all over the world in the fields of sorghum and millets. One of the primary tasks of the Center was to collect documents on sorghum and millets dating from 1970 onwards and publish the references together in the form of subject bibliographies.

For all these bibliographies, excepting one, the indexes were prepared using conventional precoordinated subject indexing procedures. These indexes, though found adequate for these bibliographies, nevertheless had some inherent deficiencies. First, they took a lot of time to prepare. By rough estimate, indexing alone required more than one-third of the total compilation time (comprising the preparation of a draft index, editing, typing, proofreading, and final composing and proofreading). Secondly, these indexes were found to be unsuitable for computerization. Being precoordinated, their structure was rigid and, therefore, nonmanipulative. Hence, for the Sorghum Bibliography 1977-1980, it was decided to prepare the author and subject indexes by computer, on an experimental basis.

Search for a Suitable Indexing System

In a multifaceted document (as most research papers are) not only the approach to the document should be provided from each significant topic dealt with, but also the terms denoting the topic should be provided with a proper context so that only the relevant document is retrieved in a IR search program. Kaiser [3] has considered the complex problem of subject heading for a multiterm document in a rudimentary way. Since then a lot of research has been done in this field. Special mention may be made of Farradane [4], Ranganathan [5,6], Coates [7], Sharp [8], and Austin [9]. The Documentation Research and Training Centre (DRTC), Bangalore, has also done considerable research work in the field of indexing [10,11].

The best known forms of computer generated indexes are KWIC and KWOC. These are permuted title indexes, whose great advantage lies in their simplicity, but which suffer from a number of disadvantages which are well known. The simplest form of computerized permuted subject index is probably the SLIC index [8]. However, like other uniterm-type indexes, the SLIC index does not specify the relationship between the terms that make up the compound subject. This is a big shortcoming of SLIC. Several attempts have been made to overcome this difficulty. Two of the more successful systems advocated are Derek Austin's PRECIS (Preserved context Indexing System) and POPSI (Postulate-Based Permuted Subject Indexing) developed by the DRTC school. A comparative study of PRECIS and POPSI has been done by Rajan and Guha [12].

In PRECIS "the initial string of terms, organized according to a scheme of role indicating operators, is computer-manipulated so that selected words function in turn as the approach term. Entries are restructured at every step in such a way that the user can determine from the layout of the entry which term set the appropriate term into its context and which terms are context-dependent on the approach term." The premise "is that relationship can generally be left to be understood provided the most closely related terms are placed closest together in the index entry." The actual form of PRECIS, however, is considerably more complex. There is also the criticism that PRECIS is unable to bring out both the semantic and syntactic roles of terms in one single string.

POPSI assumes an arrangement of the elements of a subject by the indexer according to principles analogous to those used in classification. It is a take-off from the principles enunciated by Ranganathan in his chain indexing. Since it is not practicable to construct the POPSI subject proposition in the absence of a classaurus (a systematic hierarchical scheme for classification having all the essential features of the thesaurus), its application for SMIC indexing was ruled out.

While selection of keywords is not very difficult for an experienced indexer, the crux of the problem in indexing seems to be the logical ordering of the keywords which will give an unambiguous idea regarding the subject content of the document. Most of the researches in this field have been directed towards designation of keywords into various categories and development of formulae for the ordering of the keywords by their categories. As this involves not very clearly defined characteristics for identifying a category (Discipline, Entity, Action, and Property in POPSI, and entities and attributes in PRECIS) and different types of relationships between them, which in turn determine their sequence in an index chain, the whole operation of indexing becomes quite complicated for the uninitiated in the particular school of thinking. Moreover "no amount of rules can take care of all problem situations. The consideration of the purpose, the analogy of prescribed rules and standards, a thorough knowledge of the terminology of the subject concerned, and a good amount of work experience go a long way in solving problems of subject indexing" [2].

In spite of considerable research, the problems involved in sequencing of terms still require further research and development, mainly in the context of machine application. In SMIC we realized that we have to adopt a more pragmatic approach than the postulational approaches advocated by the existing systems. The analysis of the subject, detection of its components, their categorization, and their sequencing not only demands some intellectual labor, but they are also subject to individual perception, and hence are subjective. It was argued: if at the end of so much intellectual exercise the results are not free from bias, why not give greater freedom to the indexer? Let him construct the chain freely based on his knowledge and experience. In this connection Ranganathan's idea of "absolute syntax" is relevant. Absolute syntax is defined as the sequence of the component ideas in a subject which is helpful and acceptable to a majority of users. It is recognized that specialists' minds are attuned to this absolute syntax in their subject area. Since SMIC indexers are knowledgeable both of their subject fields and of the primary users, we considered, they should be able to make superior indexes. The outcome of this thinking is PASI—Pragmatic Approach to Subject Indexing.

There is great similarity of approach between PASI and NEPHIS—Nested Phrase Indexing System, advocated by Craven [13]. NEPHIS "is a system of computer-aided indexing in which the indexer decides on suitable subject descriptions and translates these into input strings from which NEPHIS program generates the required permutations. The system was designed with a number of fairly specific objectives in mind. These could be summed up in the basic requirement that it should be *easy*." PASI, similarly has a set of clearcut objectives, whose basic aim is that it should be *practical*. The system should be commensurate with the resources available—human, financial, time, and the end results expected.

Steps in PASI Indexing

Indexing, as we have defined earlier, consists in describing and identifying a document in terms of its subject content. The indexing process involves the conceptual analysis of the recorded knowledge in the form of documents, expressing this analysis by selection of a set of words or phrases in the form of a statement, translating the relevant subject descriptions into standard descriptor language, and finally arranging the standardized subject descriptions according to the syntax of the indexing language used in the information system. However, when a subject has been formulated in the preferred index language, it can provide only a single access in the searchable index file. To provide access from the other words or concepts of the main subject formulation, provision of a special mechanism or device is necessary for rotating or changing the position of the words in such a way that the correct meaning is available from each approach point. The usual mechanism available, within the language itself, is a system comprising the orderly rotation of terms. These rules of rotation are actually special rules of syntax in an indexing language. The problems of syntax and rotation of terms have been tackled by PASI. Various steps in PASI indexing are detailed below.

Step 1: Selection of Keywords. Keywords are selected mainly from the title. However, where an abstract is available, additional keywords are selected to enrich the title, if necessary.

Step 2: Standardization of Keywords. Keywords selected should be transcribed into standard terms as per the thesaurus being used. Cross references are also provided from the thesaurus.

Step 3: Formation of Logical String/s. Next the selected keywords are arranged in an order that according to the indexer conveys the thought content of the document. We designate this as a logical string. In some cases, it may be necessary to make more than one string, because two independent entities are being discussed in a document. The following examples will make the idea clear. The concept of absolute syntax is dependent on the environment, and the order of terms may vary from situation to situation. However, the logical string should convey the right meaning to the user.

Example 1:

Title: Intercropping of sorghum and pigeonpea in Andhra Pradesh

Keywords: Intercropping, Sorghum, Pigeonpea, Andhra Pradesh

Logical string: Sorghum: Pigeonpea, Intercropping, Andhra Pradesh

Note: The significance of putting a colon between Sorghum and Pigeonpea is that they should be considered as associative terms. This is explained below.

Example 2:

Title: Yield of sorghum and millet in semi-arid regions

Keywords: Yield, Sorghum, Millet, Semi-Arid Regions

String(a): Sorghum, *Yield, Semi-Arid Regions

String(b): Millet, *Yield, Semi-Arid Regions

Note: The significance of putting an asterisk before Yield is that it is a nonindex entry term. This is also explained below.

Step 4: Rotation of the String. The next step is to bring each keyword into entry term position. The first keyword in an index chain is the entry term. This is effected by cyclic rotation of the keywords. Each keyword is separated by a comma. For example, for the logical string ABCDE, the index entries will be:

A, B, C, D, E
B, C, D, E, A
C, D, E, A, B
D, E, A, B, C
E, A, B, C, D

Such examples are simplistic, however. In practice, a number of problems are encountered. The following devices are proposed to solve them.

Device 1. It is recognized that the mechanical rotation of the keywords in a string may result in an index entry that does not give the correct indication of the thought content of the document. Hence, it is necessary to provide some clue to obtain the logical string. This is done by putting a semi-colon in front of the first keyword of the logical string, when it is not in the index entry position. For the logical string ABCDE, the index entries are written as follows:

A, B, C, D, E
B, C, D, E; A
C, D, E; A, B
D, E; A, B, C
E; A, B, C, D

Device 2. It is also recognized that there are certain keywords in a logical string that are necessary for the complete description of the topic dealt with, but which may not be considered as search terms, and hence should not be made into entry terms. Usually, such keywords as analysis, estimation, effect, relationship, etc., are of this category. Such terms are indicated by putting an asterisk (*) before them. For example, for the logical string ABCDE, where E is not considered as an entry term, the index entries will be as follows:

A, B, C, D, *E
B, C, D, *E; A
C, D, *E; A, B
D, *E; A, B, C

Device 3. It is also recognized that there are certain keywords that should be considered in combination, because a close relationship exists between them. These associative terms can be of three types:

(1) Associative terms with an adjectival qualifier, e.g., infectious disease, endoplasmic reticulum.
(2) Associative terms with a noun modifier, e.g., food industry, child labor.
(3) Associative terms that are additives, e.g., nitrogen and phosphorous *In*: Effect of nitrogen and phosphorus on growth and yield of sorghum.

For indicating these three types of relationships, the following devices are used.

Adjectival qualifier. If it is decided that there should not be any entry from the adjectival qualifier, it is put in parentheses after the substantive word, e.g., Disease (Infectious), Reticulum (Endoplasmic). If, however, it is decided that an index entry should be made from the qualifier part as well, then it may be treated in the same manner as the noun modifier.

Noun modifier. For this, the two terms are separated by a slash and the associative terms are rotated when they are in the entry term position, e.g.,

Food/Industry and Industry/Food
Child/Labour and Labour/Child

Additive association. This differs from a noun modifier in that in the association, two (or more) entities considered in combination are joined together by "and" or its equivalent. For these the terms are joined together by a colon, and when they become entry terms, all the elements are rotated so that each element becomes the entry term by rotation, e.g.,

N:P:K, P:K:N, K:N:P

Device 4: In some cases it is found that the string becomes meaningless, or confusing, unless a preposition (or a prepositional phrase) is included. In such cases a preposition (in parentheses) is attached to the appropriate keyword. However, these are not made index entry terms (See Examples 1 and 5 worked out below).

Some Examples

Taking all these factors into account, a few examples are worked out below to explain the steps taken in PASI indexing.

Example 1:
Title: An ultra-structural analysis of Aleurone cells: Lamella bodies in Aleurone layers of wheat seeds during germination
Keywords: Ultra-structure, Lamella, Aleurone cells, Grain, Wheat, (at) Germination
Logical string: Wheat, Grain, Aleurone cells, Lamella, Ultra-structure, (at) Germination

Example 2:
Title: Vegetation-site relationship in the presettlement forests of northeastern Ohio
Keywords: Vegetation: Site, Relationship, Forests (presettlement), Ohio
Logical string: Forests, Vegetation: Site, *Relationship, Ohio

Example 3:
Title: Mutagenic effects of combination treatments of hydrazine, ethyl methanesulphonate and gamma rays in Sorghum bicolor (L.) Moench
Keywords: Sorghum bicolor, Mutation, Ethyl methanesulphonate, Hydrazine, Gamma rays
Logical string: Sorghum bicolor, Mutation, Hydrazine: Ethyl methanesulphonate: Gamma rays, *Effect

Example 4:
Title: Nitrapyrin and etradiazole effects on nitrification and sorghum production
Keywords: Nitrapyrin, Etradiazole, Nitrification, Sorghum, production
Logical strings: (a) Sorghum bicolor, Nitrogen metabolism: *Production, Nitrapyrin, *Effect (b) Sorghum bicolor, Nitrogen metabolism: *Production, Etradiazole, *Effect

Enriched Title. In the examples given, terms have been chosen from the titles only. However, the same principle applies when the title is enriched by keywords chosen from the abstract. In such cases, after the title, the next step will be to compose an "Enriched title."

After that, the steps are similar, e.g., as in the following example.

Example 5:

DABHOLKAR, A. R., and BAGHEL, S. S. "Inheritance of yield and other quantitative characters in sorghum." *Indian Journal of Agricultural Sciences* 50(12): 891-898; 1980.

Two varieties of sorghum (*Sorghum bicolor* (Linn.) Moench) susceptible to grain mould (mostly *Curvularia lunata* (Walker) Boedijin) and 5 lines that are moderately resistant or less susceptible were crossed in all possible combinations. The F_1s and parents were planted on different dates and at different fertility levels. Hayman's method was used for analysis. Grain yield, 1000-grain weight, number of grains and plant height indicated complete dominance to overdominance, whereas partial dominance was noticed for days to flowering. Since the degree of dominance was not constant at all the loci for these attributes, and even the distribution of genes was asymmetrical, it was presumed that repulsion-phase linkages were responsible for the observed overdominance. Earliness and yield-increasing genes were dominant. Early and high-yielding varieties could therefore be developed from present material by adopting a conventional breeding approach.

Title: Inheritance of yield and other quantitative characters in sorghum

Enriched title: Inheritance of yield and other quantitative characters in sorghum bred for grain mould (*Curvularia lunata*) resistance

Keywords: Sorghum bicolor, Varieties, Crossbreeding, Curvularia lunata Resistance

Logical string: Sorghum bicolor, *Varieties, Crossbreeding, (for) Curvularia lunata Resistance

Cross reference: Molds see also Curvularia lunata

Computerization

As mentioned above, the first stipulation for the selection of an indexing system for SMIC was that it should be amenable to computerization. Hence PASI has been designed in such a way that using a computer for indexing does not pose any problem. ICRISAT's computer, a VAX -11/780 has been used for index generation.

The design of system software for PASI was approached with four main objectives. The first was that the system must produce printed indexes whenever required to eliminate the need to maintain manual files. The second was that the system must be reliable, which means that it should be carefully designed so as to incorporate in its capabilities all those operations that are prescribed to it by the rules of syntax of PASI. Thirdly, the file and the record structures should be such that they should effect maximum economy in disk capacity and help in reducing the processing time. (Such aspects were particularly important in view of the large volume of data to be processed for annual bibliographies). Finally, it should be simple, and capable of operation by someone without computer experience.

An index entry in PASI consists of a set of keywords linked together by means of special symbols. Though the length of a keyword has been restricted to a maximum of 30 characters, no limit has been set on the number of keywords that are taken to form an index entry. This has been done with the purpose of providing flexibility in selecting as many keywords as required to represent fully the subject content of a document. However, our experience shows that on an average only six keywords are required for an index entry with an average length of 90 characters.

Out of the various options available for file organization on VAX -11/780 Computer system, it has been found adequate to use a sequential file with variable length records to store our index strings. This has helped in effecting economy in the use of storage space on disk and provided flexibility in appending new records whenever required.

The software operates in interactive mode and consists of three major subprograms. It generates index strings based on the data provided to the computer, arranges the records in alphabetical order, and provides output in the desired format.

The input subprogram performs the following tasks:

(1) it provides system promptings for data input;

(2) it generates index strings consisting of keywords, special symbols and reference locators;

(3) for each index entry it rotates the keywords and keyword blocks to generate index strings in rotational sequence;

(4) it provides a facility for editing index entries;

(5) it stores index strings as variable-length records in a sequential file on disk; and

(6) it provides a facility for adding new records to the file.

The index terms selected by the indexer are keyed in directly to the computer through a VT-100 terminal. The system identifies the symbol provided with each keyword and decides the next course of action it has to take. In case of a comma (,), it is assumed that for an index entry there is at least one keyword more to be keyed in, and the system provides relevant prompting. Each index entry is divided into blocks for the purpose of generating index entries in rotational sequences. A block may consist of a single keyword or a group of keywords. Each keyword separated by a comma forms a block. All the keywords linked together by a colon (:) are associative terms and they together form a single block. The same is true for keywords linked together with a slash mark (/).

Consider the following index entry that consists of three blocks:

Catenaria allomycis: Allomyces javanicus, Interface,
↓ Block-I ↓ Block-II

Ultrastructure
↓ Block-III

The first block has two keywords that are linked together by a colon (:). The remaining two blocks consist of one keyword each. The generation of index entries in rotational sequence is achieved by the cyclic movement of blocks and keywords within a block. Thus, the entry strings generated in rotational sequence for the aforesaid index entry are:

Allomyces javanicus: Catenaria allomycis, Interface, Ultrastructure
-Interface, Ultrastructure; Catenaria allomycis: Allomyces javanicus
-Ultrastructure; Catenaria allomycis: Allomyces javanicus, Interface

As already described, the semicolon (;) in index entries is introduced to help in rebuilding the logical string. The placement of semicolon at appropriate places is done automatically by the computer. Some of the keywords that are preceded by an asterisk (*) are not considered as entry terms in the index. In block as well as keyword rotation, these terms are suppressed from becoming lead terms. The asterisk (*) is not displayed in index strings. A sequence of typical index entries generated by computer is shown in Appendix 1. Through the editing facility provided by the software, it is possible to modify each element of an index entry.

Once all the records are generated, they are sorted in alphabetical order using VAX/VMS Sort-Merge routine. PASI software calls the Sort-Merge routine to perform this job, when instructed.

The index entries in their final output form consist of Heading, Subheadings, and Reference locators as shown in the example below

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Heading                         Reference locator
   ↓                                   ↓
Forests,                              128
   Vegetation: Site, Relationship, Ohio
                   ↑
              Subheadings
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The left-hand block of an index entry forms the heading. It may consist of a keyword or a group of keywords. The remaining keywords of the index string act as subheadings. The index output is obtained through the output subprogram of PASI software. In particular, it performs the following tasks:

(1) identifies headings, subheadings, and reference locators;
(2) compares the entries and groups together subheadings which correspond to common headings;
(3) compares and groups together the reference locators of entries which have common headings and subheadings; and
(4) prints the output in the desired format.

The system provides a facility for incorporating cross-references in the index, wherever required. A sample output is shown in Appendix 2.

Conclusion

In spite of considerable development that has taken place in the field of indexing, any one confronted with the task of timebound indexing of large mass of documents, faces a serious problem of selecting a suitable system tailored to his needs. SMIC also had to face the same challenge, and decided to adopt a simple system of indexing, not linked to any depth classification schedule or limited by any cumbersome postulates. We believe that PASI developed by us provides the simplest answer to indexer's problems. The only stipulation is that the indexer should be conversant with the subject field, and well attuned to the needs of the user he serves. The system has a flexible structure which makes it equally suitable for manual operation as well as for computerization. We believe that the system will be cost-effective because once the logical string is constructed by the indexer (which is an intellectual operation) the rest of the operations can be handled through a computer or by a typist after some brief instructions.

PASI has been found suitable to meet the special needs of SMIC. It is hoped that this will prove equally helpful in other similar situations where the mass of information to be processed is considerable, the time available for indexing is limited (as all time-bound programs have to be) and where "quick-and-functional" is preferable to "perfect-but-tardy."

Note: A preliminary outline of the idea was presented at the DRTC Annual Seminar (20) held in Bangalore during February 21-25, 1983 (Paper DA—"Pragmatic approach to subject indexing," by P. K. Sinha, S. Dutta, and S. Prasannalakshmi). The present article is an extensive revision of the idea presented based on comments received during the seminar.

Appendix 1: Computer-Generated Index Strings

Wheat, Grain, Aleurone cells, Lamella, Ultra-structure, (at) Germination 001
Grain, Aleurone cells, Lamella, Ultra-structure, (at) Germination; Wheat, 001
Aleurone cells, Lamella, Ultra-structure, (at) Germination; Wheat, Grain, 001
Lamella, Ultra-structure, (at) Germination; Wheat, Grain, Aleurone cells, 001
Ultra-structure, (at) Germination; Wheat, Grain, Aleurone cells, Lamella, 001
Germination; Wheat, Grain, Aleurone cells, Lamella, Ultra-structure, 001
Forests, Vegetation: Site, Relationship, Ohio 002
Vegetation: Site, Relationship, Ohio; Forests, 002
Site: Vegetation, Relationship, Ohio, Forests, 002
Ohio; Forests, Vegetation: Site, Relationship, 002
Sorghum bicolor, Mutation, Hydrazine: Ethyl methanesulphonate: Gamma rays, Effect 003
Mutation, Hydrazine: Ethyl methanesulphonate: Gamma rays, Effect; Sorghum bicolor, 003
Hydrazine: Ethyl methanesulphonate: Gamma rays, Effect; Sorghum bicolor, Mutation, 003
Ethyl methanesulphonate: Gamma rays: Hydrazine, Effect; Sorghum bicolor, Mutation, 003

Gamma rays: Hydrazine: Ethyl methanesulphonate, Effect; Sorghum bicolor, Mutation, 003
Mutagens see also, Hydrazine $$
Mutagens see also, Ethyl methanesulphonate $$
Mutagens see also, Gamma rays $$
Sorghum bicolor, Nitrogen metabolism: Production, Etradiazole, Effect 004
Nitrogen metabolism: Production, Etradiazole, Effect; Sorghum bicolor, 004
Etradiazole, Effect; Sorghum bicolor, Nitrogen metabolism: Production, 004
Sorghum bicolor, Nitrogen metabolism: Production, Nitrapyrin, Effect 004
Nitrogen metabolism: Production, Nitrapyrin, Effect; Sorghum bicolor, 004
Nitrapyrin, Effect; Sorghum bicolor, Nitrogen metabolism: Production, 004
Sorghum bicolor, Varieties, Crossbreeding, (for) Curvularia lunata Resistance 005
Crossbreeding, (for) Curvularia lunata Resistance; Sorghum bicolor, Varieties, 005
Curvularia lunata Resistance; Sorghum bicolor, Varieties, Crossbreeding, 005
Molds see also, Curvularia lunata $$

Appendix 2: Computer-Generated PASI Index

Aleurone cells,
Lamella, Ultra-structure, (at) Germination; Wheat, Grain, 001
Crossbreeding,
(for) Curvularia lunata Resistance; Sorghum bicolor, Varieties, 005
Curvularia lunata Resistance;
Sorghum bicolor, Varieties, Crossbreeding, 005
Ethyl methanesulphonate: Gamma rays: Hydrazine,
Effect; Sorghum bicolor, Mutation, 003
Etradiazole,
Effect; Sorghum bicolor, Nitrogen metabolism: Production, 004
Forests,
Vegetation: Site, Relationship, Ohio 002
Gamma rays: Hydrazine: Ethyl methanesulphonate,
Effect; Sorghum bicolor, Mutation, 003
Germination;
Wheat, Grain, Aleurone cells, Lamella, Ultra-structure, 001
Grain,
Aleurone cells, Lamella, Ultra-structure, (at) Germination; Wheat 001
Hydrazine: Ethyl methanesulphonate: Gamma rays,
Effect; Sorghum bicolor, Mutation, 003
Lamella,
Ultra-structure, (at) Germination; Wheat, Grain, Aleurone cells, 001
Molds see also,
Curvularia lunata
Mutagens see also,
Ethyl methanesulphonate,
Gamma rays,
Hydrazine
Mutation,
Hydrazine: Ethyl methanesulphonate: Gamma rays, Effect; Sorghum bicolor, 003
Nitrapyrin,
Effect; Sorghum bicolor, Nitrogen metabolism: Production, 004
Nitrogen metabolism: Production,
Etradiazole, Effect; Sorghum bicolor, 004
Nitrapyrin, Effect; Sorghum bicolor, 004
Ohio;
Forests, Vegetation: Site, Relationship, 002
Site: Vegetation,
Relationship, Ohio; Forests, 002
Sorghum bicolor,
Mutation, Hydrazine: Ethyl methanesulphonate: Gamma rays, Effect 003
Nitrogen metabolism: Production, Etradiazole, Effect 004
Nitrogen metabolism: Production, Nitrapyrin, Effect 004
Varieties, Crossbreeding, (for) Curvularia lunata Resistance 005
Ultra-structure,
(at) Germination; Wheat, Grain, Aleurone cells, Lamella, 001
Vegetation: Site,
Relationship, Ohio; Forests, 002
Wheat,
Grain, Aleurone cells, Lamella, Ultra-structure, (at) Germination 001

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