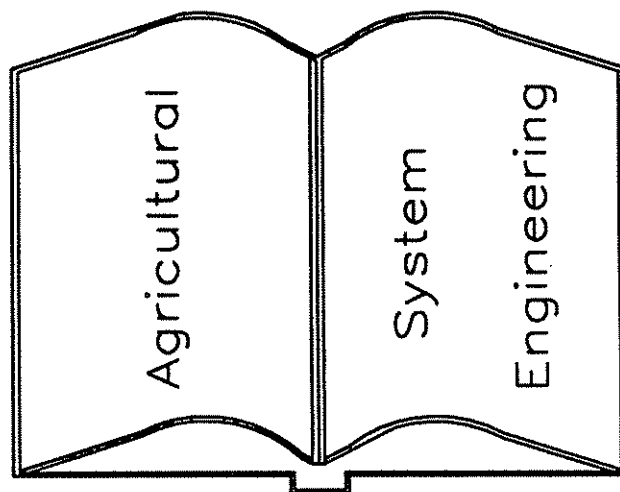


**SVERIGES
LANTBRUKSUNIVERSITET**

**A Literature Search for Agricultural
System
Engineering Education in Developing
Countries:
Selected Bibliography**

Girma Gebresenbet



Institutionen för lantbruksteknik

**Swedish University of Agricultural Sciences
Department of Agricultural Engineering**

**Rapport 160
Report
Uppsala 1992**

ISSN 0283-0086

ISRN SLU-LT-R- -160- -SE

**DOKUMENTDATABLAD för rapportering till SLU:s lantbruksdatabas LANTDOK,
Svensk lantbruksbibliografi och AGRIS (FAO:s lantbruksdatabas)**

Institution/motsvarande Sveriges lantbruksuniversitet Institutionen för lantbruksteknik Box 7033, 750 07 Uppsala		Dokumenttyp Rapport	
		Utgivningsår 1992	Målgrupp F, R
Författare/upphov Girma Gebresenbet			
Dokumentets titel A Literature Search for Agricultural System Engineering Education in Developing Countries: Selected Bibliography			
Ämnesord (svenska och /eller engelska) Literature Search, Agricultural System, Engineering Education, Developing Countries, Bibliography			
Projektnamn (endast SLU-projekt)			
Serie-/tidskriftstitel och volym/nr Sveriges lantbruksuniversitet Institutionen för lantbruksteknik Rapportserien, Rapport 160			ISBN/ISRN SLU-LT-R--160--SE
			ISSN 0283-0086
Språk Engelska	Smf-språk Engelska	Omfång 82 sid	Antal ref. 16

Postadress

Besöksadress

Telefonnummer

Telefax

SVERIGES LANTBRUKSUNIVERSITET
 Ultunabiblioteket, Förvärvsavdelningen/LANTDOK
 Box 7071
 S- 750 07 UPPSALA
 Sweden

Centrala Ultuna 22
 Uppsala

018-67 10 00 vx
 018-671103

018-3010 06

Contents	Page
Summary	4
1. Introduction	5
1.1. Background and review of literature	5
1.2. Evolutionary patterns of sources of power for rural technology	8
1.3. Role of international institutions	10
2. Objectives	12
3. Methods	13
4. Results of the assessment	15
4.1. General comments on the identified literature	15
4.2. Textbooks and references for Mechanization	16
4.3. Textbooks and references for Crop processing	18
4.4. Do universities in developed and developing countries use the same textbooks ?	20
5. Selected books	23
5.1. Crop processing	23
5.1.1. Drying	26
5.1.2. Storage	28
5.1.3. Cleaning	30

5.1.4. Post-harvest losses	31
5.2. Mechanization	35
5.3. Soil conservation and irrigation	44
5.4. Energy	46
5.5. Rural structure	52
6. Scientific Journals	54
7. Discussion and Conclusion	55
Acknowledgement	58
References	58
Appendix I	61
Appendix II	65
Appendix III	69
Appendix IV	71
Appendix V	73
Appendix VI	77
Appendix VII	79

Summary

The role of textbooks in transferring skill and knowledge is very decisive especially in developing countries where the shortage of teachers and teaching facilities is the bottle-neck problem in the education system. The education system in these countries is very specific due to the introduction of new subjects and this necessitates equally specific textbooks.

In the current work, a survey was performed on the textbooks commonly in use at higher institutions in the fields of mechanization, crop processing, on-farm energy and rural structure all over the world. The most popular textbooks both in developing and developed countries are identified. Further investigation was made to identify relevant textbooks, among the popular and other books, and ultimately recommend relevant textbooks for different academic levels, i.e., Diploma, BSc and MSc, at higher institutions in developing countries, particularly in Africa in the fields of agricultural system engineering.

From the results of the investigation, no significant difference could be identified between higher institutions in developing and developed countries with regard to the type of textbook they use. Both categories use almost the same textbooks with the exception of some literature specific to certain countries.

Numerous books are written on the above-mentioned subjects under the assumption that they are relevant for developing countries. Most of these books were found to be very general, descriptive and with an anthropological approach. However, some books which could be valuable were identified and recommended to be used together with other theoretically based and well organized books that are currently being used in many higher institutions.

1. Introduction

1.1. Background and review of literature

Education is a means of building-up one's ability to meet situations of life in a given society by producing human resources. Education at university level provides students with a basic knowledge and scientific skills in such a way that they could be in a position to understand and analyze problems and contribute to the best solutions which lead to the development of society.

To meet the contemporary burning demand of food supply and environmental degradation (problems associated with soil erosion, deforestation, etc) in tropical developing countries, there is a need for the promotion of a sustainable and appropriate technology and effective acquirement and utilization of higher technology from industrialized countries (Rosenberg, 1985). This can only be done if a relevant education system is established to educate and train adequately skilled personnel to tackle the problem.

The knowledge of higher technology and basic theories could be used as a basis to build a relevant education system and has the capacity of reaching the need of any society in developing countries. Effective education and training programmes are essential parts of any successful development programme including agriculture (Mackson, 1971; Giles, 1990).

The main problems associated with the education system in developing countries are:

- a) lack of relevant curriculum,
- b) lack of relevant textbooks, and
- c) lack of other educational facilities.

Lack of textbooks is the most challenging constrain to education in developing countries. In his article, Heyneman (1990) emphasized the importance of textbooks as, " .. the absence of textbooks is a major handicap that will not only affect the students but also the development prospect of their countries." He described also the situation in the developing world as, " ... half the world's children typically sit in classrooms sharing only one book among the entire class, learning by rote, or copying, probably inaccurately, old and often inappropriate texts written on a blackboard by teachers." Heyneman stressed further that " ... developing nations unable to provide adequate numbers of textbooks are likely to see a further decline in already low levels of educational achievement among the school children."

Investigations were made in Nicaragua and in the Philippines to study the effect of availability of "well-designed" textbooks. As reported by Lockheed (1990), the availability of the textbooks significantly increased the achievements of the students.

AGROTEC, a Swedish sponsored and UNDP administered programme on Agricultural Operations Technology for Small Holders in Eastern and South-Eastern Africa, organized a study group (Nilsson et al, 1990) which visited higher educational institutions in the above-mentioned countries to evaluate educational and research activities and identify main problems related to education, training and research, and ultimately prepare concrete proposals regarding the contributions of AGROTEC to increase the capability of these institutions. The group reported similar problems, i.e., shortage of textbooks, to those reported earlier by Heyneman (1990).

The problems associated with textbooks is not only lack of adequate numbers, but also the alarming problem of irrelevancy of the textbooks and curriculum of the education systems in developing countries. The heritage of colonial practices in many of these countries determined the educational structure and contents of the curriculum (Altbach, 1983). Altbach

emphasized in his article that prominent experts in educational and curriculum planning are from the metropolitan and therefore this certainly affects the organizational patterns of education. Lockheed (1990) noted that, currently, there is no clear difference between curricula of developed and developing countries.

Almost all countries in developing countries are trying to adopt the western curriculum and educational values, which is to some extent irrelevant to their society. The educational system is not built on indigenous knowledge related to life to meet their needs.

The constraint related to quantities of textbooks is the other side of the educational problem and depends on the financial capacity of a country and its resource allocation for the education sector. In the present situation, developing countries allocate about 3 % of their GNP to education and within the education sector too much goes to salaries than to textbooks (Verspoor, 1990). In this regard, the role of international donors is equally crucial by paying more attention to the critical need of textbooks. A means of local manufacture should be examined, and this may preserve a strong national identity.

Heyneman (1983) assessed factors affecting the level of cognitive skills students can acquire at school and concluded that limited educational facilities adversely play an important role in this aspect. He emphasized further that a higher achievement of the acquisition of new knowledge by the students in the developing countries is associated with the availability of relevant textbooks.

1.2. Evolutionary patterns of sources of power for rural technology

In developing countries, educational dynamism can be observed . The innovate capacity in general and the proper utilization of appropriate technology (in this case the role of animal power as an alternative energy source) in particular, is increasing in many countries.

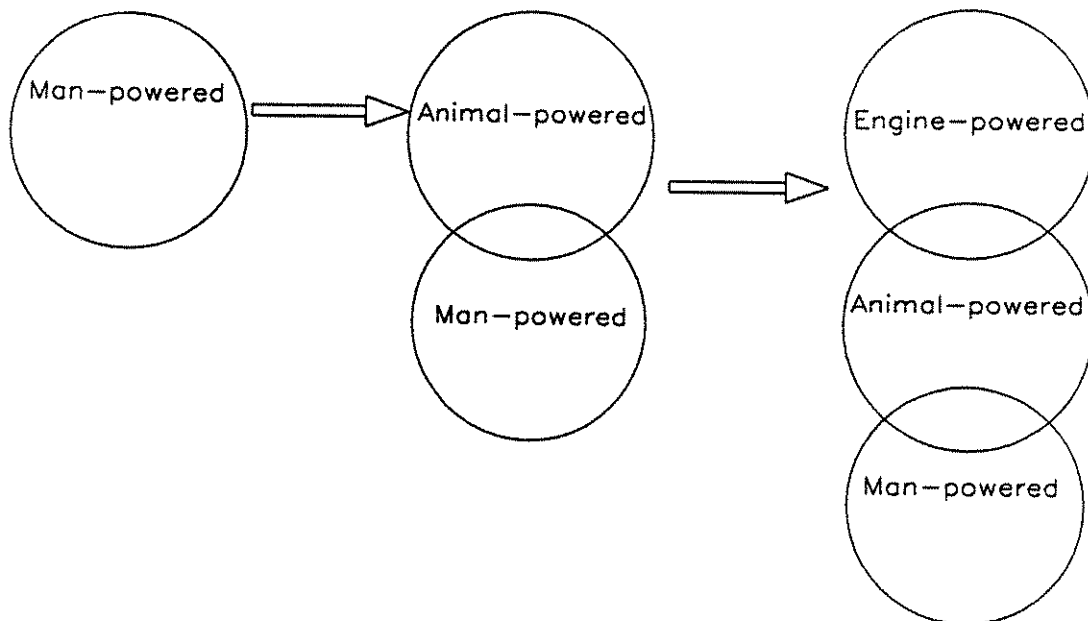


Fig. 1. Evolutionary patterns of rural technology

Patterns of rural technology systems (Fig. 1) based on the sources of power, i.e., man, animal or engine power, are clearly appearing. The power selection depends mainly on the socio-economic development of a given society. The

predominant number of countries lie in the first and second phases, as shown in Figure 1. Since the level of development varies significantly, it is not easy to draw a boundary line between these countries on the basis of sources of power utilization and level of development. They may roughly be classified as:

- (a) countries where only man power is used for agriculture,
- (b) countries where man power and animal power are used, and
- (c) countries where man and animal power and advanced machinery are used.

A smallholder technology, based on manual labour, comprises about 80 to 85 % in many countries in Africa, including those countries where the programme of AGROTEC is supposed to cover. Advanced machinery for agriculture is used in these countries only by state and commercial farmers. A small number of countries lie in the third category, and these countries are of course approaching the level of developed countries in terms mechanization.

The development of an educational system which is intact with the complexity of evolutionary development in rural technology is questionable. Reports on the assessment of curriculum and contents of the textbooks assigned for basic education at university level in these countries have not showed clearly whether the smallholder technology, particularly effective utilization of animal power, is included in the education system. In his assessment, Altbach (Altbach, 1983) noted that:

" ... textbooks are central to schooling at all levels. Textbooks are particularly important in the Third World, not only because educational expansion has been especially impressive but because new subjects have been introduced into the curriculum requiring new text."

Institutions and universities in these countries are attempting to emphasize on Draught animal and intermediate technology. In most of these countries, it has been realized that animal power is the most appropriate to increase agricultural production and therefore the integration of knowledge on animal power into the education system is inevitably increasing.

1.3. Role of International Institutions

Institutions from industrialized countries sponsored by international donating organs are contributing to strengthen the local educational capability and research. Figure 2 roughly illustrates the interrelation between external and local educational and research institutions, and the influence of donating organs on the continuous growth of the education system in less developed countries. The question of curriculum development, instructional methodology, institutional expansion, etc., plays an important role (Bor, et. al., 1989).

It is very important to bridge the gap between the education system designed to promote higher technology and the education system intended to promote appropriate technology. This facilitates the effective transfer of relevant technology (the progress made in industrialized countries) from industrialized to developing nations.

The contemporary approaches of international institutions are:

- offering scholarships for students from developing countries to obtain their higher education in Europe and North America, and
- to assist in building the capacity of institutions.

Cashman and Person (1988) examined the relevance of the education and training at higher institutions in the USA for foreign students from less developed countries. They reported that the education and training of

students from less developed countries at US higher institutions "does not relate sufficiently to the resource base and domestic needs of farming cultures in the less developed countries". This conclusion is true even for students at higher institutions in their own countries, since it is difficult to observe a clear difference between the nature of the education system in the USA and developing countries with the exception of facilities.

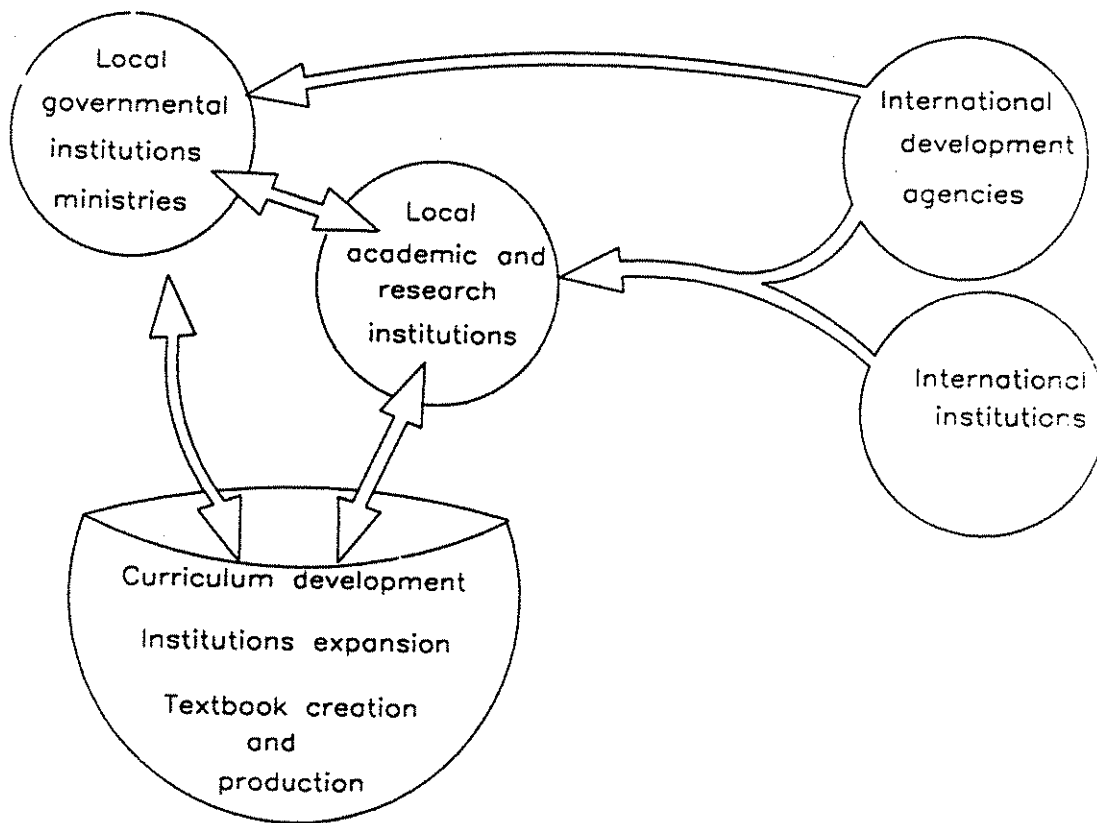


Fig. 2. Interrelation among components contributing to the promotion of the education system.

AGROTEC participates in the promotion of rural technology for small holders in Eastern and South-eastern African countries by providing assistance in training and education.

The current study is the integrated part of the structure shown in Fig. 2. Based on the report of AGROTEC's commission on the evaluation of the capacity of higher institutions in Kenya, Tanzania, Zambia, Zimbabwe and Lesoto, the current work was motivated to search for relatively appropriate textbooks for the courses in rural technology. The work has been carried out, based on the library of Swedish University of Agricultural Sciences, on information from various relevant databases and from different universities and institutions engaged in research and education in Agricultural Engineering all over the world.

Virtually little research has so far been done in the investigation of paradoxes of irrelevancy of some literature in the educational system, particularly in agricultural engineering in developing and less developed countries. Olsen and Kennedy-Olsen (1991) conducted similar investigation to determine the current core literature in the agricultural sciences especially agricultural economics and reported useful results.

2. Objectives

The objectives of the current study were to search for appropriate and relevant literature which could be used as textbooks and teaching materials at higher institutions in developing countries, especially for African conditions, and ultimately proposing the selected textbooks for Diploma, BSc and MSc degree level courses. This necessitated conducting an exhaustive survey on contemporary textbooks used in the fields of

mechanization, crop processing, on-farm energy and farm structure in different countries to identify the most popular books. The investigation was designed to answer the following questions.

Do higher institutions from developed and developing countries use the same textbooks or not ?

Which are the most popular textbooks for the university level to-day ?

Are there any relevant textbooks for higher education in rural technology for use in developing nations, particularly for Eastern and South-eastern African countries ?

It was assumed that the results of the investigation :

- can be used as a basis for further development of the education system,
- offer better understanding in applying advanced theories to practise in small-scale farming,
- can be used for various courses for different standards.

3. Methods

In the present work, the methods of investigation has been divided into three steps:

- (1) identify the most frequently used textbooks at various universities, colleges and institutions, both in the industrialized and developing countries by:

- (a) contacting universities, institutions, departments, etc.
and examining the literature they currently use for teaching for
different levels (Diploma, BSc and MSc),
- (b) visiting known institutions and their libraries
engaged in similar fields.
- (2) searching for relevant scientific articles, congress and
conference papers, monographs and reports in different databases
and international journals of agricultural engineering and proceedings.
- (3) identify and recommend textbooks which can be used as
textbooks, references and research reports in developing countries,
especially in Africa.

A questionnaire was designed and sent to 235 international institutions. Because of the limitation of literature translated into English, most of the textbooks being used in the Eastern European countries were not assessed. It was found also important to visit some institutions, like Intermediate Technology, mostly engaged in publishing literature for developing countries. The literature selected were then ordered with the help of the library of Swedish University of Agricultural Sciences.

The main criteria used to select textbooks were:

- a) does the book cover all subjects in the given field,
- b) are fundamental theories included for each chapter,
- c) are the practical applications of the theories relevant to
conditions of developing countries,
- d) are the recent research findings included and updated,
- e) is there any special emphasis on the importance of choosing the
correct energy sources, etc.

4. Results of the assessment

4. 1. General comments on identified literature

Questionnaires were sent to 235 higher institutions of Agricultural Engineering all over the world. Of those institutions, 152 replied according to the request and sent lists of literature for the specified fields: *Mechanization, On-farm energy, Crop processing and Farm structure*. About 11 institutions (most of them are from Europe and North America) have not specified any textbook. According to their reply, some of them use only part of certain textbooks and papers from scientific journals and proceedings of congresses and conferences. There are also institutions that organize compendia for each subject and update the compendia continuously. About 72 institutions have not replied. This might be due to change of postal addresses.

The obtained lists of textbooks and reference books were investigated to identify the most common textbooks in various fields. Almost all textbooks being used for teaching in developing countries are textbooks written for use in the industrialized countries. Of course, the basic theory could not be different, but practical applications in developing countries are different when compared with the developed countries.

Some monographs have been published by international institutions and organizations like FAO by a small range of authors. Many of the authors are not agricultural engineers and the literature is very general and extensively descriptive by nature.

However, there are valuable research reports made by local scientists and some scholars. Interesting research reports and articles, both general and specific in approach, have been presented at various conferences and symposia. Some of these articles could be used for teaching purposes. Reports

in which the maximum utilization of animal power was emphasized, especially in the fields of mechanization, crop processing and on-farm energy, were considered as the most relevant and useful.

4.2. Textbooks and references for Mechanization

The most widely-used books identified, both in developing and developed countries are:

Kepner, Bainer & Barger. Principles of Farm Machinery;

Liljedahl, Turnqvist, Smith and Hoki. Tractors and Their Power Units;

Culpin, C. Farm Machinery.

About 34%, 21% and 18% of the 152 institutions contacted use the books; *Principles of Farm Machinery*, *Tractors and Their Power Units*, and *Farm Machinery*, respectively. The popularity of the above mentioned and other books is portrayed in Fig. 3. Books which are equally popular are placed in one group. Books below 10% are numerous, and therefore their list is not given here.

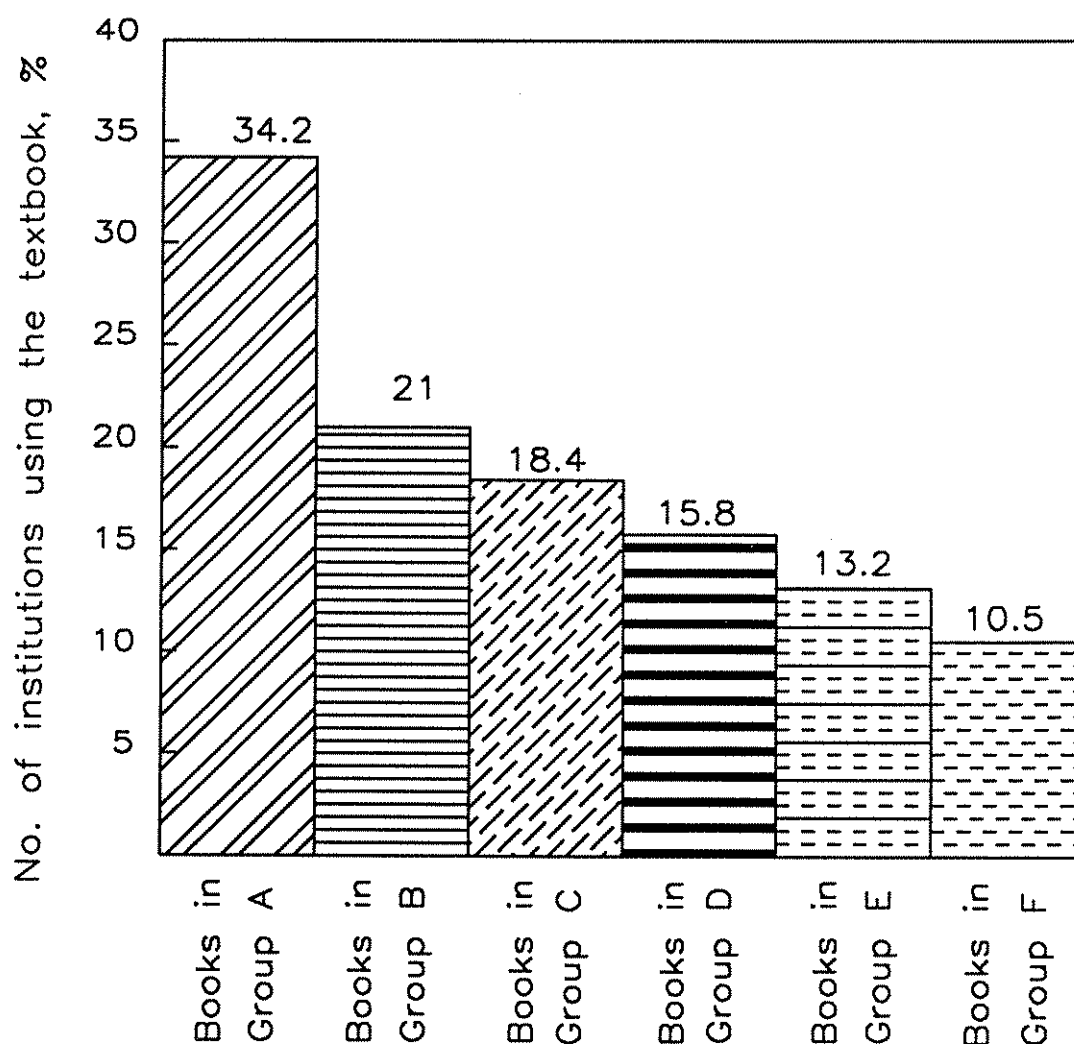


Fig. 3. Textbooks being used various institutions in the fields of mechanization.

- Group A: Kepner, Bainer & Barger. Principles of farm Machinery
- Group B: Liljedahl et al. Tractors and Their Power Units.
- Group C: Culpin, C. Farm Machinery
- Group D: Hunt, D. Farm Power and Machinery Management.
- Group E: Witney, B.D. Choosing & Using Farm Machines;
Shippen, et al. Basic Farm Machinery
- Group F: Butterworth, B and Nix, J. Farm Mechanization for Profit;
McKyes, E. Soil cutting and tillage;
Barger et al. Tractors and their power units, 3rd edition

4.3. Textbooks and references for Crop Processing

The books:

Drying cereal grains (authors: Brooker et al,)

Agricultural process engineering (authors: Henderson and Perry) and

Drying and storing (author: McLean)

are found to be the most widely-used in the fields of crop processing. About 23% (Fig. 4) of the contacted institutions use the book: *Drying cereal grains* (authors: Brooker et al,), at university level (BSc and MSc degree). The contents of the books are briefly described elsewhere in this report.

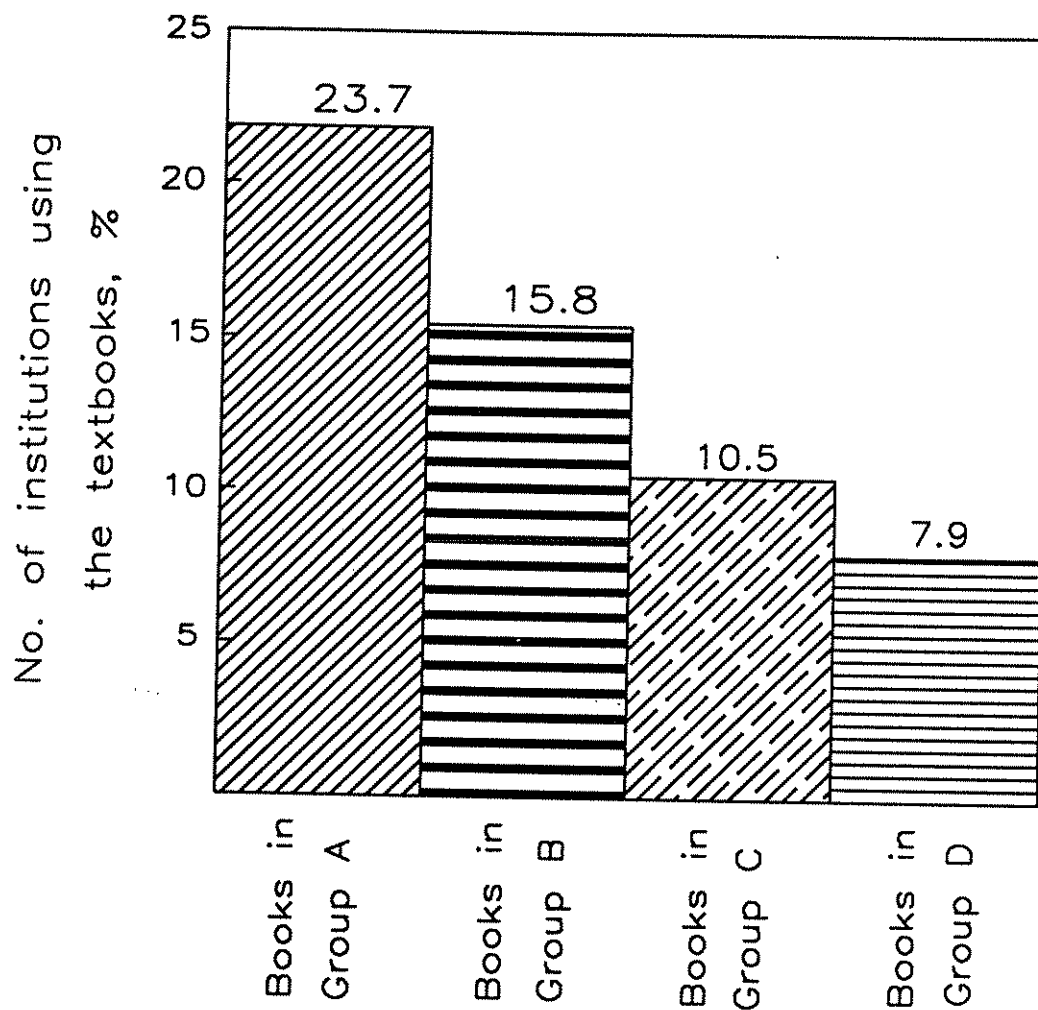


Fig. 4. Textbooks being used various institutions in the fields of crop processing.

Group A: Brooker et al. Drying cereal grains. 1974

Group B: McLean, K.A. Drying and storing combinable crops. 1980.
Henderson, S. and Perry, R. Agricultural process engineering, 1981.

Group C: Hall, C. W. Drying and Storage of Agricultural crops. 1983.

Group D: Balls, R. C. Horticultural Engineering Technology, Fixed Equipment and Buildings. 1986.
Mohsenin, N. Nuri. Physical properties of Plant and Animal material. 1986.
Hall, D.W. Handling and Storage of Food Grains tropical and subtropical areas. 1970.

4.4. Do universities in developing and developed countries use the same textbook ?

Part of the assessment of the present work is to answer the above question. The result of the investigation showed that most of the popular books are almost equally used both in developing and developed countries. The differences observed are found to be insignificant (Table 1). However, there are books which are very specific to certain countries or region.

Table 1. Comparison between developed and developing countries on the usage of given textbooks. No. of institutions using a given textbook in percentage is in relation to the total number of institutions (152) responded.

Textbook	No. of institutions using the textbook, %		
	Developed	Developing	Total
Kepner, Bainer & Barger. Principles of Farm Machinery. 3rd edition. AVI Publisher, 1978	15.8	18.4	34.2
Brooker, D.B., Bakker-Arkema, F.W. and Hall, C.W. Drying cereal grains. AVI Publ. Co. 1974.	7.9	15.8	23.7

Table 1 Continued

Textbook	No of institutions using the textbook, %		
	Developed	Developing	Total
Liljedahl, Turnqvist, Smith, Hoki. Tractors and Their Power Units 4th Edition. Van Nostrand Reinhold, NY, 1989	10.5	10.5	21
Culpin, C. Farm Machinery. Collins, London, 1986.	13.2	5.2	18.4
McLean, K.A. Drying and storing combinable crops. Farming press Ltd., 1980.	10.5	5.3	15.8
Henderson, S.M. and Perry, R.L. Agricultural process engineering. 3rd edition. AVI Publisher, Westport, Conn., 1976.	5.3	10.5	15.8
Hunt, D. Farm Power and Machinery management.IOWA State Univ Press, Ames (USA), 1983	5.3	7.9	13.2

Table 1 Continued

Textbook	No of institutions using the textbook, %		
	Developed	Developing	Total
Shippen, J.M., Ellin, C.R. and Clover, C.H. Basic Farm Machinery. Pergamon Press Ltd. Hadding Hill Hall Oxford, England. 1980	5.3	5.3	10.6
McKyes, E. Soil cutting and tillage. Elsevier, 1980	5.3	5.3	10.6
Balls, R. C. Horticultural Engineering Technology Field Machinery. Macmillan publisher, UK, 1986	5.3	2.6	7.9
Hall, C. W. Drying and Storage of Agricultural crops. AVI Publisher, Connecticut, 1983	5.3	5.3	10.6
Mohsenin, N. Nuri. Physical properties of Plant and animal material. Gordan and Breach Science Publisher, NY, 1986	2.6	5.3	7.9

5. Selected Books

Lecture and study materials include journal articles, booklets, reference books, textbooks, compendia, etc. Usually it is very difficult to obtain suitable and updated textbooks. Therefore educational institutions use journal articles along with relatively older textbooks and references or use compendia where a full summary of both the fundamental theories, practical applications and recent research findings are included. Compendia are very popular in many of the universities contacted and could continuously be updated. Therefore it should be stressed that the selected and recommended books serve only as a basis and should be supplemented by journal articles or booklets.

Laboratory and field work are the most important parts of the education system where students can test and understand the theoretical concepts they have been taught. An education system where theoretical and practical work flourish side by side can be a milestone for the future capability of a student in developing science to enhance the social development of societies. Thus textbooks which contain practical problem-solving exercises, forwarding challenging questions to the students are preferable and considered to be the best. Guidances for the laboratory and field work are usually prepared by institutions as a special booklet.

The suggested textbooks are classified as the main textbook, supplementary reading or as a reference for each field.

5.1. Crop Processing

There are no books found which perfectly fulfil the criteria for the appropriate textbook on the subject. However, there are excellent books where only some chapters fit the criteria and can be used successfully.

Fundamental theories included in many of the textbooks designed to be used in developed countries may also be appropriate in developing countries. Most of the books oriented towards developing countries lack theories, and are general and descriptive. However, important reports and research results can be found in proceedings and journal articles. Even among descriptive books, excellent information can be found. Therefore, it was not found possible to propose only one book for each subject, rather than several complementing books.

A list of textbooks recommended for Crop processing is given in Appendix II. Some of the literature is commented below.

Henderson, S.M. and Perry, R.L. Agricultural Processing. The AVI Publishing Company, Inc. Westport, Connecticut. 1976 (442 pages)

The book is among the most popular books in the fields of processing. About 16% of the institutions contacted use the book as a textbook for BSc and MSc degree level. The book is divided into 16 chapters. Chapters one to five deal with:

- Principles of engineering approach in solving problems,
- Basic theories of fluid mechanics,
- Pressure, velocity and flow measurements of fluids,
- Types and performances of pumps and fans.

Chapters six through sixteen cover:

- Size reduction,
- Cleaning and sorting,
- Material handling,
- Heat transfer,
- Air-vapor mixtures (the Psychrometric chart),
- Drying,

Refrigeration,
 Process condition observations, records and controls,
 Cost analysis,
 Process analysis and plant design,
 Manual operation economy.

Theories, principal functions of processing machines and elements, examples and questions to the texts are presented in each chapter. The schematic sketches, photos and experimental diagrams included are of good quality. The book is highly technical.

Since most of the main subjects within the field of processing are included in the book, it can serve as a main textbook. However, no considerations have been taken concerning the practical application of the theories in developing countries. Therefore, the book should be complemented by other literature where the subjects, specific for developing countries and tropical conditions are discussed.

Books which can be recommended as complementary to the above book and on specific subjects, such as drying, storage, cleaning and postharvest losses, are given below. Subjects like milling, shelling or threshing can be found in most of the recommended books.

Brooker, D.B, Bakker-Arkema, F.W. and Hall, C.W. Drying and Storage of Grains and Oilseeds. Van Nostrand Reinhold, NY, 1992 (450 pages)

The book appeared after this report has almost been written, and it was found worth to comment the book. The book is a revised form of its predecessor, *Drying Cereal Grains* by the same authors. The former book deals mainly with drying. In the present book the principle of grain storage

management is included and grain quality is emphasized. Theories, examples, problems for exercises and data in table form are given in most of the chapters.

The book can serve as a main text for the subjects of drying and storage for the higher level (final phase of BSc and for MSc) courses in the universities and for researchers.

5.1.1 Drying

Brooker,D., Bakker-Arkema, F. and Hall, C.W. Drying Cereal Grains. The AVI Publisher Company. Westport, Connecticut, 1982. (265 pages)

From the assessment made, the above book was found to be one of the most widely-used textbooks in the fields of drying. About 23% of the contacted institutions use this book as a textbook at different levels, BSc, MSc and even for PhD level degrees, depending on the way the teaching process is presented. The book is divided into nine chapters:

1. Principles of grain drying,
2. Grain quality deterioration,
3. Grain equilibrium moisture content,
4. Air movement,
5. Introductory analysis of fixed bed drying,
6. Grain drying systems,
7. Theory and simulation of cereal grain, and
8. Controls for dryer operation and safety.

The book describes bio-technological processes using the fundamental theories, curves of research results, tables, charts and schematic diagrams. In the appendixes, useful tables and equations and calculation examples are given.

In the main body of the book, the basic theories related to drying processes, selective methods and various problems associated with drying during practical application were included and discussed thoroughly.

The fundamental principles and some practical examples presented in the book are found to be useful and can successfully be used as a textbook for teaching in developing countries. It provides students with a good understanding of the subject and enables them to solve the local problems. However, the book does not cover examples and problematic backgrounds specific for tropical and developing countries. Therefore, the book should be complemented by other books.

Hall, Carl W. P.E. Drying and Storage of Agricultural Crops. The AVI Publisher. Westport, Connecticut, 1980. (Total no. of pages 382, of which pp 291-309 are of interest)

In this chapter of the book, systems for the application of solar energy in the drying process are elaborated. The potential application and availability of solar energy in drying processes, solar collectors and review of research conducted up to the end of 1970's on solar crop drying are briefly discussed.

The concepts discussed in this chapter are not included in the book: *Brooker, D., Bakker-Arkema, F. and Hall, C.W., 1982. Drying Cereal Grains*, and therefore the chapter may be a useful complementary.

McLean, K.A. Drying and Storing Combinable Crops. 2nd edition, Farming Press. UK, 1989. (258 pages)

About 16% of the contacted institutions use the above book for different academic levels. The book covers different aspects of drying and storing, handling and cleaning of grains. It also deals with drying of specific crops like, cereals, maize, oilseed rape, linseed, peas, beans, grass seed, sugar beet seed, etc.

Good quality photos, schematic diagrams, informative tables, examples and concise texts make the book readable. The book is general and very limited theories are included. The author included updated information related to the subjects.

The general concepts around which the book is organized are basic and fit in without any boundaries of geographical or level of development. Although methods specific to the tropical and developing countries are not included, the book may be a good reference for BSc degree level in these countries.

5.1.2. Storage

Hall, D. W. Handling and Storage of Food Grains in Tropical and Subtropical Areas , third edition 1980. Food and Agriculture Organization, FAO, of the United Nations, Rome, 1980 (350 pages)

The book is presented in a very descriptive way with a limited number of photos for illustration and some useful data. Neither practical exercises nor questions to the readers are included. The book covers a wide range of subjects, with a short description of each, such as losses of food during storage, design of stores, storage methods, insect and rodent control methods, etc. It also discusses drying methods (natural and artificial drying) in general and pays more attention to storage methods of cereals, legumes

and oil seeds in the tropics and the subtropic. The author elaborated the traditional storage methods of food grains, especially storage constructions and associated problems, in the regions (pages 157--172) and also compares with 'modern' storing methods.

In the appendix, the author presents rules and legislation in many of the tropical and subtropical countries regarding treatments, quality and pests.

The 'manual' may serve as supplementary reading or as reference for post-diploma and BSc degree courses together with a good theory-based book since some practical examples related to the developing countries can be taken from the book.

Hall, Carl W. P.E. Drying and Storage of Agricultural Crops. The AVI Publisher Company. Westport, Connecticut, 1980. Pages 310-359. (Total pages: 382)

Pages 310 - 359 deal with the storage of vegetable crops and moisture control with, particular emphasis on potatoes, sugar beets and onions in the USA. Storage environment and structural considerations were elaborated as important criteria for the storage design of each type of the mentioned vegetables. Essential formula and tables are given to determine the design parameters of air distribution and temperature control systems.

The concepts presented in this chapter give a good understanding and are recommended for BSc and MSc courses.

Appert, Jean. The Storage of Food Grains and Seeds. The Tropical Agriculturist. Macmillan Publishers. 1987 (146 pages)

In the book, the author gives a general account of storage methods, damage, losses and 'pest control and store hygiene' in the tropics. The problems raised and the solutions suggested are relevant to conditions in most of the

developing countries. The book is written in a very general form (no theories) and is not suitable for higher level education. However, the information included is important and therefore it is reasonable to recommend students on diploma and post-diploma courses to read the book.

5.1.3. Cleaning

Grochowicz, Josef. Machine for Cleaning and Sorting of Seeds (translated from Polish, and available from the U.S. Department of Commerce, National Technical Information Service), Springfield, Virginia, 1980 (374 pages).

The book is translated from the Polish language. It discusses varieties of cleaning and separating machines and properties of seeds. The book is divided into 15 chapters:

- Introduction and introductory information,
- Characterization of and methods for measuring the differentiating characteristics of seeds,
- Theoretical principles of planning and the course of separation processes,
- Pneumatic seed separators,
- Screening machines,
- Driers,
- Complex separators,
- Gravity separators,
- Friction separators,
- Separators based on seed texture,
- Separators based on mechanical properties of seeds,

- Electrostatic separators,
- Photoelastic separators, and
- Accessory equipment in cleaners.

Relevant basic theories and schematic diagrams were used in a simplified form to describe the process. The book is highly technical and no exercises are included in the chapters. The book can be recommended to be used as a textbook for the post BSc and MSc degrees. It is also worth to use as a reference for the PhD level courses and for scientific researchers. No examples specific for machines relevant to developing countries are included. However, it gives a good background for students, especially those interested in the design and construction of cleaning and sorting machines.

McLean, K.A. *Drying and Storing Combinable Crops*. 2nd edition, Farming Press. UK, 1989 (pages 193 - 223)

In these pages of the book, the author presents cleaning processes and devices (conveying, elevating and handling equipment) in a clear and concise form. Useful tabular information and descriptions of the principal functions of separators are included. These pages of the book can be a good supplement to the book: *Grochowicz, Josef. 1980. Machine for Cleaning and Sorting of Seeds*. The pages may also be recommended for the post-diploma and BSc courses.

5.1.4. Post-harvest losses

Salunkhe, D.K., Chavan, J.K. and Kadam, S.S. *Postharvest Bio-technology of Cereals*. CRC Press, Inc. Boca Raton, Florida, 1985 (208 pages)

The main theme around which the book is organized is postharvest losses. The authors, all Indians, attempt to summarize the existing loss assessment methods and information on the nature of losses in a wide range. They also describe "the physico-chemical properties of cereal grains and their relationship with resistance or susceptibility to the quantitative and qualitative losses caused by physical, biological or chemical factors", and finally discuss the future need of suitable bio-technical methods to attenuate post-harvest losses with particular reference to developing countries.

The book is divided into 13 chapters. The first chapter is introductory, but data from developed and developing countries are given. Chapters two and three deal with the nature of losses (Eg., identification of losses during harvesting, threshing or shelling, drying, transportation, storage, processing, etc) and loss assessment methodologies. Chapters four through eleven discuss separately cereals such as wheat, rice, maize, sorghum, millets, oats and rye.

The book is written in a very descriptive form with a limited number of illustrative schematic diagrams. Photographs (mostly from India) and data in tables are presented. Relevant literature which can be very useful for the reader are given at the end of each chapter.

The book is developing countries oriented and the examples and data are mostly from developing countries. Exercises and practical problems are not included in the book. However, the book can be recommended as a textbook for post-diploma or BSc courses.

Proceedings of the ICIPE/ECA Regional Study Workshop held in Nairobi, Kenya, 10-17 October 1987. Insect Science and its Application; International Journal of Tropical Insect Science, volume 9, Number 6, 1988

In the journal, reports of selected scientific investigations regarding on-farm and post-harvest losses of cereal crops in Africa due to pests and diseases, and storage methods in relation to post-harvest losses are included.

The contents of the articles are very useful and can be used as teaching material for BSc and MSc degrees. It can also be used as a reference for further research work. The works included are best examples which are relevant to scientific investigations in Africa.

Prevention of post-harvest food losses: a training manual. FAO, Rome, 1985. (120 pages)

The Food and Agriculture Organization of the United Nations, FAO, prepared the book for training workshops in developing countries. The main subject deals with food-losses during storage. Topics like storage pests, loss assessment, pest control, etc., are elaborated in general. Other subjects such as drying, processing of cereals (threshing, grading, milling, etc.) are also included. Some photographs, schematic diagrams and very limited data in table form are included for demonstration.

The book is fairly suitable for Diploma courses and may also complement for the book: *Salunkhe, D.K., Chavan, J.K. and Kadam, S.S. 1985, Postharvest Bio-technology of Cereals. CRC Press, Inc. Boca Raton, Florida.*

Snowdon, A.L. A colour Atlas of Post-Harvest Diseases and Disorders of Fruits and Vegetables. University of Cambridge, Wolfe Scientific. Barcelona, 1990 (302 pages)

The book presents an excellent illustration of postharvest deterioration of fruits and vegetables in two volumes. The photographs are illustrative, all in colour and of very good quality.

Volume I is composed of seven chapters: " (1) Nature and causes of postharvest deterioration, (2) Citrus fruits (oranges, mandarins, grapefruits, lemons and limes), (3) Miscellaneous tropical and subtropical fruits (avocados, bananas, guavas, litchis, papayas, passion fruits, persimmons, pineapples, pomegranates, sour sops and sweet sops), (4) Pomes fruits (apples and pears), (5) Stone fruits (peaches, nectarines, apricots, plums and cherries), (6) Soft fruits and berry fruits (strawberries, raspberries, blueberries, cranberries, currants, gooseberries, grapes, kiwifruits) and (7) Melons and watermelons.

In the first chapter, deteriorating factors, classification of disorders and diseases are generally discussed. Chapters two through seven deal with the occurrence, symptoms, biology and control of diseases and disorders of each type of fruit.

The fruits discussed are very common in the tropics and it is appropriate to recommend this book for demonstration and reading at different levels of courses depending on the way it is intended to be used.

5.2. Mechanization

No book has been found which exactly fits the criteria used to select the appropriate textbook in developing countries. However, there are some important books where some parts could be used successfully.

The list of textbooks recommended for Mechanization is given in Appendix I. Some of the literature is commented below.

Kaul, R.N. and Edbo, C.O. Introduction to Agricultural Mechanization. The Macmillan Intermediate Agricultural Series. Macmillan Publishers Ltd. London, 1985 (193 pages).

Some developing countries use the book as a textbook for Diploma level courses and when starting BSc degree level courses. The first part of the book covers power sources. The presentation of the theme on animal power, which is very interesting and essential, is too brief. The second section deals with machinery for tillage (ploughs, harrows, ridger, roller), planting, crop protection, harvesting (forage harvesting, cereal harvesting, threshing, harvesting root crops like cassava), irrigation (pumps) and crop processing (milling, mixing, etc). Examples of cost analyses of farm equipment and farm materials are also presented in the last part of the book. At the end of each chapter, questions are included to test the students.

The book is written in a descriptive form and important illustrative pictures and simplified functional schematic figures are used. Although most of the machines described, in a functional schematic form, are conventional machinery used in industrialized countries, their applications for large and intermediate scale agriculture in the tropics are discussed. Some specific machines like the cassava digger-elevator, ridgers, etc., are also described. However, mechanization for small scale (man and animal powered) farming

is not emphasized sufficiently. This could have made the book more suitable for teaching. Lack of theories is another comment to be mentioned, and this determines the level at which the book should be used.

The book can be recommended to be used for Diploma and BSc courses if other material is supplemented where equipment for small scale farming in developing countries is exclusively discussed.

Crossley, P. and Kilgour, J. Small farm mechanization for developing countries. John Wiley & Sons Ltd. UK, 1983 (253 pages)

The book contains a wide range of subjects in agricultural engineering, related to mechanization, emphasizing small scale farming systems where man, animal and small engine-powered technologies are utilized. Rather than mechanization, some elements of processing at the level of farmsteads and transportation using vehicles are described. The book is divided into three main parts:

- Part 1, The Agricultural Requirements,
- Part 2, Mechanization Equipment and
- Part 3, Matching the Equipment to the Task.

In Part 1, chapters like *Farm Tasks and Conditions*, *Farmsteads*, and *Transport Task and Conditions* are included. Under the topic of *Farmsteads*, processes like milling, threshing, cleaning, etc., are included.

Part 2 describes hand, animal and small engine powered mechanizations. It also describes the characteristics of different implements (tillage implements, weed control equipments, etc.). In Part 3, economics of small farm mechanization and performances of different equipment are described.

In both parts 1 and 2, important topics are raised. However, the subject matter is presented in a very short, general and descriptive way. Some theoretical examples and very simplified diagrams are also included. The inclusion of practical examples, questions to each chapter, and better illustrative diagrams would have increased the quality of the book. In comparison with the small engine mechanization, the account given on animal mechanization is very brief. Descriptions of animal-drawn implements and animal power driven farm equipment would have increased the relevancy of the book. However, good conceptual approaches were used and the book may be recommended for Diploma and BSc degree in a special course on 'agricultural engineering for small scale farming'. However, the book should be supplemented with other sources covering the above-mentioned shortcomings.

Roth, L. O. and Harry L. Field. Introduction to Agricultural Engineering. Second edition, Van Nostrand Reinhold, 1991 (346 pages).

Some countries in Asia use the earlier edition of the book for Diploma courses and the beginning of BSc level for practical problem-solving exercises. The major theme around which the exercises are organized covers simple mechanics, energy, economics of machinery, soil erosion, irrigation, structure, electricity, etc.

The exercises included are simple, and can be used as an aid to the textbooks lacking practical exercises and it is also valuable as an introductory before starting relatively complex topics.

Starkey, P. Harness and Implements for Animal Traction. German Appropriate Technology Exchange (GATE), 1989.

The author described various harnessing systems and implements for animal traction. The book gives a good understanding of the position and role of animal power in tillage, transportation, water pumping, animal-powered gears and post harvest operations, etc., in developing countries. Experiences from different countries in Africa, Asia and Latin America are presented in the book.

Few institutions in Africa use the book as a reference for Diploma level studies. The subjects discussed in the book are relevant to animal mechanization and can be used as a supplementary textbook together with the book, *Introduction to Agricultural Mechanization* (authors: Kaul and Edbo, 1985), or with the book, *Small farm mechanization for developing countries* (authors: Crossley and Kilgour, 1983).

Hopfen, H.J. Farm Implement for arid and tropical regions. FAO Agricultural development paper No. 91, Rome, 1969, reprinted 1981. (159 pages)

A great variety of man and animal powered farm implements such as:

- tillage implements (spades, ploughs, cultivators, etc),
- seedbed preparation and sowing equipment,
- sprayers, harvesters, winnowers, threshers and transportation equipment,

being used in the arid and tropical regions are summarized in clear and concise descriptions and illustrations (sketches, drawings, etc.). Most of the implements (particularly tillage implements) presented in the book are indigenous in the countries (particularly developing countries) where they are currently in use. The author outlines the historical development,

mechanical function and design of animal-drawn and hand-operated equipment very commonly found in many countries throughout the world to provide a good background for the reader.

The book is very relevant and a significant reference for students attending Diploma, post-diploma and training courses and can be recommended. Inclusion of the basic concepts of the mechanics of the implements would have increased the quality of the book.

Tools For Agriculture. A buyers guide to appropriate equipment. Intermediate Technology Publications in association with GTZ/GATE, 1985.

The book contains a collection of various animal or small-engine powered tools available for commercial purposes. The tools presented are suitable for agricultural development in developing countries, in the subject area of processing, tillage and cultivation, water pump devices, etc. The presentation is in the form of photographs, drawings and short texts describing the tools and addresses of manufacturers. The book can serve as a good source of information and reference, but cannot be used as a textbook.

Kepner, Bainer & Barger. Principles of Farm Machinery, 3rd edition. AVI Publisher. Connecticut, 1978.

Among the universities contacted, about 34% use this textbook for BSc courses. The authors recommend the book for agricultural engineering students and the subjects included could serve as basic knowledge before the students choose a specific and special line. The book deals with machinery for cultivation, crop protection and harvesting.

Although recent research achievements are not included in the book, it has a good structure. For exercises and further reading, problems and references are given at the end of each chapter. However, examples of practical

calculations are not included. Application of more basic theories and simplified schematic presentation of the function of machines would have enhanced the quality of the book.

The book does not cover subjects on small scale mechanization, especially for African conditions. However, parts of the book are useful as teaching material and for reference purposes.

Culpin, C. Farm Machinery. 11th edition. Collins, London, 1986

The book is among the most widely-used (about 18%) textbooks at universities contacted. Most of the universities use the book for the Diploma and Bachelor degree courses and some universities even use it for the MSc level. In comparison with the book, *Principles of Farm Machinery* (author: Kepner), the book covers a wide range of topics. It describes machinery for:

- tillage and soil preparation,
- manure distribution,
- crop protection,
- pumps and irrigation,
- harvesting,
- crop processing,
- livestock husbandry,
- milk production,
- transport and material handling,
- land drainage and reclamation.

The book is written in a very descriptive way and the machinery functions elaborated are advanced and applicable for larger scale farming. No practical calculations and examples, related to theories, are included and no questions or problems, as usually found in most textbooks, are included. However, the book is structured and written in a good, cogent and simple

manner that students can easily read and understand. The book may be used as a reference book and as a compulsory book to be read for Diploma and BSc courses.

Hunt, D. Farm Power and Machinery Management. IOWA State University Press, Ames, 1983, (365 pages)

The book is one of the popular (about 13%) of the agricultural engineering textbooks used for BSc and MSc level. The author states that the objectives of the textbook as:

- " a) to analyze the factors that comprise machinery management,
- b) to explain the function of the various machines and mechanisms as they affect economic operation,
- c) and to indicate approaches and procedures for making management decisions."

The author describes the functional process of advanced machinery for various field operations (tillage, seedbed preparation, cultivation, chemical application, harvesting), for processing and material handling from management points of view.

The book is divided into 6 chapters:

- 1) Economic Performance,
- 2) Costs,
- 3) Operations,
- 4) Power (only the farm tractor is described),
- 5) Equipment Selection, and
- 6) Laboratory Exercises.

The book is written in a simple descriptive form and theories are also included. Good photos, drawings and illustrative diagrams are used to describe the working process of the machines. Some basic formulas are used

for calculations. At the end of each sub-chapter, practical problems are presented for the students to exercise. The laboratory exercise presented in the last chapter makes the book more interesting.

The authors recommend the book for "students preparing for careers in agricultural education, agricultural mechanization, or agricultural business and to the agricultural engineer who might serve as a machinery manager on a large commercial farm."

Although the book is prepared for students in the USA, many countries in other regions are using it. It is worth using the book as a reference and as teaching material, especially the operations part in order to achieve a good understanding of the functional process, and this can enable the basic concept of the book to form a bridge with the functional processes of appropriate machinery for developing countries.

Liljedahl, J.B.; Turnqvist, P.K.; Smith, D.W. and Hoki, M. Tractors and Their Power Units 4th, Edition. Van Nostrand Reinhold, NY, 1989

Among the universities and institutions using the above book as a textbook, 50% of them are from industrialized countries and 50% from developing countries. The book is among the most popular textbooks. The textbook is widely in use for BSc and MSc programmes. The authors have also recommended it for graduate students and senior engineers.

The textbook can be used as complementary reading and for reference, where knowledge of the tractor should be emphasized.

Mere L. Esmay and Carl W. Hall. Agricultural mechanization in developing countries. Tokyo, 1973 (221 pages)

About 5% of the universities contacted in developing countries (most of them are from Asia) use the book for teaching at university level for BSc degree. The book is divided into eight chapters:

- 1) Principles of Agricultural Mechanization,
- 2) Agricultural Mechanization in Equatorial Africa,
- 3) Agricultural Mechanization in Asia,
- 4) Agricultural Mechanization in Latin America,
- 5) Ownership patterns for Tractors and Machinery,
- 6) Drying, Storing and Handling Food Grains in developing countries,
- 7) Irrigation in Developing countries, and
- 8) Education and Training for Agricultural Mechanization in Developing Countries.

The authors attempt to present the level of mechanization, using statistical data, in the three developing continents with their specific conditions. Such statistical data are useful but they are outdated. The book is written extensively in a descriptive and general form with the exception of chapters 6 and 7, where the problems associated with policies and other factors limiting the development of the topics mentioned in each chapter are discussed. The concepts raised in chapters 1 and 8 are still very valuable and actual. It may be worth using the book as a teaching material and for reference purposes.

5.3. Soil Conservation and Irrigation

The list of textbooks recommended for Soil Conservation and Irrigation is given in Appendix V. Some of the books are commented below.

Doorenbos, J. And Kassam, A. H. Yield Response to Water. FAO Irrigation and Drainage paper 33. Rome, FAO, 1979. (193 pages)

This is one of FAO's good publications and presented in a simplified way. The authors gathered information by direct contact with scientists involved in the subject and through literature reviews. The selected bibliographies, given as an appendix, are very useful for further studies.

The authors presented a methodology to study the response of the yield of twenty-six crops to water. The methodology enhances the practical application of the research results published hitherto on the relationship between water and crop growth.

The publication contains a lot of information and the methods presented are very simple. It can be used as a guidance for the field engineers, teaching material for the practical part of special courses on irrigation for the BSc level, and even for Diploma level. To make the publication interesting, a book in which fundamental principles related to the subject discussed should be used beforehand.

Fraenkel, P. Water Pumping Devices. A handbook for users and choosers. Intermediate Technology Publishers. London, 1986.

The author attempted to present various types of pumping devices appropriate for small scale farming, especially in developing countries. Each type of device is described and some simplified diagrams are included. Powers (human power, animal power, wind power, electrical power, solar

power, hydro power, biomass and coal, and combustion engines) for pumping and the performance of differently powered pumps are elaborated. The topics presented in the book are very useful and therefore it can be recommended as a reference for Diploma courses and for initial levels of Bachelor courses at universities. The book may also be used as lecture material for a special course at lower level in the field of irrigation.

Hudson, N. Soil Conservation. Batsford Limited, London, 1981 (Revised reprint 1986, 324 pages)

The critical problem associated with tillage is soil erosion. To date, many of the on-going research activities are attempting to develop tillage systems to be in line with contemporary soil conservation methods.

The author discusses thoroughly the causes of soil erosion (erosion due to rainfall, wind, etc.), presenting erosion control methods (mechanical protection, control of erosion by means of crop management). Design of mechanical protections are demonstrated using photographs and sketches. Some formulas are given to estimate soil loss and for the construction of mechanical erosion controls.

The author stresses the aim of the book, "to present the engineering approach to soil conservation" He recommends the book for "not only agricultural engineers but also for students of agriculture, geography, geology and ecology".

The book may play a great role in system engineering, and therefore it is quite reasonable to recommend it for students of agricultural system engineering at different levels (post-Diploma, BSc and MSc courses). It may also be logical to recommend the author's earlier book: *Hudson, N.W. 1975.*

Field Engineering for Agricultural Development, Oxford University Press, London (226 pages), for reference. It covers drainage, irrigation and water storage, which are included in the later book.

5.4. Energy

The list of textbooks recommended for Energy is given in Appendix III. Some of the books are commented below.

J. Twindell and T. Weir. Renewable Energy Resources. Cambridge, The University Press, 1986 (439 pages)

The book contains varieties of subjects in the field of energy and in each chapter corresponding fundamental theories are given and then followed by applications. The first chapters discuss the principles of renewable energy, basic concepts of fluid mechanics and heat transfer.

The book is organized and structured in a good approach and presents a wide range of energy sources:

- solar energy,
- hydro-power,
- power from the wind,
- biofuels,
- wave energy,
- tidal energy,
- geothermal energy, etc.

Each energy resource is analyzed and examples of practical applications are elaborated.

The theme around which the book is organized is applicable both in developed and developing countries and can successfully be used as a textbook for BSc, MSc and PhD courses depending on the way the contents are presented to the students. The book is advanced and therefore some chapters can be omitted for the BSc course.

Draught animal power, which is proved to be one of the most important energy sources in developing countries, is not included in the book. Thus, the book should be supplemented by other literature where this subject is thoroughly discussed.

Stout, B.A. Handbook of Energy for World Agriculture. Elsevier Science Publishers Ltd. 1990.

The book is composed of 504 pages and it is recommended by the author to be used as a reference for a comprehensive overview of energy in agriculture. Many universities use parts of the book as a textbook for Diploma and BSc degree courses. The book emphasizes energy usage of small scale or non-commercial energy sources.

Draught animal power, as one of the main energy sources in developing countries, is described. Examples of research results and reports, and energy use in different developing countries are given.

Practical applications of small scale hydro-power, wind power, solar energy, etc., are elaborated. However, not much attention has been paid to theoretical parts. Therefore, the handbook may be used as a reference as a whole, and the part discussing the draught animal (pages 81 - 87) and applications of hydro-power, solar energy and wind power in small scale agriculture can be used as lecture material for energy courses at university levels of Diploma, BSc and even for MSc degrees. The book can serve to supplement the suggested textbook, *Renewable Energy Resources*.

Kristoferson, L.A. and Bokalders, V. Renewable Energy Technologies, their application in developing countries. Intermediate Technology, London, 1991.

Very general descriptions of hydro-, solar-, wind- and bio-energy and their application in developing countries are given in the book. Beside the above sources of energy, the roles of animal draught in transportation, tillage, forestry and in pump technologies are described.

However, no fundamental theories are used and this may undermine the quality of the book as a textbook. The book may be used for Diploma courses as material for the lectures and reference purposes and as a reference for the BSc course.

The book can complement for the book, *Renewable Energy Resources* if the book, *Handbook of Energy for World Agriculture* is not available.

ACIAR Proceedings No. 27, 1989. Draught Animals in Rural Development. Proceedings of an International Research Symposium, Cipanas, Indonesia, July 3 - 7, 1989

The book contains a wide range of papers related to Draught Animal Power, DAP. The position of DAP research in some countries of Africa, Asia and Latin America is presented. Engineering and economic aspects of DAP are discussed and useful research results are presented. The book includes interesting papers where application of animal power for various operations are elaborated.

The proceedings contain some important examples of accumulated research results which may form a basis for further research work and education in this subject area. The proceedings can be used as reference and teaching material (some of the papers are suitable to be used directly for lectures). It can be a complementary for the book, *Renewable Energy Resources*.

Starkey, P. and Ndiame, F. Animal Power in Farming Systems. The proceedings of the second West Africa Animal Traction Networkshop. Freetown, Sierra Leone, September 19 - 25, 1986 (363 pages)

The proceedings is divided into two parts. Part 1 reports the background to the Network and workshop, and general presentation of the Network programme. Activities of the participants during the field visit and its evaluation are also presented in the first part.

Individual papers prepared for the Networkshop are included in the second part of the proceedings. The potential for animal power in Western African countries in general and Animal power in Liberia, Mali, Nigeria, Senegal and Togo in particular are presented in different useful papers. Some of the papers are written in French. Most of the papers presented are general and descriptive by nature. However, very useful information (statistical data) is included in many of the papers.

The proceedings may be helpful for students as a reference, to get an overview of the potential of animal power and its role for the promotion of agriculture.

Pryde P.R. Non-Conventional Energy Resources. John Wiley and Sons, New York, 1983.

The book covers, in a general form, most of the topics included in the book, *Renewable Energy Resources*. Although the book discusses the energy resources in the USA, many developing countries are using it as a textbooks for the BSc and MSC programmes. However, in the current assessment, it is only recommended to be used as a reference.

Duffie, J.A. and Beckman, W.A. Solar Energy of Thermal Processes. Second edition. John Wiley & Sons, Inc. 1991 (919 pages)

The authors recommend the book as a textbook for university level engineering courses and reference for researchers working in the field of solar energy.

The book is advanced and well organized. It is divided into three parts. In Part I, basic theories and calculations and examples are discussed, whereas in Parts II and III applications and design methods are elaborated, respectively.

The book does not cover applications in agriculture, but can serve as a source book or textbook, for special courses on solar energy, to give students studying for MSc and PhD programmes, a good theoretical background upon which to base competence in the application of the theories in order to promote utilization of solar energy in developing countries.

Goswami, D.Y. Alternative Energy in Agriculture. Volumes I & II. CRC Press, Boca Raton Florida. 1986, (Volume I, 226 pages, Volume II, 181 pages, both hardcover)

The books present the use of alternative energy sources;

- solar energy (thermal and photovoltaic),
- wind energy,
- methane
- alcohol and
- biomass gasification

in agriculture.

The two volumes have 12 chapters and each chapter is written by different authors. Chapter 3, volume I, discusses on-farm energy use (energy use in crop production, irrigation and on-farm drying) and energy use off-farm

(energy use in food processing and transportation). Fundamental theories, design examples and some data are included for each of the alternative energy sources mentioned earlier.

The authors recommend the books for students (without specifying the category), researchers, teachers of agricultural engineering and agricultural extension agents. Most of the examples and data used in the books are from the USA, and the books are written to be used in the USA. However, the principles, and to some extent, the examples of methods of utilization included are still valuable in Africa. The books can be recommended as a reference for BSc and post-graduate courses.

Parker. B. F. Solar Energy in Agriculture. Volume 4. Elsevier, Amsterdam, 1991 (447 pages)

The book is rather new, where the application of solar energy is presented. The book is divided into 15 chapters:

- 1) Techniques of Estimation of Incident Solar Radiation,
- 2) Photovoltaic System Design,
- 3) Agricultural Application of Photovoltaic System,
- 4) Solar-Thermal Design,
- 5) Solar water heating,
- 6) Production Solar Greenhouse,
- 7) Animal House: Solar Application,
- 8) Water Desalination,
- 9) Solar Grain Drying,
- 10) Design of Solar-Heated Forage Dryers,
- 11) Solar Fruit Drying,
- 12) Solar-Heated Lumber Kilns,

- 13) Solar Curing of Special Crops,
- 14) Free-Convection Dryers, and
- 15) Solar Thermal Water Pumping.

Each chapter is written by different authors. The book is written in a higher standard to be used by designers. Theoretical equations and data are presented along with the descriptions. No practical problems specific for the developing countries are raised in the book. However, the book can be used as a reference for research purposes by PhD and MSc students and for special solar energy courses.

5.5. Rural Structure and Functional Planning

The list of textbooks recommended for Rural Structure is given in **Appendix IV**. Some of the books are commented below.

Bengtsson, L.P. and Whitaker, J.H. Farm structure in tropical climates. F.A.O. Rome, 1986. (394 pages).

Some universities in Africa use the book for courses held as parts of BSc and MSc programmes. The authors present the material in the book in a simplified way and include examples of problem solving. The book is divided into 14 chapters and appendixes, latter presenting SI-base units, conversion tables, list of symbols and various tables of properties of building materials. The chapters include:

- presentation technique,
- surveying,
- building materials,
- structural design,
- elements of construction,

- building production,
- climate and environmental control,
- functional planning,
- crop handling,
- conditioning and storage,
- animal housing,
- sundry farm buildings,
- farm dwellers,
- external facilities and rural water supply, and
- sanitation.

The authors have attempted to integrate some theoretical concepts with the subjects around which the book is organized. At end of each chapter a list of literature is presented for further reading. The book is one of the examples of appropriate textbooks and it may serve as a relevant textbook if the specified literature for each chapter is available for the students. Some of the drawings and illustrative pictures are of poor quality.

Balls, R.C. Horticultural Engineering Technology, Fixed Equipment and Buildings. Macmillan, London, 1986

About 8% of the institutions on which this study is based use the book for BSc degree courses and a small number of universities use it for the MSc level. "The book deals in depth with the buildings, structure and equipments used for processing agricultural products." The chapters include packhouse design and operation, glasshouses and translucent plastic structures, buildings, equipment for protected crop structures, equipment and systems for crop storage, etc. Some formulas are given for design calculations. Considerable and interesting, but too brief, information is given. With the exception of some chapters eg., the discussion on the glasshouse, the book is recommendable as a reference.

Barnes, M. and Manger, C. Farm Building Construction. Suffolk, Farming Press Ltd, 1986.

The book is designed as a guide-line to be used by farmers. The book deals with practical construction and planning where advanced equipment and machines are required. The book could be used as a reference.

6. Scientific Journals

To up-date the textbooks, they are usually supplemented by other newly produced teaching material in which recent research findings are published. Scientific journals are one of the main sources of teaching material today. Contemporary reports of research findings are found in data bases (in the form of abstracts), in scientific journals (the journals can be international or national) and proceedings of congresses, conferences, symposia and seminars.

In the present work, some journals are recommended. In the journal of *Agricultural Mechanization in Asia, Africa and Latin America*, various articles, valuable and relevant to agricultural system engineering, can be found more frequently than in other journals. It is worth subscribing to the above journal and also other journals listed below.

AMA Agricultural Mechanization in Asia, Africa and Latin America

Journal of Agricultural Engineering & Research

Transactions of American Society of Agricultural Engineering

Soil and Tillage Research

Journal of Agricultural Sciences

Journal of Solar Energy Engineering

Agricultural Engineering Abstracts.

7. Discussion and Conclusion

In the present work, the most widely-used books in the fields of Agricultural Engineering are identified. The result of the assessment showed no significant difference between higher institutions in developing and developed countries with regards to the type of textbooks they use for different levels. The books identified are equally popular in both categories of the world. However, there is a slight tendency in the promotion of appropriate technology in developing countries. But this technology has not been sufficiently integrated into the education system. Numerous monographs written as textbooks for the above field were assessed and many of them are very general and poor in theories. However, reports of recent research findings in these countries are available in the form of journal articles, conference or congress papers.

It was not found easy to recommend one single book for each subject: Mechanization, Crop processing, On-farm energy and Farm structure. Instead a number of complementary books are recommended. No full-scale textbooks were found to be appropriate for the above subjects specifically for developing countries.

The economic growth of most developing countries depends on agriculture. And effective growth of agricultural products depends on the effectivity and relevancy of agricultural education. To ameliorate the problems associated with the relevancy and quality of textbooks, and to increase the quality of education, a curriculum should be developed on the basis of a local need for technological and social development in general and stimulation of economic

growth in particular. The design of a relevant curriculum for the basic science education and inclusion of practical experience would certainly strength the capability to conduct research and improve the degree of creativity and understanding and development of scientific methods of problem solving. Thereafter, textbooks with contents in line with and consistent with the objectives included in the designed curricula should be prepared. This would certainly promote the cognitive and problem-solving skills of the students. From the assessment made in the current work, no such textbooks are presently available.

As observed from the result of the assessment, the standard of education related to theories in the developing countries and industrialized countries are almost the same. The fundamental theory parts of the textbooks being used are very essential. They are important because they offer basic theories and are also important in coping, more or less, with the educational standard in developed countries.

Recommendation

The tendency of uncritical imitative nature of institutions in developing countries should be changed if education is to enhance the technological and social development of a given society.

The experiences and accumulated research results reported in different journals, proceedings, etc., have not been yet organized in the form of teaching materials or textbooks. This is one aspect of the weak point of the education system in developing countries.

Therefore, it can be recommended that, using the existing fundamental theories and results of applied research and experiences from developing countries (Fig. 5), appropriate textbooks should be written.

A good textbook should contain:

- a) fundamental theories related to the subject,
- b) practical applications of the theories relating to the specific conditions,
- c) recent research findings,
- d) practical problem-solving exercises and challenging questions to the students at the end of each chapter,
- e) clear illustrations (photos and schematic diagrams).

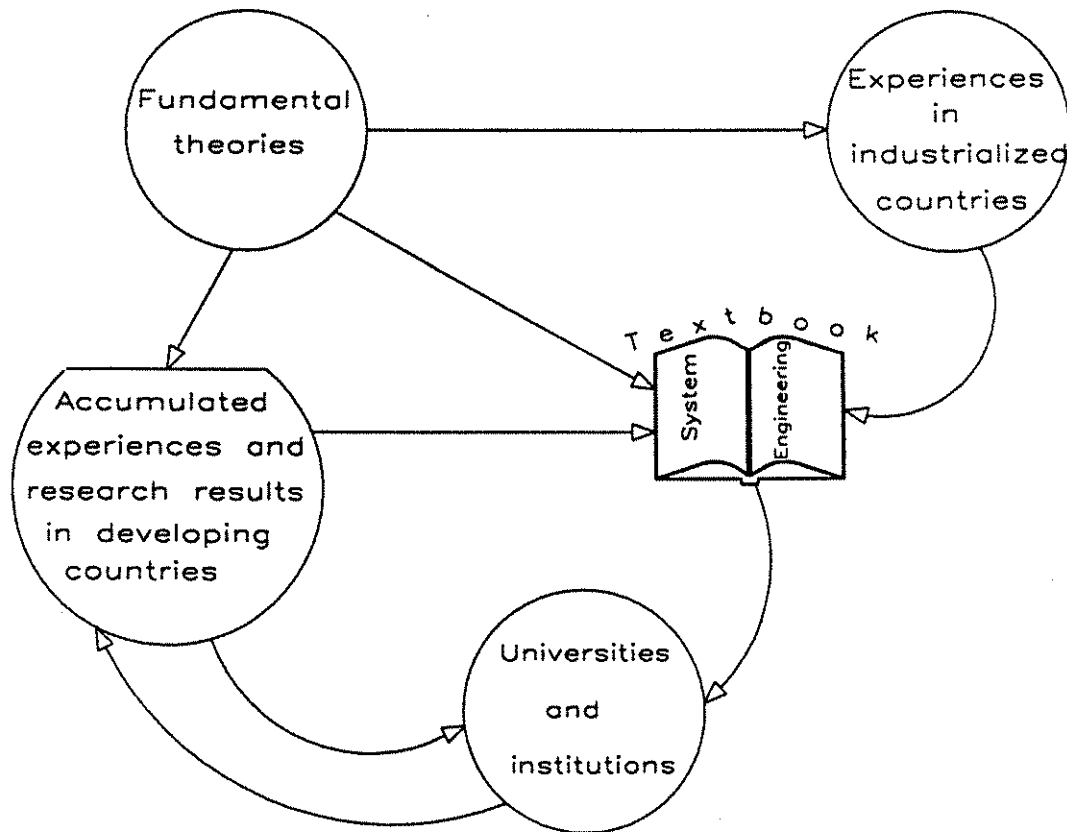


Fig. 5. Simplified diagram showing sources for the contents of textbooks.

In writing the textbooks, an integrated effort by indigenous scientists and scientists from the developed world is highly necessary. This integration is an advantage when unravelling and solving the problems associated with the education system, and also an advantage in transferring knowledge and skill from the developed countries and promoting technology growth in developing countries.

Acknowledgment

The author extends his warmest thanks to all institutions who cooperated in this work. The project was financed by AGROTEC.

References

- Altbach, P.G. Key Issues of Textbook, Provision in the Third World. Prospect, vol. XIII, No. 3, 1983.
- Cashman, K. and Person, E. Improving the relevance of formal education and training in preparing international students as change agents for low-input agriculture. American journal of alternative agriculture. 1988, Volume 3, Number 1.
- Darrow, K. and Saxenian, M. Appropriate Technology Sourcebooks. A Volunteers in Asia Publication, 1986
- Giles, S. The Third World Directory, A Guide to Organizations Working for Third World Development. A Directory of Social Change Publication. 1990
- Heyneman, S. P. Producing Textbooks in Developing Countries. Finance & Development / March 1990, pp 28 - 29.

Heyneman, Stephan P. Improving the quality of education. Finance and development/ March 1983

Lockheed, M. Improving Primary Schools in Developing Countries. Finance & Development / March 1990. pp 24 - 27.

Mackson, C.J. A Guide for Instructors in organizing and conducting agricultural engineering training courses. FAO Agricultural Service Bulletin, 12, 1971

Merle L. Esmay and Carl W. Hall. Agricultural Mechanization in Developing Countries. Shin-Norinsha co., Ltd, Tokyo, 1973

Morgan, M.J. & Smith, R.J. Agricultural Engineering by Mixed Mode Study. Proceedings of the 11th International Congress on Agricultural Engineering /Dublin / 4 - 8 September 1989.

Nilsson, B., Nick Kwendakwema and Kaliski, J. Utilization of Existing Institutions of Higher Education and Training in Rural Technology. AGROTEC report, Harare, Zimbabwe, May 1990

Olsen, W.C. and Olsen, J. Kennedy-Olsen. Determining the Current Core Literature in the Agricultural Sciences. IAALD VIIIth World Congress /QB XXXVI, 1-2, 1991.

Publishing for Schools Textbooks and the Less Developed Countries. World Bank Staff Working Paper No. 398. June 1980.

Rosenberg, N. and Frischtak, C. International technology transfer. Concepts, Measures and Comparisons. Praeger Publishers, 1985

Van den Bor, W.; Shute, J.C.M. and Moore, G.A.B. South - North partnership in strengthning higher education in agriculture. Pudoc Wageningen, 1989.

Verspoor, A. Educational Development: Priorities for the Nineties. Finance & Development / March 1990. pp 20 - 23.

Appendix I

Textbooks for Mechanization

* Text recommended

* Alcock, R. Tractor implement systems. AVI Pub., Westport, Connecticut, 1986

Barger, E.L., Liljedahl, J.B., Carleton W.M. and Mekibeen E.G. Tractors and their power units, 2nd edition. John Wiley & Sons, New York, 1963.

Bell, B. Farm Machinery. 3rd ed. Farming Press. 1989.

* Bishop, C.F.H. and Maunder, W.F. Potato Mechanisation and Storage. Farming Press, 1980

Butterworth, B. & Nix, J. Farm Mechanisation for Profit. Granada Publishing Ltd., Great Britain, 1983.

Butterworth, B. Materials Handling in Farm Production. Granada Publishing, 1979

* Carruthers, I. Tools for Agriculture. 3rd Ed. Intermediate Technology Publications, 1985.

* Crossley, P. & Kilgour, J. Small farm mechanisation for developing countries. John Wiley, 1983.

* Culpin, C. Farm Machinery. 11th Ed. Collins, London, 1986

* Esmay, M. L. and Hall Carl W. Agricultural Mechanization in Developing Countries. Tokyo, 1973

- * Geankoplis, C. K. Transport Processes and Unit Operations. 2nd Edition, Allyn and Bacon, Boston, 1983

- Gill, W. R. and Vanderberg, G. E. Soil Dynamics in Tillage and traction. Agriculture reasearch service, United State department of agriculture, 1968.

- Hawker, M.F.J. & Keenlyside, J.F. Horticultural Machinery, 3rd Ed. NY, 1985

- * Hopfen, H.J. Farm Implement for arid and tropical regions. FAO Agricultural development paper No. 91, Rome, 1969, reprinted 1981.

- Hudson. Field Engineering for agricultural development. Clarendon Press, Oxford, 1975

- * Hunt, D. Farm power and machinery management. Iowa State University Press, Ames, 1983.

- Jaerger, W.K. Agricultural Mechanization. The economics of Animal Draft power in west Africa. Westview press, 1986.

- * Kaul, R.N., C.O. Egbo. Introduction to Agricultural Mechanization. MacMillan Publishes, Hong Kong, 1985

- * Kepner, Bainer, Barger. Principles of Farm Machinery 3rd Edition. AVI Westport, Conn, 1982.

- Kuznesov, L.C. Exploitation of Tractors in the Tropics and the Subtropics (in Russian). Patric Lumumba University, Moscow, 1987.

- * Liljedahl, J.B., Turnquist, P.K., Smith, D.W. and Hoki, M. Tractors and their power units 4th ed. Van Nostrand Reinhold, NY, 1989.

Matthew, G.A. Pest management. Longman, NY, 1984

Matthew, G.A. Pesticide application methods. Longman, NY, 1988

McKyes, E. Soil cutting and tillage. Elsevier, 1985.

Michael, A.M. and T.P. Ojha. Principles of Agricultural Engineering, volume-II. India, 1978.

Pellizzi, G. Agricultural Machinery. Bologna, 1991.

Pellizzi, G. Agricultural Machinery and Mechanization. Bologna, 1987.

Pingali, P., Bigot, Y. and Binswanger, H.P. Agricultural Mechanization and evolution of Farming System in sub-Sahara Africa. World Bank, 1987

Promersberger, J.W., Priebe, D.W. and Bishop, F.E. Modern Farm Power. Reston Publing comp. Reston, Virginia, 1979

Robertson, J. Mechanising Vegetable Production, 2nd Ed. 1978

* Roth, C. M. An Introduction to Agricultural Engineering: A Problem solving Approach, Second Edition. Van Nostrand Reinhold, NY, 1991

* Shippen, J.M., Ellin, C.R. and Clover, C.H. Basic Farm Machinery. Bergamon Press Ltd. Hadding Hill Hall Oxford, England, 1980.

Sitkei, G. Mechanics of Agricultural materials. Elsvier, 1986.

Smith, P.A. Farm Machinery and Equipment. McGraw-Hill Book Company, New York, 1965.

- * Starkey, Paul . Harness and Implements for Animal Traction. German Appropriate Technology Exchange (GATE), Braunschweig/Weisbuden, 1989.
- * Witney, B.D. Choosing and Using Farm Machines. Longman, England, 1988.

Appendix II

Textbooks for Crop Processing

* Text recommended

* Appert J. The Storage of Food Grains and Seeds. Macmillan publishers, Hong Kong, 1987.

Arthey, D. & Dennis, C. ed. Vegetable processing (Blackie) 1991.

* Balls, R.C. Horticultural engineering technology - fixed equipment and buildings. Macmillan Education, UK, 1986.

Bishop, C.F.H. & Maunder, W.F. Potato mechanisation and storage. Farming Press, 1980.

Boumans, G. Grain handling and storage. 1985, Elsevier

Brenndorfer, B. et al. Solar dryers - Their role in post - harvest processing. Commonwealth Science Council, UK

* Brooker, D.B; Bakker-Arkema, F.W. and Hall, C.W. Drying of cereal grains. AVI, Westport, 1974 (Fifth Printing 1982).

* Brooker, D.B, Bakker-Arkema, F.W. and Hall, C.W. Drying and Storage of Grains and Oilseeds. Van Nostrand Reinhold, NY, 1992

Chakraverty A. & D.S. De. Post Harvest Technology of Cereals and Pulses. Indian Institute of Technology, Kharagpur, Oxford & I B H Publishing Co., New York, 1981.

Chung, C.J. and Kim, H.K. Agrcultural process machinery. koh, 1978.

Clarke, B. Manual on crop/seed processing equipment (ELE International) 1985.

Copeland, L.O. and McDonald, M.B. Principles of Seed Science and Technology. Burgess, Minn., 1985

Food Storage Manual, 2nd edition. World Food programme. TDRI, London, 1983

Geankoplis, C. J. Transport Processes and unit Operations - 2nd Edition. Allyn and Bacon, Inc., Boston, 1983

* Grochowicz, J. Machine for Cleaning and Sorting of Seeds (translated from polish, and available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia), 1980 (374 pages).

* Hall, C. W. Drying and Storage of Agricultural crops. AVI publisher, Connecticut, 1980

* Hall D. W. Handling and Storage of Food Grains in tropical and subtropical areas. FAO, Rome, 1970.

Hardenburg, R.E., Watada, A.E. and Wang, C.Y. The commercial storage of fruits, vegetables and florist and nursery stocks. United States Department of Agriculture, 1986

* Henderson, S.M. and Perry, R.L. Agricultural process engineering 3rd edition. AVI publisher, Connecticut, 1980.

Kader, A.A., Kasmire, R.F., Mitchell, F.G., Reid, M.S., Sommer, N.F. and Thomson, J.F. Postharvest technology of horticultural crops. University of California, 1985

Keey, R.B. Introduction to Drying operations. Pergamon press, New york,

Kuprits, Y. N. Technology of grain processing and provender milling (translated from Russian). Israel program for scientific translations Jarusalem, 1965.

Luh, B.S. & Woodroof, J.G. Commercial vegetable processing 2nd ed. Van Nostrand Reinhold, 1988.

* McLean, K.A. Drying and Storing Combinable crops. 2nd Ed. Farming Press, UK, 1989.

Mohsenin, Nuri N. Physical properties of plant and animal materials. Gordon and Breach Science publisher, NY, 1986.

* Prevention of post harvest food losses: A Training Manual. FAO, 1985.

* Proceedings of the ICIPE/ECA Regional Study Workshop held in Nairobi, Kenya, 10-17 October 1987. Insect Science and its Application; International journal of Tropical Insect Science, volume 9 Number 6, 1988

Raymond, W.F., Redman, P. & Waltham, R.W. Forage conservation and feeding. 4th ed. Farming Press, 1986.

* Salunkhe, D.K., Chavan, J.K. and Kadam, S.S. Postharvest Bio-technology of Cereals. CRC Press, Inc. Boca Raton, Florida, 1985 (208 pages)

Sinha R.N., W.E. Muir. Grain Storage: part of a System. Westport, London, 1983.

* Snowdon, A.L. A colour atlas of postharvest diseases and disorders of fruit and vegetables. Vol.I. General introduction and fruits. Wolfe Scientific, Barcelona, 1990.

Thomson, J.R. An Introduction to Seed Technology. Blackie, Glasgow, 1979

Weichmann, J. ed. Postharvest physiology of vegetables (Dekker) 1987.

Wills, R.H.H. et al. An Introduction to the physiology and handling of fruit and vegetables. 3rd ed. Hong Kong, 1989.

Appendix III

Textbooks for On-farm Energy

**** Text highly recommended,**

*** Text recommended**

* ACIAR Proceedings No. 27, 1989. Draught Animals in Rural Development. Proceedings of an International Research Symposium, Cipanas, Indonesia, July 3 - 7, 1989

* AMBIO: Journal of the Human environment. Royal Swedish Academy of Science. Volume XIV, number 4-5, 1985

* Duffie, J.A. and Beckman, W.A. Solar Energy of Thermal Processes. Second edition. John Wiley & Sons, Inc., 1991 (919 pages)

* Goldenberg, J. et al. Energy for Sustainable World. New Delhi (India), 1990.

* Goswami, D.Y. Alternative Energy in Agriculture. Volume I & II. CRC Press, Boca Raton Florida, 1986 (Volume I 226 pages, Volume II 181 pages)

** Kristoferson, L.A. and Bokalders, V. Renewable Energy Technologies, their application in developing countries. Intermediate Technology, London, 1991

Oskar and Samir Plenum press. Biomass conversion process for energy & fuels., New York and London.

* Parker, B.F. Solar Energy in Agriculture. Elsevier, 1991

Pellizzi, G. Castelli, F. Mazzetto. Models for the design of integrated energy systems for agriculture. Milno, 1990.

* Pellizzi, G. et al. Energy Savings in Agricultural Machinery and Mechanization. London, 1988.

* Pryde P.R. Non-Conventional Energy Resources. John Willey and Sons, New York, 1983.

Robinson and Mollan. Energy managment in Agriculture. The Royal Dublin society, 1981.

* Starkey, P. and Ndiame, F. Animal Power in Farming Systems. The proceedings of the second West Africa Animal Traction Networkshop. Freetown, Sierra Leone, September 19 - 25, 1986 (363 pages)

Stout, B.A. Energy Use and Managment in Agriculture. Breton Publishers, North Scituate, MA, 1984

** Stout, B.A. Handbook of Energy for World Agriculture. Elsevier science publishers Ltd., 1990

** Twindell, J. and Weir, T. Renewable Energy Resources. Cambridge University press, 1986 (439 pages)

Vogt, F. Energy conservation and use of Renewable energies in Bio-industries. Pergamon Press, 1982.

Appendix IV

Textbooks for Farm structure

**** Text highly recommended,**

*** Text recommended**

* Albright, L. Environment Control for Plants and Animals. American Society of Agricultural Engineers, 1991

* Balls, R.C. Horticultural engineering technology - fixed equipment and buildings. Macmillan Education, 1986.

** Barnes, M.M. and Mander, C. Farm Building Construction. Farming Press, 1986

** Bengtsson, L.P. and J.H. Whitaker. Farm structures and tropical climates. FAO, Rome , 1986

Brent, G. Housing the Pig. Farming Press, 1986

Canadian Farm Building Code. Associate Committee on the National Building Code, National Research Council, Ottawa, Canada, 1990

Fabos, J.G. Land-Use Planning: from Global to local challenge. New York, 1985.

Foster, J.S. Structure and fabric. Part 1. 3rd ed. (Batsford) 1991.

Grundey, K. Tackling farm waste. Farming Press, 1980.

Hindson, J. Earth roads (Intermediate Technology Publications) 1983.

Introduction to Design in Wood. Canadian Wood Council, Ottawa, Canada, 1991

* Whitaker, J. H. Agricultural Buildings and Structure. A Prentice-Hall company, Reston, Virginia, USA, 1979.

Mathee, J.G. Building Construction on the Farm.

Maton, A., J. Daelemans and J. Lambrecht. Housing of Animals. Elsevier, New York, 1985.

Noton, N.H. Farm Buildings. College of Estate Management, 1983.

Pringle, R.T. A design guide to mechanically ventilated livestock housing. NOSCA Bull. No 26, 1981.

Sitkei, G. Mechanics of Agricultural materials. ELSEVIER, 1986.

Stanley E. Curtis. Environmental management in animal agriculture. The IOWA State university press, Ames, 1983.

* Structure and Environment Hand book. Midwest plan service, IOWA, USA

Winter, G and Nilson, A.H. Design of Concrete Structure. New York, 1979.

Appendix V

Textbooks for Irrigation and Soil conservation

**** Text highly recommended,**

*** Text recommended**

Arlosoroff, S. and others. Community water supply: the handpump option (World Bank) 1987.

Bailey, R. Irrigated crops and their management. Farming Press, 1990.

* Batey, T. Soil husbandry. Soil and Land Use Consultants Ltd., 1988.

Blakie, P.M. The political economy of soil erosion in developing countries (Longman) 1985.

* Bottrall, A. Comparative study of the management and organisation of irrigation projects (IBRD) 1981.

Brady, N.C. The nature and properties of soils. 9th ed. Macmillan, 1984.

Castle, D.A., McCunnall, J., Tring, I.M. Field Drainage, Principles and Practices. Batsford 1984.

D'itri, F.M. A systems approach to conservation tillage. Wiley 1985.

* Davies, D.B., Eagle, D.J. & Finney, J.B. Soil management. 4th Ed. Farming Press 1982.

Davies, D., Eagle, D. & Finney, B. Soil management. Farming Press, 1982.

** Doorenbos, J. Guidelines for predicting crop water requirements. Paper No. 24, 1977.

Driscoll, F.G. Groundwater and wells 2nd ed. (Johnson Division, Universal Oil Products) 1986.

Food and Agriculture Organization. Crop water requirements. Irrigation & drainage paper no.24. FAO, Rome, 1977.

Food and Agriculture Organization. Organization operation and maintenance of irrigation schemes (FAO) 1982.

Food and Agriculture Organization. Yield response to water. Irrigation & drainage paper no.33. (FAO) 1979.

** Fraenkel, P. Water pumping devices (Intermediate Technology Publications) 1986.

Hallsworth, E.G. Anatomy, physiology and psychology of erosion (Wiley) 1987.

Hofkes, E.H. ed. Small community water supplies (Wiley) 1983.

Hofkes, E.H. ed. Small community water supplies (Wiley) 1984.

** Hudson, N.W. Soil Conservation. 2nd ed. Batsford Limited, London, 1986.

Jensen, M.E. Design and operation of farm irrigation systems. A.S.A.E. Monograph No. 3, Michigan, 1980

Jordan, T. A handbook of gravity flow water systems (I.T. Publications) 1984.

- Kay, M. Sprinkler Irrigation: Equipment and Practice. Cranfield Press. 1983.
- Kay, M. Surface Irrigation: Systems and Practice. Cranfield Press 1986.
- Koolen, A.J. & Kuipers, H. Agricultural soil mechanics. Springer Verlag, Berlin.
- ** Landon, J.R. ed. Booker tropical soil manual. Pb.ed. (Longman) 1991.
- Marshall, T.J. & Holmes, J.W. Soil physics. 2nd ed. Cambridge Univ. Press., 1988.
- ** Morgan, R.P.C. Soil erosion and conservation. Longman, 1986.
- Nakayama, F.S. & Bucks, D.A. Trickle Irrigation for Crop Production. 1st Edit. Elsevier, 1986.
- Nelson, K.D. Design and construction of small earth dams (Inkata Press) 1985.
- Russel, E.W. Russell's soil conditions and plant growth 11th ed. Longman, 1988.
- ** Schwab, G.O. Soil and water conservation engineering 3rd ed. Wiley, 1981
- Shaw, E. Hydrology in practice 2nd ed. (Chapman & Hall) 1990.
- Smedema, L.K. & Rycroft, D.W. Land Drainage. 1st Ed. Batsford 1983.
- Smethurst, G. Basic water treatment 2nd ed. (Telford) 1988.
- Stephans, T. Handbook on small earth dams and weirs (Cranfield Press) 1991.

Todd, D.K. Groundwater hydrology 2nd ed. (Wiley) 1980.

Twort, A.C. and others. Water supply 3rd ed. (Arnold) 1985.

White, A. Community participation in water and sanitation
(International Reference Centre for Community Water Supply and
Sanitation) 1981

Wilson, E.M. Engineering hydrology 4th ed. (Macmillan) 1990.

World Health Organization. Disinfection of rural and small community
water supplies (Water Research Centre) 1989.

World Health Organization. Guidelines for water quality 3 Vols. (WHO)
Vol.1. 1984.

Appendix VI

Books for Animal Behaviour and Animal Welfare courses

Cooper, M.E. An Introduction to Animal Law. Academic Press, London, 1987.

Curtis, S.E. Environmental Management in Animal Agriculture. Iowa State University Press, 1983

Dawkins, M.S. Animal Suffering: The Science of Animal Welfare. Chapman and Hall, London, 1980

Dawkins, M.S. Unravelling Animal Behaviour. Longman, 1986

Fraser, A.F. and Broom, D.M. Farm Animal Behaviour and Welfare. 3rd Ed. Baillière Tindall, 1990

Griffin, D.R. The Question of Animal Awareness. 2nd Ed., Rockefeller University Press, New York, 1981

Griffin, D.R. Animal Thinking. harvard University Press, 1984

Haines, M. An Introduction to Farming Systems. Longman, 1982

Huntingford, F. The Study of Animal Behaviour. Chapman and Hall, 1984

Kiley-Worthington, M. The Behaviour of Horses - in Relation to management and Training. J.A. Allen, 1987

Krebs, J.R. and Davies, N.B. An Introduction to Behavioural Ecology. 2nd Ed. Blackwell Scientific, Oxford, 1987

MacFarland, D. Animal Behaviour: Psychobiology, Ethology and Evolution. Pitman, 1985

Martin, P. and Bateson, P. Measuring Behaviour: An Introductory Guide. Cambridge University Press, 1986

Moberg, G.P. Animal Stress. American Physiological Society, 1985

Monaghan, P. and Wood-Gush, D.G.M. Managing the Behaviour of Animals. Chapman and Hall, 1990

Sainsbury, D. Farm animal welfare. Collins, 1986.

Sainsbury, D. Farm Animal Welfare: Cattle, Pigs and Poultry. Collins, London, 1986

Sainsbury, D. and Sainsbury, P. Livestock Health and Housing. 3rd Ed. Baillière Tindall, 1988

Ufaw handbook. 1988. (3rd Ed.) Management and Welfare of Farm Animals. Baillière Tindall.

Appendix VII

Books for general purposes

Batey, T. Soil Husbandry. Soil and Land Use Consultants Ltd., 1988

Boothroyd, G. & Poli, C. Applied engineering mechanics: statics and dynamics (Marcel Dekker) 1980.

Bowers, Jones, Olver. Engineering Application in Agriculture. Stipes Publishing Company, Chicago, Illinois, 16th edition, 1986.

Britton, M.G. On Being an Engineer in a Biological World. University of Manitoba Bookstore, Winnipeg, Canada, 1991

Butchbaker, A. F. Electricity and Electronics for Agriculture. Iowa state

Callister, W.D. Materials science & engineering 2nd ed. Wiley, 1991.

Collett, C.V. & Hope, A.D. Engineering measurements. 2nd ed. Longman, 1986.

Coulson, J.M. & Richardson, J.F. Chemical engineering Vol.II. 4th ed. (Pergamon) due Sept 1991

Davies, D.B., Eagle, D.J. & Finney, J.B. Soil management. 4th Ed. Farming Press, 1982.

Desrosier, N.W. and J.N. Desrosier. The Technology of Food Preservation. AVI Publishing comp.

Erokin, V., M. Makhanko et al. Fundamentals of Thermodynamics and Heat Engineering. Mir publisher, 1986

- Fundamentals of Machines and Operation - 2nd Edition. Published by Deer and Company Moline, Illinois USA, 1981
- Gill, William R and Glen E. Vanderberg. Soil Dynamics in Tillage and traction. Agriculture reasearch service, United State department of agriculture, 1968.
- Hawker, M.F.J. & Keenlyside, J.F. Horticultural Machinery, 3rd Ed. 1985
- Hearn, E.HJ. Mechanics of materials. Vol. 1. 2nd ed. Pergamon, 1985.
- Heldman, D.R. & R.P. Singh. Food Process Engineering. Van Nostrand Rinehold - Publisher, 1981
- Holland, C.E. & Liapis, A. I. Computer Methods for Solving Dynamic Separation Problems. McGraw-Hill - publisher
- Jones, W.P. Air conditioning engineering. 3rd ed. Arnold, 1985.
- Hunt, D. Engineering models for agricultural production. AVI Publishing company. AVI, Westport, Conn., 1986
- John Deere Limited. Fundamentals of Machine Operation Series. Machinery Management. By W. Bowers, 1979
- Kaplan,S. Energy Economics. McGraw-Hill -publisher, New York, NY.
- Machine Design. Hall Holowenko Laughlin (Schaun)
- Marshall, T.J. and Holmes, J.W. Soil Physics. 2nd Ed. Cambridge University Press, 1988
- Mathew A.A. Ergonomics in agricultural equipment design. Silsoe Research Institute, 1971

McCabe & Smith. Unit Operations and Chemical Engineering.
McGraw-Hill -Publisher

McKyes, E. Soil cutting and tillage. Elsevier, 1985

Mohsenin, N. Electromagnetic Radiation Properties of foods and
agricultural products. Gordon and Breach Science publisher, 1984

Mohsenin, N.H. Physical properties of plant and animal materials 2nd ed.
Gordon & Breach, 1986.

Newland, D.E. An introduction to random vibrations and spectral
analysis 2nd ed. Longman, 1984.

Prentis, J.M. dynamics of mechanical systems 2nd ed. Ellis Howard,
1980.

Ryder, G.H. & Bennett, M.D. Mechanics of machines 2nd ed. (Macmillan)
1980.

Scott, Bill. Communication for professional engineers. Thomas Telford,
1984.

Simon A.L. Practical Hydraulics. John Willey and Sons Inc., 1976.

Smith, M.J. Soil mechanics 5th ed. Longman, 1988.

Sverker Persson Assae Technical Editors James A. Basselman.
Mechanics of Cutting plant materials. 1987

Terzaghi, K. & Pack, R.B. Soil mechanics in engineering practice 2nd ed.
(Wiley) 1967.

Thermodynamical processing of biomass. Butter worth. London, 1984.

William R. Gill, Glen E. Vanderberg. Soil Dynamics in Tillage and traction. Agriculture reasearch service, United State department of agriculture, 1968.

Wong, J.W. Theory of Ground Vehicles. Wiley & Sons -Publisher

Yong, R.N., Fattah, E.A. Vehicle Traction Mechanics. Elsevier, 1984.