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# Diseases of Annual Edible Oilseed Crops

## Volume III: Sunflower, Safflower, and Nigerseed Diseases

S. J. Kolte

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# PREFACE

These three volumes deal with the diseases of primarily cultivated annual edible oilseeds, i.e., peanut (groundnut), rapeseed-mustard, sesame, sunflower, safflower, and nigerseed. Diseases of other annual crops, e.g., soybean, cotton, and corn, which also contribute significantly to the world supply of edible vegetable oils and fats, have been excluded. Linseed oil, though used in certain parts of the world as edible oil, is mostly useful for industrial purposes. Hence, diseases of the linseed crop also have been excluded.

A great deal of information has been accumulated on the diseases of peanut, rapeseed-mustard, sesame, sunflower, safflower, and nigerseed. This is evident from the proliferation of research papers and reports in scientific journals throughout the world. The progress of research on diseases of some of these crops has been summarized periodically by review articles or popular articles and by occasional brief chapters in books and monographs or bulletins. Some of those chapters are quite old indeed. Yet, to the best of the author's knowledge, no one has presented a thorough discussion of diseases of these crops. Besides a pressing need for such a comprehensive work, the experience of the author in research in the pertinent field has prompted this attempt to bring together the scattered information on the subject in a comprehensive manner in order to present it in a useful form. An attempt has been made to present a broader view of the subject than that generally included in bulletins and manuals. Discussions on development of a straightforward nature and also of a controversial nature have been included to stimulate thinking especially among the graduate students. The information presented represents a careful synthesis of research articles. The survey of literature has been made as complete as possible up to the beginning of 1983. In most cases original papers are consulted, and the temptation to use review articles or abstracts as a major source of information is avoided. However, *Review of Plant Pathology* (formerly *Review of Applied Mycology*), *Field Crop Abstracts*, and *Plant Breeding Abstracts* have been freely consulted, especially when access to the original papers was not possible, particularly in the case of sunflower diseases and especially because of limitations of linguistic ability to do justice to numerous pertinent original publications in the Russian, German, French, and Spanish languages.

Each volume of this set contains the "Introduction", which deals with the uses and chemistry of vegetable oils and fats, trends in world production and consumption, production constraints, crop management and disease problems. Volume I covers peanut diseases; Volume II covers rapeseed-mustard and sesame diseases; Volume III covers sunflower, safflower, and nigerseed diseases. Depending upon the available literature, the treatment of all the above crop diseases follows a uniform plan which will be seen from the main paragraph headings in each chapter. The aim has been to make the subject matter regarding each disease as complete and self-contained as possible. At first the reader is introduced to the respective edible oilseed crop in each chapter with a brief botanical description of the crop, its origin, and distribution. The diseases are arranged under each crop (except nigerseed) on the basis of the primary causal factors as follows: fungal diseases, bacterial diseases, virus diseases, mycoplasma diseases, parasitic nematodes, phanerogamic parasites, and nonparasitic diseases. The sequence of description of diseases under each causal factor has been taken depending on the economic importance or prevalence of the disease. Illustrations of symptoms are given to assist in the proper diagnosis of the diseases. Under each category of the causal factors, wherever possible, diseases of less frequent occurrence or the less known diseases are briefly described under the head "Other Fungal Diseases", "Other Bacterial Diseases", etc. The aflatoxin problem is described separately in detail under the peanut crop in Volume I, Chapter 2, on peanuts. Deterioration of edible oilseeds mainly due to storage fungi is described under the separate head "Biodeterioration" in the case of each crop except safflower and nigerseed, where information on this topic is scanty.

In order to provide more readily accessible information, the sections devoted to specific diseases are arranged in the following form: geographic distribution, economic importance, symptoms, pathogen, host-range, physiological races, survival, infection, factors affecting infection and disease development, and control. The control section for many diseases is further divided into host resistance, chemical control, cultural control, and biological control. Chemicals suggested for control of various diseases are given mostly by common names or sometimes by trade names. The names of chemicals are listed alphabetically and their chemical names and principal manufacturers are given in the appendix.

The morphological description of a pathogen affecting more than one crop is given under one crop only, and a cross-reference is made at the appropriate place.

In describing the economic importance of the diseases and chemical control, units of measurement have been retained as mentioned in the original research papers or abstracts, without necessarily converting them into metric units. This has been done intentionally to avoid confusion among the readers and, more particularly, to present the original available information.

It is reliably believed that this book will be of great help not only to students, researchers, and teachers but also to agricultural extension workers, field workers, seed growers, and seed crop inspectors, and subsequently to the farmers, to achieve the over-all objective of increase in oilseed crop yields throughout the world.

Any criticism that readers may wish to make in order to improve the book or to make it more useful to all concerned will be greatly appreciated.

**S. J. Kolte**

# THE AUTHOR

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He gained his Master of Science Degree in Agriculture with specialization in Plant Pathology from Nagpur University in 1967 and a doctorate degree in Plant Pathology from Pantnagar University in 1971. Since that time, he has been working on biological and control aspects of diseases of edible oilseed crops at Pantnagar University. He has authored about 30 research papers in the field of edible oilseed crop diseases. He traveled to visit leading oilseed research stations in Canada, the United Kingdom, and Sweden in 1981 under the IDRC- (Canada) assisted project on oilseeds.

Besides research on oilseed crops, he is also engaged in teaching certain courses in plant pathology and in guiding graduate students for their research at Pantnagar University.

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Most of the illustrations, particularly the photographs of symptoms of different diseases, are the results of the author's original work. A few photographs have been obtained from other scientists working in India, the U.S., and Canada, whose help is acknowledged in the legends. Particular mention is gratefully made to: Dr. J. M. Klisiewicz, Research Plant Pathologist, Department of Plant Pathology, University of California at Davis; Dr. H. C. Huang, Plant Pathologist, Agriculture Canada Research Station, Morden, Canada; Dr. D. V. R. Reddy, Principal Virologist, Peanut Improvement Program, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India; Dr. P. A. Shinde, Professor and Head, Department of Plant Pathology and Agricultural Microbiology, Mahatma Phule Krishi Vidyapeeth, Rahuri, India; Dr. A. K. Deshmukh, Senior Safflower Breeder, Nimbkar Agricultural Research Institute, Phaltan, India.

Some of the figures are partly drawn from previous published records, and sources of illustrations have been duly given in the legends.

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VOLUME OUTLINE FOR VOLUME I: Peanut Diseases

VOLUME OUTLINE FOR VOLUME II: Rapeseed-Mustard and Sesame Diseases

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Chapter 2 — Rapeseed-Mustard Diseases
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Chapter 1

# INTRODUCTION

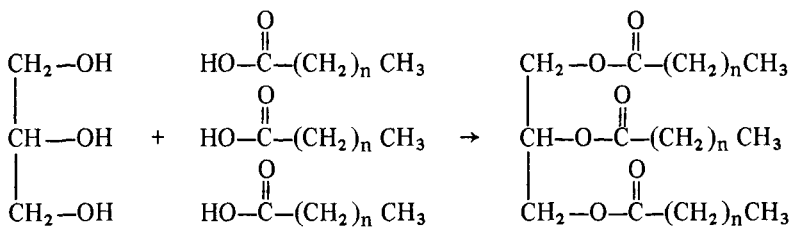
## I. EDIBLE OILSEED PLANTS

Edible oilseed plants are those plants whose seeds bear fixed non-volatile oil. Such seeds could be consumed directly or may be eaten fried, roasted, or pounded and mixed with sugar; or the oil may be extracted from such seeds and directly used for cooking the food, or for confectionery purposes.[1] Usually, refining of the oil is done before it is used as food. Edible vegetable oils may, however, be used occasionally for industrial purposes, e.g., manufacturing of soaps, varnishes, hair oils, lubricants, etc. The residues left, i.e., the oil-cakes, serve as excellent animal or poultry feed. Oil-cakes may also be used as manure to increase the fertility status of soils.

The demand for edible oilseeds for human consumption in different parts of the world is principally derived from three categories of cultivated crop plants: (1) primarily cultivated annual oilseed crops, e.g., peanut *(Arachis hypogaea* L.), rapeseed-mustard *(Brassica campestris* L., *B. napus* L., *B. juncea* (L.), Czern and Coss, *Eruca sativa* Lam.), sunflower *(Helianthus annuus* L. var. *macrocarpus* (DC) Ckll.), sesame *(Sesamum indicum* L.), safflower *(Carthamus tinctorius* L.), nigerseed *(Guizotia abyssinica* Cass),and soybean (Glycine max (L) Merrill); (2) an annual fiber crop cotton *(Gossypium hirsutum* L.) through its seed-byproducts, and (3) perennial oilseed plants such as coconut palm *(Cocos nucifera* L.) and oilpalm *(Elaeis quineensis* Jacq). Corn *(Zea mays* L.) oil also contributes significantly to the world edible oil supply. Thus the range of plants that could be cultivated for edible oils is extensive, but only a few that are included in the first (1) category are suitable for large-scale commercial production or produce oil which is required in large quantities. In this book only this category of crops, excepting the soybean, is considered with respect to diseases and control.

## II. CHEMICAL NATURE OF EDIBLE OILS AND FATS

Edible oils and fats of vegetable origin are composed of triglycerides which are esters of one molecule of glycerol and three molecules of fatty acids.[2,3] A reaction leading to the formation of a triglyceride is shown below:



**Glycerol** **Fatty Acid** **Triglyceride**

Triglycerides that are solids at room temperature are termed as "fats", whereas, the liquid ones are termed as "oils". The latter contain ester-bound unsaturated fatty acids.

Fatty acids by and large are straight-chain aliphatic monocarboxylic acids (see Structure 1). Most of the members of this series contain an even number of carbon atoms in the molecule. Individual fatty acids are distinguished from one another by the nature of the

hydrocarbon chain. This chain can vary in length from 4 to 24 carbon atoms. When fatty acid contains one or more double bonds in the molecule, it is said to be unsaturated. Thus the fatty acid may be saturated (no double bond) as stearic acid, monounsaturated (one double bond) as oleic acid, or polyunsaturated (with two or more double bonds) as linoleic acid. The fatty acids are abbreviated according to the number of carbon atoms in the molecule and degree of unsaturation (number of double bonds). The common names, abbreviated symbols, systematics, and structural formulae of certain important fatty acids found in vegetable oils are given in Table 1. Physical and chemical properties of oil are determined by iodine number (IN), saponification value (SV), refractive index (RI) of oil. The IN, SV, RI, and fatty acid composition of important primarily cultivated annual edible oilseed plants are shown in Table 2. The natural configuration of fatty acids is the *cis* configuration, which is considered to be nutritionally more desirable.[2]

## III. TRENDS IN WORLD PRODUCTION AND CONSUMPTION OF VEGETABLE OILS AND FATS

The average annual rate of world production and consumption of oils and fats is about 3%, with the total annual production being 1 million metric tons.[5] The production of annual oilseed field crops has increased considerably since 1960, and it now constitutes over 50% of the total production of fats and oils in the world.[5] However, the supply of vegetable oils from annual field crops tends to remain quite flexible from year to year in relation to the total world supply of vegetable oils and fats.

The present average per capital consumption of edible oils and fats is 30 g/day (highest) in Western Europe, 5 to 11 g/day (low) in India and other Asian countries, and 2 g/day (lowest) in Africa.[5-7] Thus, the consumption of fats and oils in Asia and Africa and in other developing countries is much less as against the required minimum consumption level of 30 g/day. This is a serious situation, particularly when it comes to meeting the requirement of an essential fatty acid, linoleic ($C_{18:2}$), and the energy supply for body functions under a balanced diet pattern. Considering the global minimum per capital consumption as required for keeping human health, the increasing world population by about 2% every year, the present rate of oilseed production on a global scale is not and will not be satisfactory. However, developed countries such as the U.S., Canada, and the Soviet Union have been and should continue to be the major producing areas. The six annual edible oilseed crops, as considered in this book, are grown in different parts of the world, covering a wide range of geographical areas. The world production[8] of some of these crops during the year 1978—79 is given in Table 3.

The yield of these crops is of higher magnitude in the developed countries as compared with the developing countries. For example, the average yield of peanuts in the developed countries, particularly in the U.S., is 25 to 27 q (quintals)/ha, whereas in India and in other semi-arid countries it is only about 8 to 9 q/ha.[9,10] A similar situation appears to be true with respect to the high production of rapeseed (now canola) in Canada and sunflower in the Soviet Union, compared with the yield performance of these crops in developing countries. Safflower production is about 20 q/ha in the U.S., 13 q/ha in Mexico, and only 3 q/ha in India.[11]

## IV. PRODUCTION CONSTRAINTS

### A. Basic Constraints

It is true that high-yielding varieties of oilseeds do not have the genetic potential to yield

## TABLE 1

### Common Names, Symbols, Systematics and Structural Formulae of Certain Important Fatty Acids Found in Vegetable Oils[2,3]

| Common name | Symbol | Systematic | Structural formula |
|---|---|---|---|
| Saturated fatty acids | | | |
| Myristic | $C_{14:0}$ | Tetradecanoic | $C_{13}H_{27}COOH$ |
| Palmitic | $C_{16:0}$ | Hexadecanoic | $C_{15}H_{31}COOH$ |
| Stearic | $C_{18:0}$ | Octadecanoic | $C_{17}H_{35}COOH$ |
| Arachidic | $C_{20:0}$ | Eicosanoic | $C_{19}H_{39}COOH$ |
| Unsaturated fatty acids | | | |
| Palmitoleic | $C_{16:1(9)}$ | 9-Hexadecenoic | $C_{15}H_{29}COOH$ |
| Oleic | $C_{18:1(9)}$ | 9-Octadecenoic | $C_{17}H_{33}COOH$ |
| Linoleic | $C_{18:2(9,12)}$ | 9,12,Octadecadienoic | $C_{17}H_{31}COOH$ |
| Linolenic | $C_{18:3(9,12,15)}$ | 9,12,Octa decatrienoic | $C_{17}H_{29}COOH$ |
| Gadoleic | $C_{20:1(9)}$ | Eicosenoic | $C_{19}H_{37}COOH$ |
| Erucic | $C_{22:1(13)}$ | 13-Docosenoic | $C_{21}H_{41}COOH$ |

*Note:* Figures in the parenthesis indicate the position of double bonds (=) in the fatty acid chain at carbon numbers starting from carboxyl group.

at par with cereals, even at the optimum management level. Besides, it could be observed that production of a unit quantity of fats and oils by a plant requires more energy than production of carbohydrates by cereals. In making comparisons, one should always keep in view the differential energy requirements for the plant to produce a quintal of oil. If for example, a plant produces 1 g of glucose, the conversion of this glucose into carbohydrate results in formation of 0.83 g carbohydrate, while if glucose is converted into lipid, only 0.38 g lipid is formed.[6,7] It is because of this high differential energy requirement, that oil yield from oilseeds has continued to be restricted.

### B. Other Constraints in Developing Countries

Poor plant population arising from poor-quality seed, particularly in the case of peanut and sunflower, inadequate nutrient status of soil and nutrient supply, no rhizobial inoculation — or use of inefficient rhizobial cultures in the case of peanuts, poor plant protection measures, and poor postharvest technology have been some other constraints for poor yields of oilseeds in developing countries. Besides, much of the oilseed acreage in developing countries — particularly in India — is rainfed and, therefore, a certain degree of instability is inherent in the production process.[6] Absence of rain or lack of irrigation water at critical stages of the crop growth before maturity causes significant loss in yield.[7]

## V. CROP MANAGEMENT

Oilseed crop management must be seriously considered in view of the very low yield of these crops in developing countries. Considerable advancement in research has led to an increase in the productivity of the oilseed crops, both in developed as well as in developing countries, particularly in India. In some crops, like sunflower and safflower, it is now possible to plan on the exploitation of hybrid vigor. Higher productivity of the sunflower in Canada and other developed countries is attributed to the cultivation of hybrid sunflower varieties. In developing countries, adoption of a package approach (technological package),

## TABLE 2

### Average Oil Content, Iodine Number, Saponification Value, Refractive Index and Composition of Fatty Acids of Edible Oils of Certain Annual Oilseed Plants[1,2,4]

| Oilseed plant | Oil (%) | Iodine (#) | Sapon. value | Refract. index at 26°C | Saturated fatty acids (%) | | | | | Unsaturated fatty acids (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $C_{14:0}$ | $C_{16:0}$ | $C_{18:0}$ | $C_{20:0}$ | $C_{18:1}$ | $C_{18:2}$ | $C_{18:3}$ | $C_{20:1}$ | $C_{22:1}$ |
| Peanut | 44—50 | 90 | 189 | 1.4550 | — | 8 | 4 | 3 | 55 | 25 | 0 | — | — |
| Rapeseed[a] | 30—48 | 81—102 | 168—175 | 1.4582 | — | 1—4 | 2—4 | — | 22—34 | 17—22 | 3—7 | 9 | 25—45 |
| Rapeseed[b] | 43 | 112 | 188—192 | 1.4550? | — | 4 | 2 | — | 60 | 20 | 10 | 2 | 2 |
| Sunflower | 40—48 | 128 | 191 | 1.4597 | — | 5 | 2 | 1 | 35 | 57 | 0 | — | — |
| Sesame | 46—52 | 111 | 192 | 1.4582 | — | 8 | 3 | 1 | 47 | 41 | 0 | — | — |
| Safflower | 24—36 | 145 | 191 | 1.4620 | — | 5 | 1 | 1 | 20 | 72 | 0 | — | — |
| Nigerseed | 38—50 | 139 | 293 | 1.4723 | 2 | 5 | 2 | trace | 39 | 52 | 0 | — | — |

*Note:* — indicates not detected or information is not known.

[a] Moderate to high erucic acid type.
[b] Canola (refined).