

An Introduction to  
**TAXONOMY OF  
ANGIOSPERMS**

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## PREFACE

**T**AXONOMY is perhaps the oldest discipline of botany and above all most advanced as a subject. Intermeshing of allied fields especially morphology, anatomy, cytology, genetics, paleobotany, geomorphology and palmology within ambit of taxonomy makes access to the subject matter difficult. To acquire basic fundamentals of these allied disciplines as prerequisite to comprehend totality of taxonomic concepts is indeed a huge task. An approach directed towards such a transcendental discipline of vast subject matter is, therefore, problematic and challenging. Taxonomic study became inherent even before dawn of systematized knowledge. As plants inhabiting earth were most attractive and wedded to human civilization for their economic usefulness.

Amongst diversity of definitions for taxonomy perhaps the best would be "*a study aimed at producing a system of classification of organisms which best reflects the totality of their similarities and difference.*" Over 3,00,000 species of plants when looked upon with this perceptive have remained a quiz and puzzle of taxonomists. It has been known within framework of taxonomic principles that a natural system of classification should be perceived as best as possible and it was realized through monumental work *Origin of Species* (Darwin, 1859) that natural system reflects evolutionary relationships.

In angiosperms fossil record provides little help to taxonomists in unravelling concepts of evolutionary origin and diversification. It has been customary to consider presence of characters more important than its absence in taxonomy. It has become, thus, imperative that taxonomic groups must be monophyletic and polyphyletic group must be abandoned. But this is too knotty a problem to be solved and adherence to the concept basically impractical and poses serious problems in taxonomy. This difficulty is because phylogeny might have been incorrectly interpreted in absence of known evolutionary sequence based on fragmentary fossil record. Should monophyletic requirement is not strictly applied cross bars between phylogeny and taxonomy would be removed. But monophylisis and polyphylisis are not well demarcated. In order to be natural and acceptable a taxon must fall toward the monophyletic end of this scale.

In crowded galaxy of angiosperm classifications Bentham and Hooker's system, Hutchinson's system, Takhtajan's system and Cronquist's system shine with a

lustre of their own and need a mention here as they represent climaxes of taxonomy. Admittedly, Hutchinson promulgated a phyletic concept in letter and spirit. His classification appears closer to ultimate than others in following harmony with currently accepted informations. Takhtajan's system is quite similar to Cronquist's for obvious reasons that both these excellent men developed their concepts independently but finally were in consultation with each other and the similarities of their views reflect necessities of current state of knowledge and considered nearest to the principles of morphological evolution. Cronquist's system is directed towards professional botanist or a reader of considerable insight in modern broad scale taxonomy and clarity of philosophic concepts in the sub-conscious mind. Cronquist's classification despite being most recent and broad based awaits its approval and adoption in the institutions of learning the world over. While the mind for the fulfilment of appetite tends to adopt Hutchinson's system of classification, practically of things cling to Bentham and Hooker's systems the only one which describes Indian plant species in his *Flora of British India*. In order to keep in tune with recent trends the authors have adopted arrangement of taxa in the text here following Hutchinson's system.

The terminology, scope and literature of taxonomy is extensive. An approach has been directed to blend observations by the authors with accepted published information elsewhere. Broader principles of taxonomy and philosophic visions on subject matter have been tried to be projected with clarity in exactness of factual references. Yet there may be lack of concomitance in subject matter for accommodation of authors' view points.

Layout of textual subject matter of this volume has been into: Profiles in history, aims and objectives; Literature on Taxonomy; Select Botanic Gardens of the World; Herbarium; Role of Herbarium in Modern Plant Taxonomy; Nomenclature; Terminology; Concept of Taxomy; Principles of Taxonomy; Concept of Taxa and Taxonomic Hierarchy; Construction and use of keys for Plant Identification; Characters and its selection; Numerical taxonomy; Chemosystematics and Systematic Serology; Anatomy in relation to Taxonomy; Embryology in relation to Taxonomy; Fossil Angiosperms; Origin of Angiosperms; Cytology, Geography and Ecology in Relation to Taxonomy; Palynology in relation to Taxonomy and classifications of angiosperms, written by Dr Shukla and Select orders and Families of Lignosae; Select orders and Families of Herbaceae; Select orders and Families of Monocotyledones, written by Mr Misra.

The origin of angiosperms has been dealt in a separate chapter and a synoptical background has been traced to evolve them from pre-angiosperms. But phylogeny of angiosperms instead of being described as a whole has been splitted into evolutionary corrections in each representative family to elucidate factual phylogenetic status for ready reference to the readers.

The textual contents of this volume provide conceptual synthesis of subject. Effort to pool vast existing literature on taxonomy into a concised form to enable the readers have a glimpse subject matter. There has been an endeavour to describe selected taxon represented in India at order, family, genera and specific level in accordance with needs of curriculum of various universities.

Authors are deeply grateful to authors and publishers of classics, original research papers, monographs and books around which the theme of this volume

revolves. These references have been cited to document factual statements, acknowledge source of information or enable readers access to the original work. Authors are grateful to Prof. N. Abraham, Principal, Christ Church College, Kanpur and Dr (Mrs) Sita Srivastava, Principal, Maitreyi College, University of Delhi for their help in various ways.

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**AUTHORS**

# CONTENTS

<b>1. PROFILES IN HISTORY: AIMS AND OBJECTIVES</b>	<b>1—5</b>
Aims and Objectives	4
<b>2. LITERATURE ON TAXONOMY</b>	<b>6—27</b>
Indexes	6
Regulations	7
Periodicals	8
Dictionaries and Glossaries	8
Revisions and Monographs	9
Classical Publications	10
Broad Scope Publications	10
General Publications	11
Floras or Manual	14
Europe	14
Africa	14
North America	15
South America	15
Asia	15
Literature on Wild Plants	21
Literature on Cultivated Plants	21
Publications on Trees and Shrubs	22
Literature on Wild Flowers	24
Publications on Grasses	25
Conclusion	27
<b>3. SELECT BOTANIC GARDENS OF THE WORLD</b>	<b>28—58</b>
Padua, Italy	28
Pisa, Italy	30
Paermo, Italy	31
Villa Toranto, Italy	31
Leyden, Netherlands	32
Royal Botanic Garden, Edinburgh, Scotland	34
Glasnevin, Ireland	35
Meiso, Belgium	36

## *x Contents*

Munich, Germany	36
Berlin-Dahlem, Germany	37
Jardin Des Plantes France	38
Les Cedr , France	38
Oxford Botanic Gardens, England	38
Kew, England	39
Uppsala, Scandinavia	40
Arnold Arboretum, USA	43
New York Botanical Gardens, USA	44
Brooklyn Botanic Gardens, USA	45
Longwood Garden, USA	46
Missouri, USA	48
Huntington, USA	49
Fairchild, USA	49
Montreal, Canada	50
Moscow, USSR	50
Yalta, USSR	50
Bogor, Java	51
Peradeniya, Srilanka	51
Singapore Botanic Garden, Singapore	52
Melbourne, Australia	53
Sydney, Australia	54
Japan Botanical Gardens, Japan	54
The Indian Botanic Garden, Calcutta, India	54
Lloyd Botanic Garden, Darjeeling, India	56
National Botanic Garden, Lucknow, India	57

## **4. HERBARIUM**

**59—63**

Type Specimens	60
Equipment and Methods	60
Herbarium	62
Drying	62
Mounting of Specimens	62
Labels	62
Filling	63
Case of Specimen	63

## **5. ROLE OF HERBARIUM IN MODERN PLANT TAXONOMY**

**64—68**

Anatomy and Physiology	65
Palynology	66
Cytology	67
Numerical Taxonomy	67
List of Some Important World Herbaria	67

## **6. NOMENCLATURE**

**69—80**

Index Kewensis	70
Bionomial System of Nomenclature	70
Uninomial System of Nomenclature	71
Organizations for Nomenclature	72
Apomixis	74
Authority	74



The Types	75
Priority	76
Names of Taxa above the Rank of Family	77
Some Remodelled Nomenclatural Rules	80

## 7. TERMINOLOGY 81—109

Vegetative Parts	81
Floral Parts	91
General Plan of the Flower	102
Fruits	105
Seeds and Ovules	108

## 8. CONCEPT OF TAXONOMY 110—116

Approach to Taxonomy	113
Modern Taxonomy	114

## 9. PRINCIPLES OF TAXONOMY 117—120

Morphological Criteria	118
Anatomical Criteria	119
Ecological Criteria	119
Physiological Criteria	120
Phylogenetical Criteria	120
Palaeobotanical Criteria	120

## 10. CONCEPT OF TAXA AND TAXONOMIC HIERARCHY 121—125

Taxonomic Categories	122
Concept of Species	123
Concept of Genus	124
Concept of Families	125
Concept of Order	125

## 11. CONSTRUCTION AND USE OF KEYS FOR PLANT IDENTIFICATION 126—129

Key for determining the sub-class	126
Dicotyledoneae	126
Monocotyledoneae	126
Indented Type of Key	127
Bracket Type of Key	127
Generic Recommendations	127

## 12. CHARACTER AND ITS SELECTION 130—133

What are Characters	130
Kind and Nature of Characters	131
Character Preference	132

## 13. NUMERICAL TAXONOMY 134—147

Principles of Numerical Taxonomy	135
Status of Numerical Taxonomy	135

## **xii Contents**

Historical Account of the Development of Numerical Taxonomy	136
Aims and Objectives	137
Relationship	140
Basis for the Classification	142
Taxonomic Ranks and the Properties of Taxonomic System	143
Taxonomic Units and their Estimation	144
Numerical Taxonomy and Nomenclature	144
Application and Defects of Numerical Taxonomy	145
<b>14. CHEMOSYSTEMATICS AND SYSTEMATIC SEROLOGY</b>	<b>148—151</b>
Chemosystematics	148
Brief History	149
Constituents of Chemosystematics	149
Reliability of Data	149
Systematic Serology	150
Terminology	150
Serological Methods	150
<b>15. ANATOMY IN RELATION TO TAXONOMY</b>	<b>152—156</b>
Vascular Bundles	152
Types of Stomata	152
Hairs and Papillae	153
Ergastic Substances	153
Storage Cells	153
Primary Xylem	153
Secondary Xylem	153
Vessels	153
Fibres	153
Medullary Ray	154
Anatomy in Solving Taxonomic Problems	154
<b>16. EMBRYOLOGY IN RELATION TO TAXONOMY</b>	<b>157—162</b>
Embryology in Solving Taxonomic Problems	159
<b>17. FOSSIL ANGIOSPERMS</b>	<b>163—171</b>
Kinds of Preserved Organs	163
Angiosperm Floras	163
Certain Fossil Representatives	164
Evolutionary Correlations	171
<b>18. ORIGIN OF ANGIOSPERMS</b>	<b>172—177</b>
Fossil Record	172
Sudden Origin	173
Possible Ancestors	174
Conclusion	176
<b>19. CYTOLOGY, GEOGRAPHY AND ECOLOGY IN RELATION TO TAXONOMY</b>	<b>178—181</b>
Karyotype Components	179
Application of Karyotype	179

Fertility, Sterility and Species Problem	179
Geography and Ecology in Relation to Taxonomy	180
Ecographic Exploration	180
Methods to Express Variation	180
Limitations of Method	180

## 20. PALYNOLOGY IN RELATION TO TAXONOMY 182—184

Palynology of Taxon Above Family Rank	182
Palynology of Taxon Below Family Rank	183

## 21. CLASSIFICATION OF ANGIOSPERMS 185—212

The Historical Classifications	186
Modern Classifications	210

## 22. SELECT ORDERS AND FAMILIES OF LIGNOSAE 213—379

1. MAGNOLIALES	213
Magnoliaceae	213
Illiciaceae	219
Winteraceae	219
Schisandraceae	221
Cercidiphyllaceae	222
2. ANNONALES	222
Annonaceae	223
Eupomatiaceae	227
3. LAURALES	228
Austrobaileyaceae	229
Lauraceae	230
Myristicaceae	231
4. ROSALES	234
Rosaceae	234
5. LEGUMINALES	242
Caesalpiniaceae	243
Mimosaceae	249
Papilionaceae	256
6. CASURINALES	265
Casuarinaceae	266
7. URTICALES	269
Urticaceae	269
Moraceae	273
8. THYMELAEALES	277
Nyctaginaceae	278
9. CAPPARIDALES	280
Capparidaceae	281
10. VIOLALES	289
Violaceae	289
11. CUCURBITALES	292
Cucurbitaceae	292
12. CACTALES	298
Cactaceae	298

13. TILIALES 304  
    Sterculiaceae 304
14. MALVALES 307  
    Malvaceae 307
15. EUPHORBIALES 317  
    Euphorbiaceae 317
16. MYRTALES 327  
    Myrtaceae 327
17. SANTALES 334  
    Loranthaceae 334  
    Santalaceae 335
18. RHAMNALES 338  
    Rhamnaceae 338
19. RUTALES 340  
    Rutaceae 340
20. MELIALES 346  
    Meliaceae 346
21. SAPINDALES 349  
    Anacardiaceae 349
22. APOCYNALES 352  
    Apocynaceae 352  
    Asclepiadaceae 357
23. RUBIALES 362  
    Rubiaceae 362
24. BIGNONIALES 369  
    Bignoniaceae 369
25. VERBENALES 373  
    Verbenaceae 373

**23. SELECT ORDERS AND FAMILIES OF HERBACEAE**

**380—479**

1. RANALES 380  
    Ranunculaceae 380  
    Nymphaeaceae 387
2. PIPERALES 392  
    Piperaceae 392
3. RHOEADALES 395  
    Papaveraceae 395  
    Fumariaceae 402
4. CRUCIALES 406  
    Cruciferae 406
5. CARYOPHYLLALES 412  
    Caryophyllaceae 413
6. POLYGONALES 419  
    Polygonaceae 419
7. CHENOPODIALES 423  
    Chenopodiaceae 424  
    Amaranthaceae 426
8. LYTHRALES 430  
    Lythraceae 430
9. UMBELLALES 432  
    Umbelliferae 432

10. ASTERALES 438  
Compositae 439
11. SOLANALES 447  
Solanaceae 447  
Convolvulaceae 455
12. PERSONALES 461  
Scrophulariaceae 461  
Acanthaceae 466
13. POLEMONIALES 472  
Cuscutaceae 472
14. LAMIALES 473  
Labiales 473

## 24. SELECT ORDERS AND FAMILIES OF MONOCOTYLEDONS

480—525

1. COMMELINALES 480  
Commelinaceae 480
2. ZINGIBERALES 483  
Musaceae 484  
Cannaceae 486
3. LILIALES 488  
Liliaceae 488
4. ARALES 495  
Araceae 496  
Lemnaceae 499
5. PALMALES 501  
Palmae 501
6. ORCHIDALES 507  
Orchidaceae 507
7. CYPERALES 515  
Cyperaceae 515
8. GRAMINALES 518  
Gramineae 518

## BIBLIOGRAPHY

527—533

## INDEX

535—546

- Subject Index 535  
Author Index 543

PROGRESS of civilization marked relative increase in knowledge of plants and revealed interesting facts about vegetative world. Plant hunt for sources of food, shelter, clothing and medicine is age-old. The ancient concept about plants has undergone an entire change with advance of knowledge and updated versions of published works. Plants provide an orderly and comprehensive array of curiosities for their identification and categorization. Such a problem became crucial before botanists for obvious reasons. The modern knowledge of plants is spread over principally morphological, biochemical and genetical aspects with ramifying ancillaries in many other domains of science. Taxonomy is one of the branch which comprehends all others. The cumulative historical advance has gradually terminated into various systems of classification of plants. There has always been an effort to place forms showing resemblances nearer in a system of classification in view to provide a natural position to plants. Phylogenetic considerations also gained importance. The history of taxonomy is fascinating and full of controversies and is still reshaping itself. Systematised story of plant description dates back to the period of Bock, de l'Obel, Brunfels and Fuchs. Philosophical giants like Theophrastus, Aristotle, Dioscoroides and Pliny added more systematic and scientific approach to the subject. Dioscoroides (1 century A.D.) published valuable work the *Materia Medica* and *Anicia Juliana*. These comprise complete description of plants with coloured illustrations. Pliny (23-79 A.D.) was a Roman naturalist who described medicinal plants exhaustively. His work is spread over 37 books. The progress in taxonomy was gradual, and assisted by all those interested in various aspects of commercial plants. The earlier descriptions were mainly for medicinal purposes, Particularly cultivated plants were studied from such viewpoints in China, Assyria, Egypt and Pre-Columbian Aztee culture of China. The taxonomic considerations were confined to a narrower range of family, genera and species, largely assisted by plant breeding work. Later on concept to delimit wider groups of herbs, shrubs and trees led to consider close similarities between individuals as important feature in taxonomy rather than differences. Accordingly suggestions were made for creation of wider groups rather than generic and specific ones as Rushes, Umbellifers and Grasses.

Earlier attempts to delimit plants from each other were purely artificial and based on external features of the plants alone. Gradually ecological study of plants and usage of environmental considerations were employed in taxonomy.

Classifications are phylogenetic in nature and are based on genetical and evolutionary interrelationships. With advance of knowledge necessity to express plant characters through certain technical terms was felt. Leonhard pioneered publication of a glossary of technical terms for the first time. In 1542 Fuchs published another glossary *De Historia stirpium commentarii insignes*. William Turner published a valuable work of *Herbal* first part in 1551 and the second a decade later. Gerard's *Herball* or *Generall Historie of Plants* has been a comprehensive treatment based on Dodoens's *Stirpium Historie Pemptades* (Antwerp 1583). Gerard spread them in three main parts, the first book describes corn, flags, grasses—bulbous forms and rushes. In second book medicinal plants and all herbs with pleasant smell are dealt with and the third part deals with gum, resin and fruit bearing trees, roses, shrubs and bushes, heath, mosses, coral, mushrooms etc. The divisions suggested by him were purely superficial and clear-cut demarcation between plant types was not possible on the basis of apparent characters. Therefore, the system met casual attention. The major drawback of this classification was removal of grasses like corn, etc. as food from the grasses. Based on superficial similarities some monocots and dicots were dealt together and the medicinal use and economic importance of various plants were taken into consideration in classifying plants which in fact has no bearing with systematics. But despite these shortcomings the system found a place for some years till later. Fuchs, a herbalist, made some valuable contributions. Pupil of Fuchs, Kaspar Bauhin (1663) suggested some improvements and published *Prodromus Theatri Botanice*. This literature has more scientific and natural description. He did not take into consideration floral characters yet classification has its own merit because of adoption of binomial system of nomenclature. Simple monocots were placed at the base. Shrubs and trees were considered as more complex and evolved plants and were placed higher up in plant kingdom. Simultaneous progress in printing skill using wood cuts added perfectness, originality and assistance in furtherance of taxonomy. A scientific and rational approach was adopted in nomenclature of plants. Many plants were given names on the basis of resemblance of their parts with organ of human body. Based on their resemblance with particular organ they were mythically considered as remedy against diseases of those organs they resembled. For example genus *Hepatica* resembles human liver and was, therefore, considered for use to cure liver diseases. Consequently many young botanists revolutionized traditional thinking and adopted a new terminology based on characters other than traditional ones. The trends changed and new nomenclatural systems were suggested. These significant contributions later became the building stones of modern systematics on incorporation of evolutionary concepts.

The Italian physician Andrea Caesalpino (1519-1603), Director of Botanical Garden at Bolōgna used Latin and Italian words for nomenclature of plants. His collection of 768 plants is preserved as relevant herbarium in Natural History Museum at Florence. He published 16 voluminous books under the title *De Plantis*. They include description of 1500 plant species without illustrations and synonymy. Linnean Society still has a copy of *De Plantis* with notations of

**Linnaeus.** His classification is based on the demarcation between trees, shrubs and herbs. The major groups are classified on the basis of seed and fruit characters. An emphasis on significance of phyllotaxy in classifying plants has been laid in his system. Jochin Jung (1587-1657) frequently known as first terminologist and a German medical man defined homologous and analogous characters with clarity. He was opposed to fundamental groupings of trees, shrubs and herbs as followed earlier. Many new terms were suggested by him. Terms like nodes and internodes, leaf blade, simple and compound leaf, pinnate or digitate condition in simple and compound leaves were coined, the term perianth was used to denote calyx and not biseriate whorls, calyx and corolla. The male parts were termed as stamens and female parts as style in flowers but the relevant functional concept regarding sex was not clearly understood. The head or capitulum type of inflorescence with ray and discflorets were also observed by him.

Later John Ray (1627-1705) a graduate from Trinity College, suggested a system of classification based on embryo characters and number of cotyledons. This was in consonance with the basic idea of delimiting plants on the basis of plant forms like trees or herbs. He recognised two major sub-divisions of flowering plants: herbae and arbores. The former was subdivided into imperfectae (flowerless individuals) and perfectae (flowering individuals). The later was divided into monocotyledons and dicotyledons.

His meritorious system received appreciation with special reference to the recognition of genera in Bacciferae on the basis of pericarp characters of fruit. But such preliminary and dynamic features like fleshy nature of pericarp were not very much reliable. He also made suggestions to subdivide compositae into four classes. Undoubtedly he was trend-setter for a natural system of classification of flowering plants. John Ray's *Historia Plantarum* (1686-1704) described flowering plants under two main sub-groups dicotyledons and monocotyledons.

John Ray's contemporary Pierre Magnol (1638-1735) subscribed a classification upto family level on morphological characters of root and stem. Floral and seed morphology was also used for the first time. Genus *Magnolia* is commemorated after his name. One of Pierre Magnol's pupil Joseph Pittonde Tournefort (1656-1708), Professor of Botany at Jordin du Roi under Louis XIV made large collection of plants and published *Elements de botanique* in 1694. This valuable work includes 10146 species spread over 698 genera. *Flora of Environ of Paris* (1698) and *Institutiones Rei Herbariae* (1700) were his more important and distinctive works. The illustrations of plants described in them are on copper plates. He also believed in broad sub-divisions of flowering plants like herbs, shrubs and trees. One of the interesting merits of his system is description of several species under characteristic representative genera. He refused to accept existence of sexuality in plants. In his work usage of relevant terms petaliferous and apetalous forms of corolla with separate or united petals or regular or irregular corolla is observed. He widely travelled Europe and scaled Ararat mountains. He died in an accident while crossing the street near the garden where he was working.

Rudolph Camerarius (1667-1721), Director of Botanical Garden at Tübingen, Germany, despite being a non-taxonomist said that plants reveal sexuality and seeds were hitherto produced only when pollen developed in stamens come in the vicinity of ovary and style representing female sex. Without pollen the



#### 4 *An Introduction to Taxonomy of Angiosperms*

ovaries in flowers normally remained sterile. His work is not evidenced by any publication but he communicated his results to the reputed scientists and scholars at various universities. These findings provided a new conceptual outlook to approach problem of classification.

### **AIMS AND OBJECTIVES**

Plants have a paramount significance and unparalleled impact on human life. The commercial and medicinal products, fodder resources and foodstuffs are all obtained from plants. Both harmful and useful species are so intimately associated with daily life that it becomes necessary to have an orderly and scientific approach for the study of plants. There are millions of plants showing resemblances as well as differences but none of them are identical. The individuals showing similarities are placed in smaller groups as species and others in larger groups as genera. The basic knowledge of plants is the first necessity and provides idea about their morphological variations. Taxonomic studies have attracted attention since past 200 years and bears the largest literature in plant sciences. The study of systematics is linked with other branches of science and knowledge of other diverse branches forms the building blocks of taxonomy. Thus, assertion of limits of taxonomy is diverse and technical and requires sophisticated techniques. The work needs comprehensive analysis of angiosperm characteristics and kinship to arrive at simple broad based knowledge about plants. Multiple usage of plants in every day life necessitated formulation of standard terminology for description of various parts as an aid to identification and nomenclature. It is very important to distinguish between useful, harmful and poisonous plants before domestic and ornamental plantation. The systematized study has benefitted not only botanists but all those who are related with forestry, coal, medicine, paper industry and food etc as it facilitates the procurement of proper material. This is also associated with the study of plant diseases as they are associated intimately with human economy. Advance in taxonomy is largely conceived through efforts of plant collectors and botanists providing descriptions in herbarium, plant chemists, botanical artists, gardeners, gardens electron microscopists, cytologists and cytogenetists further add to knowledge of taxonomy. Modern work is saturated with extensive development of hybrid plants since they are more useful for people as providing better fruit, seed and flower products. Hybridization and taxonomy are closely related. Without taxonomic knowledge it is difficult to identify and compare plants and thus conduct hybridization work. Taxonomy provides varied interests since Roman period. It deals with facts regarding natural surroundings, nature of organs, morphological descriptions and economic significance of plants. Taxonomist has to analyse the characters carefully, correlate the data available and synthesize with accuracy the similarities and dissimilarities between large number of plants. In order to procure the products from plants it is very important to have basic literature about them. The published work is of great help to those selecting plants from nature increasing potentiality of identification. Interesting features of plants are employed as ecological indicators in soil conservation, soil erosion, loss of soil, soil fertility forming important aspects in human economy. These features can be helped by plantation methods to establish stability of the soil environment. Vegetation plays a very important role in controlling environ-