CHAPTER 1: INTRODUCTION

Family Poaceae is economically the most important family of flowering plants for their manifold use as food, fodder and for soil conservation. More than 75% of calorific value to the world population is provided by members of this family. It accounts for 20% of world’s vegetational cover (Ture & Bocuk 2007). Grasses are the signature of Poaceae with more than 10,000 species. It is the fourth largest family of flowering plants, surpassed only by Asteraceae (24,000 species), Orchidaceae (20,000 species) and Fabaceae (18,000 species). The value of grasses as food for human and animals hardly needs any emphasis. Family is of special importance not only from agriculture point of view but unfolding the complex problems of their origin and evolution. Environmental stability and economy of any country mainly depends upon the cultivation and wild flora of this family. Grasses play pivotal role in man’s economic activity and composition of natural plant communities. Due to their competitive adaptability, grasses are cosmopolitan in distribution and are uniformly distributed in all continents, and in all climatic zones from littoral zone to the highest alpine region. These are relatively more common in mountainous regions and extend up to the highest elevation inhabitable by flowering plants. The economic and ecological significance of the grasses has led to widespread interest in their evolution and classification.

1.1 Characteristic morphological features:

The members are mostly annual or perennial herbs with Bamboos (Bambusa & Dendrocalamus) as woody members. Stems are with distinct nodes and internodes, termed culm, with lot of tillering and fibrous root system. Leaves simple with sheathing leaf base, ligulate and having alternate distichous arrangement. Flowers in spikelets arranged either in spikes or panicle or raceme. Each spikelet has two basal empty bracts called glumes, one or more florets, each floret having lemma and palea, reduced perianth in the form of lodicules, 3-6 versatile anthers, unilocular ovary with single basal ovule, 2-3 feathery stigma and caryopsis fruit, where seed coat is developmentally fused with pericarp. Unlike other monocots, the embryo is lateral, highly differentiated with shoot and root meristem and leaves. Being anemophilous, flowers are inconspicuous and without any nector or fragrance. Thus the important
feature of grasses is adaptation to consistent anemophily i.e. structure of spikelets, loss of perianth and long flexible filaments and adaptation to harsher climatic conditions i.e. from many seeded fruit to single seeded fruit, xeromorphization of leaves and seed protein prolamin (Tzvelev 1989).

1.2 Economic importance:

Earlier man was gatherer and hunter, and used many underground plant parts like rhizomes or roots and fruits which could be taken raw, such food can’t be stored. With the discovery of fire, he started taking cereals which can be consumed after cooking only, and can be stored. Thus, started the settlement, designing of civilization and cultivation of crops and domestication of animals. Grasses have been used as source of food and fodder, since the dawn of civilization and start of agriculture. All the present day cultivated grasses such as wheat, rice, maize, barley, sugarcane, etc. have developed through selection from wild plants. Exploitation, improvement and utilization of grasses are a continuous process in developing societies. Since the dawn of civilization, the evolution of man and his present position in the biological world, he has been significantly affected by the grasses. The historical records suggest that most of the world civilizations developed around the regions of grasslands due to the prominent importance of grasses as food and fodder.

Human civilization is linked with cultivation and development of cereals, grasses around the world and their importance to human being can hardly be over estimated. More than 75% of the world’s population is estimated to consume wheat as part of the daily diet (Afzal et al. 2008). More than 50% food throughout world is obtained from three major cereals, rice (Oryza sativa), wheat (Triticum aestivum) and maize (Zea mays), besides some minor cereals like barley (Hordeum vulgare), finger millet (Eleusine sp.), Pennisetum americanum, Sorghum vulgare, Avena sativa, Secale cereale, etc. These are major source of carbohydrates for human population. The major source of sugar in whole of tropical countries is sugarcane (Saccharum officinarum, S. barberi, S. sinense). Volatile oils obtained through hydrodistillation from leaves of species of Cymbopogon (C. coloratus, C. martini & C. citratus) and roots of Vetiveria zizanoides are used in perfumery, insect repellant and also in medicines.
Grasses sweeten what are drunk with cane sugar, molasses and high fructose corn syrup. Corn by-product also provides raw materials for many chemicals used in industry. Grasses also provide the raw materials for most alcohol products such as rum from sugarcane, beer from barley and whisky and other spirits from wheat and rye. For the protection of environment, grasses play the most important role in keeping a balance of $\text{O}_2$/CO$_2$ cycle.

Natural grasslands and cultivated species are the major source of food for domesticated animals like cows, buffaloes, sheeps, goats, etc. and insects like butterflies and moths. Bamboos, popularly called poor man’s timber, have multifarious uses such as construction purposes, food, shelter, cottage industries, pulp for paper, etc. A number of species of grasses are grown in gardens for their beautiful foliage (eg. Pennisetum setaceum, P. alopecuroides) and inflorescences (Lygeum spartum, Miscanthus sinensis, Panicum vurgatum, Phalaris paradoxa) and are grown as source of lawn/natural and modern landscapes (Cynodon dactylon, Dactylctenium austral, etc.). Many grasses have medicinal importance also. Rhizome of Agropyron repens is used as demulcent diuretic, leaves of Cymbopogon nardus as stomatic and carminative, C. citratus as laxative, Vetiveria zizanoides roots as cure for snake and scorpion sting, decoction of roots of Thyranolaena maxima as mouth wash, Bamboos as stimulant, cooling and aphrodisiac, besides many other ayurvedic preparations use wheat, sugarcane and other grasses. Desmostachya bipinnata and Cynodon dactylon are used in many sacred Hindu ceremonies, besides being a source of some medicines.

Due to spreading fibrous roots, grasses act as major source of soil binders and stabilizers and by their growth check the soil erosion in hills and sand dunes. Dicanthium annulatum, Imperata cylindrica and Elusine indica act as true guardian of soil. Many grasses (Erianthus ravennae, Imperata cylindrica, Saccharum spontaneum, S. procerum, Themeda arundinae, etc.) are highly valuable as thatch grasses for temporary roofs of huts. Some others are grown as turf grasses for covering of playing surfaces in many sports. Thus the family has immense economic importance. Phragmites australis (common reed) is important in water treatment, wetland habitat preservation and land reclamation. Many grasses such as Phalaris minor, Lolium temulentum, Echinochloa colona, Dactylenium aegyptium and Setaria sp. are obnoxious weeds. A few grasses absorb Selenium and other harmful substances from
soil. Maize is model plant material for the cytogenetical phenomena. Presently genomics analysis is also being done in rice and maize.

1.3 Distribution:
In India, with varied environmental conditions ranging from tropical, temperate and alpine areas including cold and hot deserts, the grasses are well represented in all the areas where vegetation can grow. Some of these can flourish in freshwater and as amphibious (Phragmites sp., Saccharum sp.). These have been recorded in marshes, deserts, woodlands, in rocks, sand, fertile and saline soils, etc.

1.4 Systematics:
Earlier the Poaceae was thought to be related to Cyperaceae, but recent studies show that the similarities are more of convergent nature (GPWG 2001a). Hutchinson (1934) and Cronquist (1968) considered the origin of both Poaceae and Cyperaceae from Juncaceous stock. However, Stebbins (1987) considered the resemblance between Poaceae and Cyperaceae as superficial, the view supported by many other workers (Christine et al. 1996). Sedges and grasses differ radically in the structure of culm, spikelet and flower. Among the monocots, the family is considered highly advanced phylogenetically by many workers (Cronquist 1968; Thorne 1968). Earlier classification of grasses is primarily based on inflorescence and spikelet characters. Later on many more characters such as chromosome numbers and size (Avidulov 1931; Stebbins 1956; Mehra 1982), embryo structure (Reeder 1962), persistant nuclei (Brown & Emery 1957), leaf anatomy (Brown 1958), physiology (Al-Aish & Brown 1958), geographical distribution (Hartly & Williams 1956), besides protein, carbohydrates, essential oil, first leaf morphology, etc. were taken into consideration. Individually these characters are not that important, but collectively have greater significance in deriving phylogenetic relationship. With the advent of computer technology and Bioinformatics, it was possible to use more and more data collectively. With the advancement of gene and molecular studies, genetic markers were extensively employed for phylogenetic studies. All these molecular characters still play only supporting role to morphological, anatomical and cytological studies. Among the grasses, Bamboos are considered to be the most primitive (Prat 1936).

Due to large size and lot of variabilities in spikelet characters, the family is divided into many groups such as sub-families, tribes, sub-tribes, etc. Adanson (1763)
first of all divided the family into several sections which was followed by Brown (1814) who divided it into two sub-families, Paniceae (equivalent to present sub-family Panicoideae) and Poaceae (equivalent to sub-family Festucoideae), on the basis of spikelet characters such as spikelet compression, articulation and floret number and further pointed out that there is tendency of Panicoides to grow in warm climate and Poroïds in cooler climate. The classification was followed by many later workers including Bentham and Hooker (1862-1883) with 9-10 tribes (Gould & Shaw 1983; Campbell 1985).

Earliest significant work in division of family is by Brown (1915) who on the basis of spikelet characters, divided it into two groups Pooideae and Panicoideae. Later on many workers divided into more and more sub-families using large number of morphological, anatomical and biochemical parameters. Besides, molecular markers (Guedes & Dupny 1976) were used for further classification and to derive evolutionary trends. Taking all these characters into consideration, many classification were given in the 20th century (Caro 1982; Clayton & Renvoize 1986; Tzvelev 1989; Watson & Dallwitz 1992; GPWG 2001b, etc.) dividing the family into many subfamilies (up to 13) and many tribes (up to 59). Some of these grasses are given below.

1. Roshevits (1946) into three sub-families:
   Bambusoideae, Pooideae and Panicoideae.
2. Tateoka (1957)- 5 sub-families:
   Pharoideae, Pooideae, Arundoideae, Eragrostoideae and Panicoideae.
3. Prat (1960)- 6 sub-families:
   Bambusoideae, Oryzoideae, Festueoideae, Phragmitiformes, Chloridoideae and Panicoideae
4. Caro (1982)- 13 sub-families:
   Bambusoideae, Olyroideae, Anomochlooidae, Streptoechaetoideae, Oryzoideae, Ehrhartoideae, Centhosteeoideae, Festueoideae, Phragmiteoideae, Mierairoideae, Aristidoideae, Eragrostoideae and Panicoideae.
5. Clayton and Renoize (1986)- 6 sub-families:
   Bambusoideae, Centotheeoideae, Pooideae, Arundinoideae, Chloridoideae and Panicoideae.
6. Tzvelev (1989)- 2 sub-families:
Bambusoideae (14 tribes) and Pooideae (27 tribes)

7. Watson and Dallwitz (1992)- 5 sub-families:
   Bambusoideae, Pooideae, Arundinoideae, Chloridoideae and Panicoideae.

8. GPWG (2001)- 12 sub-families:
   Bambusoideae, Anomoechlooideae, Pharoideae, Pueliodeae, Ehrhartoideae, Centothreoideae, Pooideae, Arundinoideae, Chloridoideae and Panicoideae.

Thus, there is tremendous instability in the grass classification as reflected by inconsistencies in the trend of sub-family recognition. Different workers have reported different numbers of species in the family: 300 genera and 3000 species from British India by Hooker (1897); 500 genera and 4000 species by Rendle (1925); 650 genera and 7000 species by Hitchcock (1950); 620 genera and 10,000 by Airy Shaw (1973); 10,000 species in 793 genera by Watson and Dallwitz (1994); 898 genera and 10,300 species by Tzvelev (1989); 737 genera and 7,950 species by Roy (1984); 7000 genera and 11,000 species by Chen et al. (2006).


1.5 Area surveyed:

   Present study is focused on the wild grasses of North-West and Central India.

1.5.1 NORTH INDIA (Himachal Pradesh):

   Himachal Pradesh

   The state is located between 31°10’-33°57’N and 76° 46’-79°E in the Western Himalayas, covering an area of 55,673 km. It is a mountainous state with elevation ranging from about 350 -7,000 m above the mean sea level. The Spiti subdivision of Lahaul-Spiti district, parts of Chamba and Kinnaur areas are considered as cold deserts. The mean annual temperature is 13°C and the annual rainfall average is
about 250 mm. In this zone, snow fall is a common occurrence. The vegetation of this cold desert region can be classified into two broad types:-

(i) **Temperate (2400-3500 m):** This type of vegetation is confined to Lahaul valley, which is characterized by the presence of trees of blue pine (*Pinus wallichiana*), junipers (*Juniperus recurva*), birch (*Betula utilis*), spruce (*Picea smithiana*), deodar (*Cedrus deodara*) and cyper (*Cupressus torulosa*). Besides, some common trees (*Juglans regia, Prunus armeniaca, Populus caspica, P. ciliarta*, and *P. euphratica, Salix spp.*), shrubby vegetation (*Ephedra gerardiana, Hippophae spp., Sorbaria tomentosa*) are also found. The herbaceous species include *Anemone spp., Cnicus verutum, Codonopsis ovata, Fumaria indica, Galium aparine, Gaultheria trichophylla, Geranium pratense, Inula grandiflora, Lotus corniculatus, Podophyllum hexandrum, Primula denticulate, Ranunculus laetus, Rheum webbianum, Rubus saxatilis, Silene vulgaris, Thalictrum foetidum*, etc. The prominent species of grasses and sedges include, *Agrostis gigantean, A. stolonifera, A. vinealis, Alopecurus arundinaceus, Bromus japonicas, B. oxyodon, Calamagrostis pseudophragmites, C. pulchella, Carex melanantha, Dactylis glomerata, Elymus nutans, Festuca rubra, F. valesiaca, Kobresia royleana, Melica persica, Pennisetum lanatum, Phleum alpinum, Poa bulbosa, P. sterilis, P. supina, Polypogon monspeliensis and Stipa jacquemontii.*

(ii) **Alpine (>3500 m):** Vegetation of the alpine zone usually thrives in short, cold and unpredictable growing season, snowy fierce winds and extensively variable temperature. The vegetation is mainly composed of perennial herbs and prostrate shrubs which survive in extreme variation in temperature including months buried under several feet of snow. The alpine vegetation can be subdivided into two broad groups: (a) alpine forests and scrubs, (b) alpine meadows.

The alpine forests and scrub vegetation (up to 3600 m) is represented by scattered trees of *Betula utilis, Salix spp.* and *Rhododendron campanulatum*. The shrubby and herbaceous elements are same as that are in temperate vegetation. The trees are generally seen on rocks and ridges as pure stands of *Salix spp.* along the Chandra River up to Chhatru (3360 m). The vegetation of the area thrives in shady depressions and along streams formed by snow melt waters. The shrubby species include, dwarf junipers (*Juniperus communis, J. indica, J. recurva, Rhododendron*
campanulatum, Berberis jaeschkeana, Cassiope fastigiata, Cotoneaster falconeri, Gaultheria trichophylla, Rosa webbiana and Salix flagellaris. The herbaceous plants are represented by Potentilla atrisanguinea, P. atrisanguinea and the species of Bupleurum, Epilobium, Erigeron, Gentiana, Geranium, etc.

Mostly perennial herbs are found under alpine meadows zone, which include; Aconitum violaceum, Adonis aestivalis, Anemone rupicola, Androsace sempervivoides, Arabidopsis himalaica, Aster flaccidus, Astragalus munroi, Barbarea vulgaris, Capsella bursa-pastoris, Corydalis meifolia, Delphinium brunonianum, Dracocephalum heterophyllum, Potentilla atrisanguinea, Rheum spiciforme, etc. The grasses and sedges are also common in the alpine meadows and the prominent among these are, Bromus gracillimus, B. inermis, Carex cruenta, Dactylis glomerata, Elymus nutans, Festuca kashmiriana, F. valesiaca, Pennisetum lanatum, Phleum alpinum, Poa alpina, P. tibetica, Triisetum spicatum, etc.

1.5.2 NORTH-WEST INDIA: (Punjab, Haryana and Rajasthan)

1.5.2.1 Punjab and Haryana:

The Punjab state lies between 29˚30’N- 32˚32’N latitude and 75˚55’E-76˚50’ E and covers an area of 50,362 sq. km which is about 1.6% of the total area of India. More than 95% of the total area of Punjab is a flat plain, varying between 200 and 250m. The state of Haryana lies between 74˚27´- 77˚36´E longitude and 27˚39´- 30˚- 55˚N latitude and covers an area of 44, 212 sq. km. It has diversified topographical range from alluvial plains in the central part to the Shiwalik range in the North East.

In general the soil of Punjab and Haryana is characterized as alluvial with huge beds of clay, sand and gravel. In sub-mountain tracts the alluvial soil consists of more sand and gravel then clay or loam. In Bathinda, district and the adjoining areas of Punjab and Haryana the sandy soil and shifting sand dunes due to the active wind erosion, mark the soil scene. In Punjab on the fringes of Ferozepur and Faridkot districts Bangar soil is found. Kallar soil is common in Sangrur district and Ambala and Kurukshetra districts of Punjab and Haryana, respectively. In the remaining area of these states the soil is fertile loamy.

The climate is typically of semi-arid monsoon type. This region is characterized by deficient rainfall experiencing long rigorous summers as well as
moderate to severe cold winters with interspersed pleasant spring and autumn season. About 75% of the rainfall is recorded during the monsoon season. Extremity of temperature in winter and summer prevails in the states. The temperature is ranging from 38˚C - 46˚C in summers to normally below 20˚C in the winters.

The hilly tracts of this region are characterized by thorny scrub type of vegetation. *Acacia catechu* (Khair) and *Dalbergia sisoo* (Sissoo) forests are common in the foot hills. Other tree species like *Acacia modesta*, *A. nilotica*, *Bombax malabaricum* and *Emblica officinalis* are also found in this region. Often seasonal vegetation grows in abundance after monsoon. The plains of this region support tropical dry deciduous vegetation. The landscape is characterized by two common trees named *Dalbergia sisoo* and *Acacia nilotica*. It is not curious sight to see trees of *Ficus bengalensis*, *F. religiosa*, *Albizia labbeck*, *Mangifera indica*, *Melica spp.*, *Azadirachta indica*, *Morus alba*, etc. growing along roads in a wild vegetation. *Eucalyptus* plantations are quite frequent. In the West Southern portion of these states, there is increase in the number of spiny (thorny) species. In waste lands along road sides, *Prosopis* spp., *Zizyphus nummularia*, *Adhatoda vasica*, etc are quite common. In the sandy places where the water holding capacity of the soil is very low, the species of *Acacia nilotica*, *Adhatoda vasica*, *Cyprus* sp. and *Zizyphus nummularia* are quite common. On the basis of physical factors such as temperature, soil types, availability of water, atmospheric humidity, etc. following type of grasses are available in the presently studied area.

(i) **Grasses of water**: The main species of grasses which grow in stagnant or running water are *Echinochloa* spp., *Eragrostis atrovirens*, *Hemarthria pcompressa*, *Leersia hexandra*, *Oryza rufipogon*, *Panicum paludosum*, *Paspalum paspaloides*, *P. scrobiculatum* and perennial grasses like *Arundo donax*, *Phragmites karka*, *Saccharum bengalense*, *S. spontaneum* and *Vetiveria zizanoides* are very conspicuous along the edges of water streams. The other grasses occurring water logged conditions are *Dichanthium annulatum*, *Hetropogon contortus*, *Lasiurus scindicus*, *Leersia hexandra*, *Seteria glauca*, *S. pumila*, etc.

(ii) **Grasses of bushes and hedges**: Certain species of grasses, namely, *Digitaria ciliaris*, *Apluda mutica*, *Cenchrus ciliaris*, *Chloris dolichostachya*, *Lagasca* spp., *Panicum antidontale*, *Setaria verticillata*, etc. are some of the important ones.
(iii) **Wall grasses:** The grasses like *Aristida tunicate*, *Chloris virgata*, *Dactyloctenium aegyptium*, *Eragrostis minor*, *Tragus roxburghii*, etc. grow on walls.

(iv) **Grasses of Sandy soils:** The sandy soils are very poor in retaining the water. However in such habitats species of grasses like *Aristida adscensionis*, *A. mutabilis*, *Cenchrus biflorus*, etc. can be seen.

(v) **Grasses of crops:** The kharif crops are grown in Punjab and Haryana in the months of April-June and harvested in October-November. The main grass species which grow in paddy fields are *Chloris montana*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Dinebra retroflexa*, *Acrachne racemosa*, *Laptochloa panacea*, *Echinochloa colona*, *E. stagnina*, *Polypogon monspliensis*, etc. In the Rabi crops, sown in the months of October-November and harvested in April-May; species of *Phalaris minor*, *Poa annua*, *Polypogon monspliensis*, *Rostraria cristata*, *R. pumila*, *Alopecurus nepalensis*, etc. are common.

### 1.5.2.2 Rajasthan:

It occupies an area of 342,239 sq. km. which imparts 10.41% of the total area of India. Soil is a mixture of several types such as: i) alluvial soil: found in the districts of Bharatpur, Alwar and Jaipur; ii) medium black: noticed in Kota and Bundi districts; iii) mixed red and black soil: in Bhilwada, Udaipur, Chittorgarh and Dungurpur districts; iv) grey and brown soils: in the west of Aravallis; v) desert soil: in Sriganganagar, Churu, Jaisalmer, Bikaner and Jodhpur; vi) rocky areas: in Jaisalmer, Barmer and Bikaner.

The climate of Rajasthan varies marginally depending on location but in general the summer season i.e. April to June the temperature rises above 40°C and below 15°C in winters. Humidity in the rainy season (July–September) varies between 55-70 %. There is great variability in the annual rainfall. In many parts there are unusual floods due to heavy rainfall.

Depending upon the area the main vegetation is xerophytic and can be classified as ‘scrub jungles’. The trees are commonly lacking, shrubs are the dominant perennials, most of which form thickets e.g. *Leptadenia pyrotechnica*, *Crotaleria burhia*, *Sericostoma pauciflorum* and *Zizyphus nummularia*. In the sandy areas: the vast sandy track which are distributed in the western and central plains are species of
Saccharum which provide suitable habitat for the growth of some annual grasses e.g. species of Eragrostis, Cenchrus, Aristida, Dactyloctenium, etc. Further, the species of Heteropogon contortus, Brachiaria ramosa, Chloris virgata, Tragus biflorus, Perotis indica, etc. are the other commonly occurring species of grasses. Majority of hills in Rajasthan are almost barren. Their permanent vegetation comprises of species of Digitaria, Cenchrus, Melanocenchrus, etc. The main species which grow in water are species of Arundo, Cenchrus, Dactyloctenium, Hemarthria, Imperata, Leersia, Paspalidium, Paspalum, Phragmites, Polypogon, Tragus, etc.

1.5.3 CENTRAL INDIA: (Madhya Pradesh)

Madhya Pradesh:

For Central India, the present study pertains to Pachmarhi forests and adjoining areas in the Satpura ranges. The Pachmarhi hills, which are commonly known as “Queen of Satpura Hills” are located at 22º28´N and 78º26´E in the Hoshangabad district of Madhya Pradesh state. The Pachmarhi town is surrounded by three peaks, Dhupgarh (1350m) on South-West, Mahadev (1320 m) on South and Chauragarh (1310 m) on South-East. Nearly, all localities from base town Pipriya (200m) to Dhupgarh (1350 m) within the radius of 40 km of Pachmarhi town were botanized from time to time. Temporary laboratory was set up at Pachmarhi town (1050 m).

The rocks of Pachmarhi hills, which belong to Dracheans and Gondwanas are composed of thick masses of coarse sand stone forming a plateau. Red and yellow clays mixed with gravel, predominate around Pachmarhi. Forest soils are rich in organic matter. Soil is shallow on steep slopes, while flat areas have thick layers of top soil. The Pachmarhi hills receive a heavy rainfall about 2020 mm/ annum.

The vegetation of Pachmarhi forests is found to be broad leaved trees. The forest type being tropical dry deciduous with Tectona grandis, Shorea robusta, Madhuca indica, Terminalia cranulata, Phyllanthes emblica, Mangifera indica, Eugenia jambolana, Diospyros spp. etc. The vegetation of Pachmarhi hills shows an intermixing of tropical and temperate elements of South India and the Himalayas, respectively. The gorges prove congenial habitat for various herbs and ferns. However, the exposed rocky slopes and the mountain tops support xerophytic vegetation. The grass vegetation is different in different areas. It is marked with
species of Apluda, Arthraxon, Arundinella, Bothriochoa, Brachiaria, Cenchrus, Cynodon, Acrachne, Chloris, Dactyloctenium, Digitaria, Eleusine, Eragrostis, Sporobolus, Chryosopogon, Tripon, Tetrapogon, Echinochloa, Melinis, Oplisments, Panicum, Pasplidium, Paspalum, Pennisetum, Rhynchelyctrum, Setaria, Andropogon, Dimeria, Eremopogon, Hemarthria, Heteropogon, Ischaemum, Narenga, Rottboellia, Saccharum, Sehima, Sorghum and Veteveria. Due to good amount of rainfall, the herbaceous elements grow luxuriantly during and after the rains.

1.6 Cytogenetic studies:

For the better survival, the premariam man recognized the need to become familiar with plants and their environment. The relative simple activity of identification and selection of the best useful plants for cultivation marked the beginning of plant breeding. Modern plant breeders depend on a variety of simple as well as complicated techniques like hybridization, mutation and genetic engineering for improvement of plants. Most of these techniques and their outcomes can best be understood by thorough understanding of cytological and genetical principles operative in the plant or related plants. Thus, the chromosomal studies have emerged as the most modern method for studying the relationships and barriers between taxa at or above species level.

Keeping in view the importance of cytological studies cytological sampling of the flora has been taken up by various workers beginning with the last decade of 19th century. The significance of chromosomal data and meiotic course in systematic, deriving phylogenetic relationships and evolutionary trends, reproductive behavior and plant improvement through hybridization is well documented and emphasized by many workers (Stebbins 1958, Semple et al. 1989).

High variation in chromosome numbers (2n=10 in Coix to 2n=266 in Poa sp.), variation in basic chromosome numbers (x=2-14, 18), high incidence of polyploidy (80%) and aneuploid cytotypes, frequent hybridization, existence of apomixis in many taxa, wide range of variation in genomic size 2C DNA content of 0.7pg in Chloris gayana to 27.6 in Lygeum sportum (Bennett et al. 1998) are prominent features of grasses which have greatly imprecise the evolutionary tendencies in the family.
The wide range in basic chromosome number \((x=2–18)\) and prevalence of polyploidy and hybridization have resulted in chromosomal evolution in Poaceae (Hilu 2004). Apomixis is considered to be a short term solution to hybrid sterility and an evolutionary dead end. The Poaceae is one among the three families (other being Asteraceae and Rosaceae) which cover more than 75% of confirmed apomictic angiosperms (Carneiro et al. 2004). Poaceae forms the largest record by having 62 genera with 110 genera of monocots showing apomictic behaviour (Czapik 1994). Some of the important genera in which apomixis is common are *Paspalum, Poa, Panicum, Calamagrostis, Eragrostis, Pennisetum*, etc.

1.7 Aims and objectives:

Lot of cytological studies have been made on grasses from Punjab plains, temperate Himalayas and South India. However, Central India, hot deserts of Rajasthan and cold deserts of Lahaul-Spiti, there are few sporadic reports on the cytology of grasses. Thus keeping in view the existence of many cytogenetical phenomena, economic and evolutionary significance, coupled with lack of cytological work on certain areas, the present work on “Cytomorphological Diversity in Grasses from North-West and Central India” is taken up with following aims and objectives-

1) To carry, extensive and intensive plant surveys of grass species on population basis covering different climatic and altitudinal zones of North, West and Central India.

2) To investigate the chromosome numbers, course of meiosis, microsporogenesis and pollen fertility in all the species.

3) To collect the information on flowering and fruiting period.

4) To carry out the detailed cytological analysis of the species with intraspecific morphological/ chromosomal diversity to know the nature of variation.