Chapter - I
Introduction
INTRODUCTION

Maize (Zea mays L.) is one of the important economic grain crop as also an ideal cereal forage crop because of its quick growing, high yielding, palatable and nutritious qualities. It is used as fodder at various stage of plant growth, particularly from tasselling onward. The maize plant does not have problems of prussic acid or hydro cyanic acid and therefore it can be used as fodder even before flowering or even in dry weather. Maize with ears at the dough stage is best for use as fodder. It surpasses all other crops used as fodder in dry matter production and digestible nutrients per hectare. Stover left after the harvest of the grain is also used as fodder, particularly if stay- green type varieties are used where stalks and leaves are still green at harvest time.

About 40% of maize produced in many countries is used as animal feed. Maize gives the highest conversion ratio to meat, milk and eggs as compared to other grains used as livestock feed. Its high starch and low fiber content makes it a highly concentrated source of energy for livestock production. Precise statistics on the use of maize for various livestock and poultry feed are not available. However, it is believed a greater portion is used as poultry feed in tropical countries. Yellow maize is preferred for livestock feed. It is fed as whole grains, cracked or coarse ground, dry or wet or steamed and usually supplemented with other protein and vitamins sources. It is expected that the use of maize in formulated feed for poultry will increase rapidly in the future.

Quite often, maize is grown as a multi-purpose crop for food fodder and feed, and various parts of the plant are used as fodder. Maize grain is an important cereal for human consumption, particularly in Asian countries. There is no doubt that the demand for maize as feed will continue to increase in the future at a very fast rate. In this respect, as per the FAO reports the
demand for feed will increase from the present level of 105 mt to almost 400 mt in 2030, corresponding to a 295 mt increase (240%). It is a big challenge to produce these additional 295 mt that will be needed in 2030 for human consumption and animal feed.

Maize is the third most cultivated cereal after wheat and rice in the world. The maize is sown in almost all the states in the country and it occupied fourth position area wise (6.59 mha) next to rice, wheat and sorghum but third in production. Demand for maize is going up in India with the increase in demand for animal feed. At present about 35% of the maize produced in the country is used for human consumption, 25% each in poultry and cattle feed and 15% in food processing and other industries (mainly dextrose, corn syrup, corn oil etc.). The present production of maize in India is only 10.16 mt and the annual demand is going up by about 4 lakh tonnes. The average yield in India is only 1.7 t/ha against a world average of 3.83 t/ha.

Maize is widely adopted in different environments. It is cultivated in tropics, sub-tropics and the temperate region of both the northern and the southern hemisphere. Maize is grown at varying elevations, as high as 3800 m above sea level and performs amazingly well under varying photo-period, rainfall, temperature and soil condition (Vasal and Taba, 1988). Another important feature is that the crop can be grown successfully during summer where irrigation is available.

The stover (entire dry plant) of maize has a crude protein content of about 7% (on dry matter basis) and has relatively poor feeding value during the later stages of growth. On the other hand, the feeding value of developing cob increases rapidly. It consists largely of easily digestible carbohydrates together with a rather higher crude protein content and about half the crude fiber content of the stover. Thus, unlike most fodder crops, as the maize crop matures the increasing contribution made by the ears results in improved feeding value. Steinhofel (2000) reported that the highest fodder energy value was reached when the translocation of starch into the maize kernel was furnished, but the water content of the rest of the plant was still high.

With the increasing accent on animal production including poultry, the demand for maize is expected to increase substantially. Hence, considering the demand projection, there is an ample scope for local consumption
provided maize production is enhanced in the region. Maize for fodder is generally ensiled and it is perhaps the best crop for making silage. It can also be fed green or grazed. The stover of maize grown for grain can be used for dry season grazing. Harvesting for ensilage is done generally at the milk or dough-ripe stages of grain maturity, for this the whole plant is harvested and chopped either by machine or hand. Maize silage provides excellent fodder for fattening cattle and milk cows. It should be supplemented, however, in these cases with a high protein feed. Alternatively, the cobs may be harvested for commercial use and remaining plants can be grazed as green stover, and/or ensilaged.

Amongst the forage crops maize is known to be adaptive to a range of soil moisture regimes, day length and temperature. The genetic improvement in forage maize, however, could not make headway and the gap still remain to be filled up through development of improved forage varieties in this crop. Systematic information on the extent of genetic diversity in existing forage maize germplasm, behavior of forage yield components, classification and its consistency of performance over the environments is scanty or hardly available. The present study is expected to generate such information.

Origin of maize and its genetic relationship with other taxa

Maize (Zea mays L.) is widely grown throughout the world today. Wilkes and Goodman, (1996) characterize maize as having “a passport without a birth certificate” because its parentage is still shrouded in mystery. Maize has been in cultivation for several thousand years in Mexico as indicated by unearthed grains and parts of ears reported from caves and rock-shelters supported by archeological excavations in New Mexico (Berger, 1962). The oldest archeological remains of maize, excavated in the valley of Tchuacan in southern Mexico, suddenly appeared in the archaeological records around 5000 B.C. (Flannery and MacNeish, 1997). Maize is said to be originated in Latin America, where maximum genetic diversity in Zea and their wild relatives exist (Margelsdorf, 1974; Hallauer and Miranda, 1981). It was the only cereal systematically cultivated by the Red Indians although some other grains were harvested from the wild. Columbus found corn being
cultivated in Haiti, where it was called *Mahiz* and from this Indian word, the name ‘maize’ was derived that is used in Europe to distinguish the cereal from other grains, which are called corn.

Based on several studies (isozyme pattern), least genetic distance was observed between maize and teosinte. The hierarchical order of Maydeae is maize > teosinte > coix > trilobanche > chionachne (Sachan and Singh, 2001). Distribution of C and Q bands in constitutive heterochromatin in maize and teosinte were terminal as well as sub-terminal and comparable to each other. Chromosome banding patterns of maize and teosinte showed reciprocal introgression of c-heterochromatin. Palynological study based on pollen exine surface indicates similarity among three species of *Teosinte* and *Zea*. Based on chiasma frequency following relationship has been deduced *Z. diploperennis* > *Z. luxurians* > *Z. parviglumis* > *Z. mays* (Sachan and Singh, 2001).

**Taxonomy**

Maize (*Zea mays* L.) belongs to the grass family, Poaceae (syn. Gramineae), subfamily, Panicoideae, which includes the majority of grasses in tropical and sub-tropical regions throughout the world. Whereas most grasses have perfect flowers, maize and its wild relatives, *Teosinte* and *Tripsacum*, are monoecious, i.e. they have separate staminate and pistillate flowers on the same plant, and this was the reason maize and its relatives were once grouped into a separate taxonomic tribe the *Maydeae* (syn. *Tripsaceae*). Stebbins and Crampton (1961) revised this classification and placed *Zea* and *Tripsacum* in the *Andropogoneae*. Other members of the *Andropogoneae* endemic to the New World are mainly *Coix*, *Trilobanche*, *Polytoca*, *Schleracne*, *Chionacne*, as well as the important economic grasses sugar cane and sorghum (Kellogg, 1998).

A maize plant is a tall, leafy structure with a fibrous root system, supporting usually a single main culm with many leaves. One or sometimes two lateral branches in the leaf axils in the upper part of the plant develop more prominently. These are terminated by a female inflorescence, which develop into an ear (cob) well covered by husk leaves. This is the food
storage part of the plant. The plant is terminated by a male inflorescence, the tassel. It has a prominent central spike and several lateral branches with male flowers, all of which produce abundant pollen grains. Maize is a monoecious plant. It develops inflorescence with unisexual flowers that are always borne in separate parts of the plant. Maize is one of the few food plants that is diploid with a basic set of ten chromosome or 2n= 20.

**Genetic variability and adaptability of maize**

Genetic diversity has played an immense role in evolution and domestication of any crop. Genetic variability constitutes the invaluable asset to meet the growing need to increase the production and productivity. Enormous diversity occurs in India for maize. The richness of this diversity is more in the tribal dominated areas where subsistence farming is being practiced. Area such as Himalayan region, northeastern part and peninsular India is rich in genetic diversity for maize and ethnic communities here are custodians of genetic resources. A wide array of maize germplasm occurs in India particularly in Northeastern Himalayan region, Himachal Pradesh and Jammu & Kashmir.

Although maize is reported to have originated in Latin America, it has attained widespread geographical distribution. This might be due to gradual evolution of new genotypes because of its cross-pollinated nature. The free intercrossing among genotypes has produced a wide diversity of genetic recombinants. Though natural selection thereof may have become adapted to the new agro-ecological niches through a gradual process of acclimatization. Maize is also known to have many races, the natural hybridization between these races as well as contribution of traits from near relatives such as *Teosinte, Tripsacum, Coix* etc. may have contributed significantly to the present array of genetic diversity in maize.

India is considered as secondary center of origin for maize. Substantial genetic diversity occurs in accessions collected from different agro-climatic zones. Gradual natural as well as selective hybridization and introduction of exotic germplasm has considerably enriched the genetic diversity of maize. This is the reason of wide adaptation of maize ranging from arid-climate of
Rajasthan to humid tropics of Northeastern India and also from mid sea level zone to higher altitude of Himalayan, Aravali and Nilgiri hills.

**Preliminary work done on the line**

Most of the research work has been carried out in India and abroad on the grains aspect of maize crop. Hence, no attempts have been made so far in India for classifying genetic materials of forage maize. Although maize is being used since a long time as a dual-purpose crop, however, forage based collection, evaluation and documentation of maize germplasm has not been done as yet. It was felt that there is need to make a systematic attempt for collection, assessment land categorization.

At IGFRI, Jhansi efforts have been made to collect the available genetic diversity from different eco-geographical parts of the country through a series of exploration programmes. It was in this context that 1571 local maize cultivars were collected under a scheme in 1969 sponsored and financed by the ICAR. The entire collection was classified into 15 races and 3 sub-races ranging from primitive to advanced types. The genetic diversity is being maintained at IGFRI as well as at National Gene Bank, NBPGR, New Delhi.

Collection and evaluation of available wide gene pool of forage maize is very important for developing suitable cultivars. It is imperative to have a clear cut idea about the correlation of different characters and their contribution to green and dry forage yield for its further genetic improvement programme.
Keeping in view, importance of the crop and the meager availability of genetic information pertaining to the genetic diversity, association and phenotypic stability in forage maize, the present investigation was conducted with the following objectives:

- To study the extent of variability present in the available germplasm for yield and yield contributing characters and their relative importance.

- To measure genetic divergence between strains of the different geographical origin.

- To study the relationship between yield and yield contributing traits, the relationship among themselves and their direct and indirect effects on yield.

- To identify the differential response of various accessions over different environments and to find out stable accessions.