REVIEW OF LITERATURE
II. REVIEW OF LITERATURE

2.1 Description and classification of maize

The term “maize” was derived from Spanish word Taino, meaning mahiz for plant. Maize or corn (Zea mays) is the principal cereal crop cultivated in tropical and subtropical countries of the world. Maize is a crop of high economic value. The grains are used as human food, fermented to produce different food and beverages, fed to livestock & poultry and used as raw material for production of starch, oil, sugar, cellulose, ethanol, extraction of syrup, and transformation into plastics and fabrics. Leaves, stalks and tassels can also be fed to livestock either as green or as silage and dried as stover. The roots can be used for mulching to improve physical structure of soil.

Selection of maize by breeders have led to development of major grain types, which differed widely in grain shape, size, color, hardness, taste, ease of processing and storage quality. The international market grain types are characterized by hardness and color. Approximately 85 per cent of the global maize crop consists of yellow grain, 10-12 per cent white grain and the rest red, blue, purple or black. On the basis of endosperm of kernels, Sewa Ram and Mishra (2010) classified maize as,

(i) **Flint corn** (Zea mays indurata Sturt): The soft and starchy portion of the endosperm is protected by a hard outer layer. This is early maturing, white or yellow colored and able to germinate in both cold and wet soils. It is the principal type of maize grown in India. Flint corn is excellent for breakfast cereals and snack foods.
(ii) **High endosperm food grade corn:** This is hybrid corn with dry milling or alkaline cooking properties, and is used for snack foods, breakfast cereals, tortillas, etc.

- **High amylose corn:** It produces larger volume of amylose starch and is used for special purposes, such as quick-setting confectionery gums (jelly beans) and certain glues.

- **High oil corn:** Has high oil content and used for livestock feed.

- **High starch corn:** In this type, limited hybrids are available currently. But they are the boon for industrial applications such as for ethanol and biodegradable plastics.

- **Improved high-lysine corn:** This corn contains high levels of lysine, hence it is good for livestock.

- **Floury maize:** This maize lacks the hard or vitreous kernels. While drying, the endosperm uniformly shrinks and results in no denting on the kernel.

- **Dent corn (Zea mays indentata):** It is a cross between floury and flint maize. The rapid drying and shrinkage of soft starch in the kernel leads to formation of dent or depression in the crown of seed, especially on the top of kernel, and is having yellow or white color. The dent results from collapse of the protein matrix structure in the floury endosperm region, which is generally in the centre of the kernel. It is a common corn cultivated in the USA.

- **Pop corn (Zea mays averta):** The corn has a smaller sized kernel with hard endosperm. The grain is mainly used as pop-corn confectioneries for human consumption.
Flour or Soft corn (Zea mays amylacea): Corn with soft endosperm, kernels are found in various colors, but white and blue are most common. They are like fruit kernels in shape. It is widely grown in the USA and South Africa.

Sweet corn (Zea mays saccharata var. rugosa): Sweet corn is sweet and tender with a creamy texture, low starch content and a pleasant aroma. This is also known as Indian corn, sugar corn or pole corn. The crop is grown in Northern half of the USA and Canada.

Pod corn (Zea mays tunicata): Each kernel is enclosed in pod or husk in an ear which is enclosed in husks like other types of corn. It is a primitive type of corn not grown commercially.

Waxy corn (Zea mays ceretina Kulesh): This contains mainly amylopectin (78 %) and less of amylose (22 %). This being similar to tapioca, has replaced tapioca in its usage not only as food products, but also in textile, adhesive, corrugating and paper industry. Nebraska is one of the white (or waxy) corn producing states in the USA.

Genetically modified maize (corn): These are deliberately, genetically modified according to the desirable agronomic practices. The traits which are engineered into corn include resistance to herbicides and to insect pests (by incorporation of a gene that codes for Bacillus thuringiensis (Bt) toxin) (Feschotte and Pritham, 2009).

Quality protein maize (QPM): In the normal maize genotypes, endosperm proteins contain about 50-70 per cent of zein, which has more of glutamine,
leucine and proline. Zeins are essentially devoid of lysine and tryptophan. Studies in Purdue University, USA, led to the discovery a mutation designated opaque-2 (o2), maize grain protein in the endosperm, which was nearly twice as nutritious as those found in normal maize. The enhanced opaque-2 is called quality protein maize (QPM). The QPM contains nearly twice the lysine and tryptophan, higher amounts of histidine, arginine, aspartic acid and glycine and lower amounts of glutamic acid, alanine and leucine.

2.2 Terms used with reference to maize

2.2.1 Stage of plant growth:

Some of the common terms used with reference to maize crop as explained by Zaidi and Singh (2005) are summarized below:

❖ **Seedling emergence**: Period from planting to seedling emergence. In general, maize seedling emergence takes 5-6 days at an average temperature of 21°C.

❖ **Early vegetative stage**: Shortly after emergence, early part of life cycle, including initiation and differentiation of vegetative and reproductive primodia in the apical meristem and cell enlargement.

❖ **Late vegetative and flowering stage**: Late vegetative stage refers to later part of life cycle prior to flowering. Flowering stage includes tasseling, silking and pollination.

❖ **Blister stage** (71 days): Kernels are filled with clear fluid and the embryo can be seen.

❖ **Milk stage** (80 days): Kernels are filled with a white, milky fluid.
- **Dough stage** (90 days): Kernels are filled with a white paste and the embryo is about half as wide as the kernel. The top part of the kernels is filled with solid starch.

- **Dent stage** (102 days): If the genotype is a dent type, the grains are dented. The 'milk line' is close to the base when the kernel is viewed from the side in both flint and dent types.

- **Physiological maturity** (112 days): The black layer is visible at the base of the grain. Grain moisture is usually about 35 per cent (Gangaiah, 2010). With new cultivars, physiological maturity is achievable as early as 90 days depending on the variety.

  The time of physiological maturity is defined for a particular genotype. Once the physiological maturity is achieved, no further gain in dry matter is possible; kernel starts losing moisture and proceeds towards maturity or drying. Rate of kernel drying is found to be significantly correlated with prevailing climatic conditions, particularly with vapour pressure deficit.

### 2.2.2 Maize fodder and byproducts

- **Green fodder**: As a green fodder, maize crop is designated by different terms reflecting their phenological development stages, such as, tassel stage, blister stage, milk stage, dough stage etc.

- **Stover**: Stover is the field residues after removal of ear or grains, of large cereal crops, such as maize and sorghum. This generally includes stalk and leaf. This can be green, usually soon after grain harvest, with high moisture content or it may be dry.
Stover is similar to straw, but straw is generally referred to the dry stalk/stems and leaves of small cereals after the grain and chaff have been removed.

- **Chaff**: is husk and glumes of seeds removed during threshing. Generally a harvester delivers straw and chaff together (FAO, 2000a).

- **Stubble**: is the stump of reaped crop, left in the field after harvest. (FAO, 2000a).

- **Silage**: is the material produced by controlled fermentation of a crop of high moisture content. Ensiling is the preservation of a forage (or crop residue or by-product) based on a lactic acid (ideally) and acetic acid fermentation under anaerobic (no air) condition. The containers which are meant for making silage are called silos.

### 2.3 Conservation of maize stover

#### 2.3.1 Drying

Efficient use of maize stover for livestock feeding can be attained in several ways. In general maize growers prefer short, high grain yielding varieties, but such varieties yield less straw. The “stay green quality” of some maize cultivars, however not only helps to increase their grain yield but also provides a better stover for animal feeding (FAO, 1993).

Among all straws/stovers, maize stover has a higher nutrient content, with about 6 per cent crude protein (CP). The traditional storage and utilization systems are not effective. The small changes in agronomic practices, at the time of harvest and immediately after harvest can be more effective for straw yield (or recovery) and quality. For example, stooking of maize and sorghum allows final ripening of the grain after the
plant is cut. This provides stover of better feeding value than if the crop is allowed to mature standing (FAO, 2000b). Topps and Oliver (1993) estimated the contents of total digestible nutrients (TDN) and CP for the early cut maize stover and late cut maize stover. The TDN (%) for the early cut and late cut stovers were respectively 45 and 40.3. Correspondingly, the CP (%) was 4 and 2.

Traditionally in the United States, maize stover has been harvested to feed beef cattle and non-lactating dairy animals for decades. Soon after mechanical harvesting of grains, 40-50 per cent of the dry matter (DM) of stover remains in the field in the form of leaves, stalks, husks and cobs. Corn stover is generally harvested as a dry product with less than 20 per cent moisture and packaged in large round or large square bales, typically involving as many as seven steps after grain harvesting (Shinners et al., 2007b). The conservation of maize stover in its dry form soon after harvest is difficult due to slow drying, short harvesting window, frequent weather delays, soil contamination, and low yield. The fraction of available stover harvested by conventional means ranged from 37 to 50 per cent (Shinners et al., 2007a) and too many field operations added to the cost of stover (Shinners et al., 2003). Harvesting wet stover immediately after grain harvest by combining shredding and windrow formation in one machine and then chopping the formed windrows with a forage harvester can eliminate the need for field drying and raking; and eliminate bale gathering, staging and loading. The fraction of available stover harvested with this system was 55 per cent (Shinners et al., 2007b).

In India, where ears are harvested manually, the standing stover is allowed to dry as much as possible, and the stover is manually harvested, tied in small bundles and
stacked in the field before it is taken for mass storage. In this system stover recovery is nearly 90 per cent unless damaged by bad weather due to intermittent rains. The stacking of dried stover is usually done on a foundation of stone or of bamboo poles or in small quantities on the roof of the house or other structures. In semi-arid areas, chaffed straw is tightly packed in stacks or heaps and protected with mud plaster (FAO, 2000a).

2.3.2 Drying versus ensiling

Harvesting and storing “wet” corn stover virtually eliminates the need for field drying. This allows stover harvesting soon after grain harvest. Harvesting wet stover by chopping with a forage harvester also eliminates bale gathering, staging and loading operations. Chopped or shredded wet stover can be stored in bunks, bags, or piles and preserved by fermentation. Losses of wet stover ensiled at 44 per cent moisture averaged 3.9 per cent of total DM with low production of typical forage fermentation products (Shinners et al., 2007b).

Moisture content is a major factor when considering alternative systems for storing and transporting biomass. Stover below 20 per cent moisture can be successfully stored in bales and aerobic piles (Shinners et al., 2007b; 2009a). Stover above 25 percent moisture must be stored anaerobically and preserved by fermentation or by the application of additives to rapidly drop the material pH to 4.0 – 4.5 (Shinners et al., 2009b).

A study (FAN Hua, 2002) was carried out to determine the changes in nutrient contents in corn straw in different conservation methods (open-air conservation, shed conservation, silage and ammoniation). The results showed that the CP, neutral detergent
fiber (NDF), Acid detergent fiber (ADF) and water soluble carbohydrates (WSC) content of corn straw were higher in silage and ammoniated straw when compared to open-air and shed conservation methods. The chemical compositions were significantly (P<0.01) affected by different conservation methods.

Losses of wet stover ensiled at 44% moisture averaged 3.9% with low levels of fermentation products. Dry stover losses were 3.3% and 18.1% for bales stored indoors and outdoors respectively, which is primarily due to leaching as a consequence of frequent precipitation (Shinners et al., 2007b). However, storing stover indoors requires more space and is most often not practicable under Indian farming scenario.

2.4 Chemical composition and nutritional value of maize stover and maize silage

2.4.1 Chemical composition and in vitro studies

Livesay et al. (1940) compared the chemical composition of three different silages such as whole crop normal silage (WCPNS) harvested at 75th day, ear silage (ES) harvested at 56 days and stover silage (SS) harvested at 126 days after the grain removal. For WCPNS, ES and SS respectively, the DM, CP fat, fiber, nitrogen free extract (NFE) and TDN (%) were 31.8, 42.9 and 26.5; 2.4, 3.3 and 1.7; 1.0, 1.7 and 0.6; 7.2, 5.0 and 9.1; 20.0, 31.9 and 13.5; and 21.7, 32.2 and 15.1. The results indicated that CP and TDN were lower in SS than in WCPNS and ES.

Johnson et al. (1984) evaluated maize silage (MS), high moisture maize stover silage (HMS), mature maize stover silage (SS) alone and with added molasses (SSM) for chemical composition. Water was added to the stover to achieve approximately 60%
moisture. The results indicated higher structural carbohydrates except hemicelluloses in HMS, SS and SSM than that found for MS. Molasses addition to maize stover at ensiling enhanced fermentation by reducing the pH of SSM compared to MS and HMS.

Hargreaves et al. (1984) reported the characteristics of corn silage (CS) and stalklage silage (SLS). The chemical analysis (%) of CS and SLS for DM, total nitrogen (TN), ADF, ADIN/N (percentage of total nitrogen as acid detergent nitrogen), ADIN/DM and IVDMI (in vitro dry matter disappearance) were 34.9 and 29.4; 1.48 and 0.86; 32.5 and 51.8; 7.0 and 20.4; 0.10 and 0.18; and 53.9 and 40.0; respectively.

Mader and Britton (1986) studied the differences in composition of corn silage (CS) and ensiled corn stover (ES) and showed a significant difference (P < 0.05) in CP (8.1 vs. 5.6), NDF (57.6 vs. 79.2), ADF (26.8 vs. 51.0), ADIN (Acid detergent insoluble nitrogen (8.0 vs. 18.1 % of N2) and IVDMD (71.2 vs. 48.5).

Hunt et al. (1993) evaluated two maize hybrids (pioneer 3377 and 3389) with similar total plant and grain yield characteristics for potential differences in nutritive value of the whole plant and stover (stalk, leaves and husk) silages. The values of CP, NDF, ADF, hemicelluloses, cellulose and lignin contents in two maize hybrids (3377 vs 3389) for whole plant silage (WPS) were 5.5 and 5.9; 42.7 and 48.1; 26.3 and 30.0; 16.2 and 18.2; 21.4 and 24.1; and 3.4 and 3.8 respectively. These values for stover silage (SS) were 4.4 and 3.9; 58.4 and 65.6; 37.7 and 42.7; 20.3 and 22.9; 31.7 and 35.6; and 4.2 and 4.7 respectively. The results indicated that the CP contents in WPS from the two hybrids were similar, but in SS, the CP content was significantly higher (P<0.05) in 3377 than in 3389 hybrid. The WPS of 3377 hybrid had lower (P<0.01) percentages of NDF, ADF,
hemicelluloses, cellulose and lignin when compared to 3389 hybrid. Similar differences, but of larger magnitude, were observed in SS. The ruminal in situ (24 h) incubation and two-stage IVDMD of WPS and SS were greater (P<0.01) for 3377 than for 3389 hybrid.

Idris et al. (1999) compared CP (%) and ME (MJ/kg) content of fresh green sweet corn stover harvested after 75 days with sweet corn stover silage. Ensiling was done in a plastic drum for a period of 30 days. The CP and ME of fresh sweet corn stover were 9.6 and 7.82 respectively. These values in the stover silage were 8.2 and 5.86.

Wang Shouyi (1999) reported a significant negative correlation between days after grain harvest and the sugar content (r=-0.989) and the number of green leaves (r=0.952) in stalks of sweet corn.

Ensiling green maize stover could lead to significant increase (P< 0.01) in the content of CP (25.51 %) and ash (9.04 %), but significant decrease (P< 0.01) in the content of NDF and ADF (16.37 and 23.66% respectively). Further, ensiling corn stover also improved significantly (P< 0.01) the DM (20.72), OM (16.91) and NDF (10.43), percent degradability. (Zhang Wenju, 2003).

Tang et al. (2008) compared the nutritive value of maize stover dry (MS) and maize stover silage (MSS). The DM, OM, CP, NDF and ADF (%) for MS and MSS were 89.3 and 88.7; 93.3 and 91.3; 5.53 and 7.5; 76.6 and 67.1; and 48.9 and 41.4 respectively. Further the cumulative gas production at 48 h (ml) and potential gas (D) (ml) production for MS and MSS were 26.8 and 29.9 and 32.7 and 39.6, respectively. The results showed that the maize stover silage is more nutritive than the maize stover.
Liu Gui-yao et al. (2009) conducted a study to compare the nutritional value of maize stover dry and four kinds of maize silages. The results showed that the DM, CP, EE, CF, NFE and NDS for maize stover and average of four maize silages were 90.5 and 19.8 to 26.8; 8.13 and 16.07 to 14.42; 6.41 and 7.8 to 8.0; 25.82 and 24.3 to 26.6; and 33.42 and 43.3 to 49.7 respectively. The results showed that the maize stover silage is more nutritive than the maize stover.

Idikut et al. (2009) compared nutritional characteristics of whole crop silage with stover silage of sweet corn hybrid and conventional corn hybrid. The results indicated that the pH of sweet corn whole crop silage (SCWCS), sweet corn stover silage (SCSS), conventional corn whole crop silage (CCWCS) and conventional corn stover silage (CCSS) were 3.72, 3.84, 3.74 and 3.76 respectively after 8 weeks of fermentation indicating satisfactory fermentation in stover silage. The CP and ME were significantly lower in stover silage compared to whole crop silage (P < 0.001). The CP (%) and ME (MJ/kg DM) in SCWCS, SCSS, CCWCS, and CCSS were 10.31 and 8.60; 9.14 and 6.91; 9.46 and 8.83; and 7.72 and 6.60 respectively. The in vitro gas production kinetic study was conducted and the values for k and D (ml) parameters in SCWCS, SCSS, CCWCS, and CCSS were 0.052 and 61.30; 0.038 and 49.55; and 0.042 and 69.20; and 0.036 and 47.70 respectively.

Since the studies conducted have revealed the possibilities of converting maize stover into silage, the general observation is that the nutritional quality of stover silage was inferior to that of whole crop maize silage. Therefore studies were conducted to
explore the possibilities of improving nutritional value of maize stover silage with additives.

Bareeb and McClure (1993) compared fermentation characteristics of untreated maize stover silage and urea treated (one per cent wet basis) stover silage subjected to 40 days of fermentation. The results revealed that, pH, lactic acid, acetic acid, butyric acid and total nitrogen levels were 4.09 vs 6.47; 7.75 vs 1.05; 1.28 vs 0.61; 0 vs 5.30 and 2.07 vs 18.07 percentages.

Tang et al., (2008) reported the effect of supplementing maize stover and stover silage with yeast and fibrolytic enzymes on in vitro digestibility. The in vitro DM and OM disappearance was evaluated when yeast was supplemented at the level of 5 g / kg, the greatest values of IVDMD occurred for maize stover (36.3 %; P<0.001) and maize stover silage (44.6 %; P<0.01). Yeast supplementation increased IVOMD of maize stover (P≤0.01). Fibrolytic enzymes increased IVDMD of maize stover, and maize stover silage (P≤0.01) at the level of 5 and 7.5g/kg. The results indicated that the application of fibrolytic enzyme preparation and yeast culture could improve in vitro gas production from fermentation of maize stover.

The influence of wilting on nutritive composition was determined for four different silage of corn stalk. The stalk were ensiled at the first, third, fifth, and seventh day after harvest. Although the pH and ammonia concentrations of silage were higher for stalk ensiled at the seventh day than first day, lactic acid, CP, NDF, and ADF content of silage had no consistent effect (Yu Ruhua et al., 2007a & b).
2.4.2 Feeding value of maize stover dry and maize stover silage

2.4.2.1 Hiefers and steers

Livesay et al. (1940) conducted a study in steers to compare normal maize silage – ears on (NS), stover silage - ears removed (SS) and ear silage (ES). Eight steers were used in each group. The coefficients of digestibility (%) of CP, fat, fiber and NFE in NS, SS and ES were 49.0, 37.0 and 54.0; 83.0, 71.0 and 80.0; 57.0, 62.0 and 34.0; and 74.0, 58.0 and 80.0 respectively. The results showed that the coefficients of digestibility of the various nutrients, with the exception of fibre, tended to be much higher in the ES than in the SS or NS. The digestibility of fibre in ear silage was lowest. This was expected because much of the fiber of the cob is lignified.

Muller et al. (1967) conducted a feeding trial of 75 days on 21 yearling heifers (7 in each group) assigned to one of the 3 treatments randomly, corn silage (CS), corn stalk silage (CSS) or corn stalk silage with 0.5 % urea (CSSU). Corn stalks were ensiled soon after harvesting grains. The DM (%), CP (%), pH and ammonia-N (mg/100ml) for CS, CSS and CSSU were 34.7, 37.3 and 40.9; 8.2, 5.7 and 8.0; 3.9, 4.3 and 4.8; and 70.9, 49.2 and 171.5; respectively. The DMI (kg/d) and daily gain (kg/d) for CS, CSS and CSSU were 7.0, 5.5 and 5.4; and 0.89, 0.47 and 0.50, respectively. The results indicated that there was no significant differences between CSS and CSSU treatments, but the animals fed with CS consumed more DM (P<0.05) and gained more weight (P<0.01). Further, it was concluded that, when requirements of other nutrients are met heifers consumed enough corn stalk silage as a sole source of fodder, to provide adequate energy for maintenance and approximately 0.5 kg of daily gain.
Colenbrander et al. (1971a) conducted a feeding trial with corn stover silage and corn stover silage supplemented with ammonium polyphosphate (APP), urea and APP + urea. The results showed the DMI of 19.30, 12.28, 18.15 and 16.41 kg per kg gain with average daily gains of 0.24, 0.42, 0.27 and 0.32 kg, respectively. The study indicated non-significant differences in DMI per kg gain and significantly (P<0.05) higher weight gain for corn stover supplemented with APP and APP+urea.

Colenbrander et al. (1971b) conducted an experiment on 28 yearling HF heifers randomly assigned to each of four corn stover silage rations containing 0.81, 0.92, 1.03 and 1.14 M cal estimated NE per kg of complete ration to determine the level of supplemental energy required to obtain the growth response recommended by NRC. The results showed a linear increase (P<0.01) in daily body weight gains of 0.34, 0.43, 0.58 and 0.68 kg respectively for the four rations. Further, the total DMI increased (P<0.01) with increase in estimated NE concentrations of the rations. It was concluded that the ENE content of 1.06 M cal per kg ration could produce better results.

With the availability of maize stover residues, use of maize stover as a source of feed for growing calves and replacement heifers has increased in recent years. Removing stalks from the field immediately after early harvest of maize (high moisture) allows highest quality stover to be obtained (Keys and Smith, 1984) and support favorable calf weight gains (Guyer et al., 1984).

Johnson et al. (1984) compared DMI from different silages in steers. The four silages were maize silage (MS), high moisture maize stover silage (HMS), maize stover silage (SS) and maize stover silage with molasses (MS). The DMI (g/ kg $^{0.75}$) for these
silages were respectively 78.9, 77.7, 77.9 and 79.6 and the difference was significant (P<0.01).

Russel (1985) reported a study on feeding trial in Angus-cross steers fed with stover (59.7 % DM) harvested and stored in silo bags (SS) and large bales of stover stored outdoors (BS). The digestion coefficients (P<0.05) were 75.5 and 75.9 per cent respectively for SS and BS fed groups. The ADG (kg/d; P<0.05) and feed to-gain ratios (P<0.05) of steers fed with SS and BS were 1.8 and 5.5; and 1.5 and 6.2, respectively. The steers fed with SS diets had a higher (P<0.05) marbling score than BS diets.

Madar and Britton (1986) reported that the DM (%), CP, NDF, ADF, ADICP (% CP) and IVDMD for corn silage (CS) and ensiled corn stover (ECS) were 34.9, 8.1, 57.6, 26.8, 8.0 and 71.2; and 57.3, 5.6, 79.2, 51.0, 18.1 and 48.5, respectively. The intake study was also conducted to study the performance of steers fed with CS and ECS. The DMI (kg/d) and ADG (kg/d) for steers fed with CS and ECS were 7.57 and 5.94; and 0.80 and 0.15, respectively and the differences were statistically significant (P<0.05).

Hunt et al. (1993) conducted digestion and growth trials in steers fed with each diet containing 65 per cent (DM basis) whole plant corn silage (WPCS) and stover silages from 3377 and 3389 corn hybrids. The digestible energy and digestibility of DM and CP were greater (P<0.05), for 3377 than for the 3389 hybrid. In growth trial, steers fed the 3377 silage diet had greater (P<0.01) daily gain (1.09 vs 1.01 kg/d), consumed numerically less (p<0.09) DM, and improved (P<0.01) feed efficiency (6.75 vs 7.49 feed:gain) compared with steers fed the 3389 silage diet. The results of the experiments
indicated that large differences in feed value of corn stover silage may exist among hybrids with similar grain content.

Finishing trials were carried out with 30 beef cattle fed with silage of whole wax-ripening corn stalk with ear and full-ripening corn stalk without ear. Results showed that the average daily gains of the two groups were 1891 and 997 g, respectively, the first was being significantly higher than that of the second group (P<0.01). The whole corn silage with ear was better than corn silage without ear (CUI Tao-qì, 2002).

2.4.2.2 Lactating cows

Morrison et al. (1920) conducted an experiment to compare feeding value of corn silage and corn stover silage, in dairy cows for 8 weeks in 2 periods, each for 4 weeks duration. The cows were divided into 2 groups of 4 in each group. All the experimental cows had an average fat yield of about one to one-fourth pounds per day before the start of the trial. Each kind of silage was fed *ad libitum* twice daily. The corn stover silage tended to be somewhat dry near the wall of silo. The cows took stover silage readily; they consumed 5 pounds per day per animal less silage than of corn silage. The results showed that the milk yield and fat yields were 27.4, 1.05, and 24.5 and 0.98 pounds in cows fed with maize silage and maize stover silage respectively.

Hargreaves et al. (1984) conducted intake study on sixteen lactating cows (8 in each treatment) fed with corn silage (CS) and stalklage silage (SS). The DMI (kg/d), feed efficiency and body weight changes (kg/d) for CS and SS fed animals were 20.0 and 16.9; 1.34 and 1.45; and 0.53 and 0.40 respectively. The results indicated that DMI was significantly higher (P<0.05) in CS fed group. The respective milk yield of cows fed with
CS and SS were 27.6 and 26.6 respectively. The milk persistency (%) of cows fed with CS and SS were 96.4 and 87.7 respectively. The results showed that only the milk persistency was found significantly higher (P<0.05) in CS when compared to SS fed animals. The milk compositions (%) such as milk fat, milk proteins and milk solids in CS and SS fed groups were 3.54 and 3.71; 3.29 and 3.33; and 12.17 and 12.50 respectively. The results indicated non-significant differences between CS and SS fed groups.

Mohamed (1997) reported that lactating buffaloes fed with corn stover silage (CSS) and whole plant corn silage (WPCS) showed no significant difference in milk yield and milk composition.

Methu et al. (2001) reported that the maize stover is the most abundant crop residue in central Kenya highlands and it is often the sole forage offered to dairy cattle during the dry seasons. In recent years increasing offer rates of crop residues (excess feeding) to promote selective feeding by confined animals has been shown to improve utilization of the residues, but no studies have been conducted with dairy animals offered maize stover (incremental doses). This study was conducted to determine the effects of increasing the ad libitum amounts of maize stover offered, on intake, selection and milk production by dairy cattle, when supplemented with cottonseed cake. The effects of post harvest handling on the quality of maize stover were also studied. Hybrid 511 maize was grown under similar agronomic conditions in 2 consecutive years, 1994 and 1995. Maize harvested under dry weather conditions in 1994 produced stover with a higher leaf+sheath+husk:stem ratio (1.48), than maize harvested in 1995 under rainy weather.
conditions (0.99). In both years, leaves recorded the highest crude protein (CP) contents among the botanical components. Acid detergent lignin (ADL) levels were highest in stem (85 \text{ g/kg DM}) and lowest in husk (29 \text{ g/kg DM}). Stem had the lowest digestible organic matter (DOMD) values (405 \text{ g/kg DM}) while husk had the highest (707 \text{ g/kg DM}). Stover intake by dairy cows increased significantly from 19 to 26 and then to 30 \text{ g DM/kg live weight per day}, as the amount of stover offered increased from 31 to 59 and then to 86 \text{ g DM/kg live weight per day}, respectively. The cows selected more of leaves and husks as the amount of stover offered increased. All animals were supplemented with 3.2 \text{ kg DM/day} of cottonseed cake. Milk yields increased significantly (P<0.05) from 10.0 to 11.2 and then to 12.2 \text{ kg/cow/day}. It was concluded that offering excess can be an effective strategy to improve the intake of maize stover and increase milk production although adoption of the technology would depend on other factors such as availability of large amounts of stover and an economical use of the refusals.

Rahaman et al. (2003) compared the effects of feeding value of silages from whole crop maize (WCM) and maize stover (MS) on intake, milk yield and milk composition in lactating Sahiwal cows. Eight cows nearly of the same age, weight and lactation stage were randomly divided into two equal groups A and B. Two rations \textit{viz}, I (60 \text{ % WCM and 40\% concentrates}) and II (60 \text{ % MS and 40\% concentrates}) were randomly allotted to these groups. Each ration was offered \textit{ad libitum} twice daily for a period of 20 days, with an adjustment period of 10 days. The DMI in Sahiwal cows were 12.8 \text{ kg/d} and 12.5 \text{ kg/d} for the diet fed with WCP silage and MS silage respectively, showing non-significant differences between the two groups. The average milk yields (l/d) were 4.2 and 4.3 for WCM and MS fed groups respectively. The results indicated
non-significant differences between WCM and MS. The results of milk composition (%) for Sahiwal cows fed with WCM and MS were 4.6 and 4.7 butter fat; 3.01 and 3.00 CP; 2.48 and 2.47 casein; 12.25 and 12.23 total solids; and 7.67 and 7.58 SNF, respectively for both the treatment groups. Gebrehawariat et al. (2010) conducted a study on 36 Boran × Friesian dairy cows (392±12 kg; mean ± SD) in early parity in a randomized complete block design. Cows were blocked by parity into three blocks of 12 animals and offered normal maize (NM) stover (T1), NM silage (T2) or quality protein maize (QPM) silage (T3) basal diets supplemented with a similar concentrate mix. The chemical composition (%) of NM stover, NM silage and QPM silage for DM, OM, CP, NDF and ADL were 91.8 88.2 and 88.1; 87.5, 91.4 and 919; 5.2, 7.7 and 73.6; 46/2, 36.6 and 37.1; and 4.9, 4.9 and 4.3, respectively. The results of chemical composition of the three maize varieties (NM stover, NM silage and QPM silage) indicated that the CP content of the NM and QPM silages were similar and both were higher than the NM stover. Feed intake, body weight and condition changes and milk yield and composition were assessed. The daily intake of DM, OM, NDF and ADF for cows fed the NM stover-based diet was higher (P<0.05) than for the cows fed the NM silage and QPM silage-based diets. However, the daily intake of DOM (9.3 kg) and ME (140.8 MJ) for cows on QPM silage-based diet was higher (P<0.05) than for cows on NM stover based diet (8.4 kg and 124.2 MJ) and NM silage-based diet (7.9 kg and 119.1 MJ). Body weight of cows was affected (P<0.05) by the diet, but diet had no effect (P>0.05) on body condition score, milk yield and milk composition. The digestible organic matter in the NM stover-based diet (724 g/kg DM) was lower (P<0.05) than that in the NM (770 g/kg DM) and QPM silage-based diet (762 g/kg DM). It was concluded that the performances of the cows on
the NM silage and QPM silage diets were similar and were not superior to that of the NM stover-based diet.

Cereal residues are an important feed source for ruminants in smallholder crop-livestock systems in the tropics. In many areas of India maize is a relatively new cash crop where farmers and development agents alike generally perceive maize stover to have limited utility, in contrast with the intensive feeding of other cereal residues. A comparative assessment of maize stover quality based on a brief review confirms it’s potential as a ruminant feed. Maize stover use is a relatively neglected area by India's agricultural R&D and merits more attention so as to exploit its potential as ruminant feed (Erenstein et al., 2011).