REVIEW OF LITERATURE
2. REVIEW OF LITERATURE

In recent years, there has been an acute shortage of agricultural labourers during sowing season due to increased employment opportunities in urban areas for rural youth. Due to non-availability of labour and work animals during sowing seasons, in many places the seed is sown even when the soil is at a low moisture content which affects the germination, plan I. stand and yield. Therefore in order to mechanize crop sowing operation under rainfed conditions, a suitable seed drill is vital as it places the seed in the zone of adequate moisture and at desired depth. The bullock drawn seed drill gives proper seed rate, uniform distribution and correct placement of seed resulting in higher yield and reduces human physical strain.

2.1 Comparitive performance of seeding devices with other sowing methods:

2.1.1 Crop yield

Studies in different parts of the country have shown that seeding devices introduced in rainfed areas have increased crop yields by 10 to 20 percent over conventional methods of seeding due to better plant establishment and proper application of inputs. In most parts of Northern India, seedcum-fertilizer drills are used for sowing whereas seed drills are found in use mostly in the Southern parts of the country. Hence both the performance of the seeding devices have been taken for review.

By using three row bullock-drawn-fertilizer drill, wheat yield was boosted up to 10.93 percent (average) higher using the same inputs and cultural practice when compared with the behind the plough sowing (Mehta and Varshney, 1970).

Singh (1971) revealed that by using a fertilizer drill for wheat crop there was an increase in yield by 13.025 percent when compared with the conventional method.
Rastogi and Vinodkumar (1974) conducted demonstrations during kharif 1971, 1972 & 1973 using hand seed drill for bajra sowing and compared it with the sowing of bajra by local method (ie.,) behind desi plough. An average increase in yield of 19.73 percent was obtained over the local method.

Vinod kumar and Rastogi (1975) compared a bullock drawn secd-curn-fertilizer drill with desi pi.nigh for wheal crop. They have reported that an increase in yield by about 10.5 percent was achieved due to the use of ferli-seed drill.

A study has shown that the use of seed drill gives an increase of 12.5 per cent in wheat yield over traditional methods (Roy and Viswanathan, 1977).

Singh and Chancellor (1977) observed upto 26 percent more yield of wheat by using seed drills at the farmer's field.

Bah! et al., (1980) reported an increase in wheat yield upto 15 to 20 percent by the use of seed drills over the traditional methods.

Sharma et al., (1980) observed 19.1 per cent increase in wheat yield with the use of seed-rum-fertilizer drill at the farmer's fields under normal sowing conditions.

Singh and Singh (1981) observed an increase of 17.3 per cent in wheat yield using the Malviya seed-cum-fertilizer drill at the farmers' fields.

Sharma et al., (1984) reported that on an average increase in grain yield of wheat and gram was 24.92 per cent and 20 per cent respectively with the use of seed drill over traditional method.

It was observed that wheat yield was influenced with the use of chisel, sweep cultivator and seedling with multicrop hoe drill that gave 1475 Kg/ha compared with 516 Kg/ha using traditional practices (Chandlery et al., 1986).
The performance trials conducted with bullock drawn I'NAU improved seed planter at nine different places in an area of 1.48 ha revealed an increase in ground nut yield by 11 to 14 per cent when compared with sowing behind the country plough (Anon, 1988).

Senapathi et al. (1988) observed that manually operated Implement Factory Seed Drill has caused 98 per cent higher yield of paddy when compared with broadcasting.

A study was conducted to evaluate the effect of use of the mechanical sowing on wheat yield in comparison with traditional methods. The animal drawn mechanical sowing has resulted in a 10.4 per cent increase in yield. (Sharma et al., 1989).

Shriclar et al., (1992) reported that the groundnut pod yield increase recorded was 23.76 per cent in tractor drawn cultivator cum seed planter sowing as against the country plough sowing.

2.1.2 Energy saving:

It was reported that by using three row huliock drawn ferti-seed drill for wheat crop, a saving of 76.37 percent man hours and 59.92 per cent bullock-hours was obtained when compared with the behind the plough sowing. (Mehta and Varshney, 1970)

Singh (1971) revealed that by using a ferti-seed drill for wheat crop, a saving of 69.96 per cent in man-hours and 55.17 percent in huliock hours was achieved when compared, with the conventional method.

Rastogi and Vinodkuinar (1974) conducted demonstration by using hand seetl drill for bajra sowing which resulted in 75.94 per cent saving in man-hours over the local method.

Vinodkumar and Rastogi (1975) reported that 69.76 per cent saving in man-hours and 56.26 percent saving in bullock-hours were achieved due to the use of bullock drawn seed-cum fertilizer drill when compared with desiplough for wheat crop.
Roy and Viswanathan (1977) observed that the use of seed drill reduces the time required for sowing by 40 per cent over traditional methods.

It was noticed that nearly 40 percent in operating time was saved by the multipurpose implement attached with sowing and covering device compared with sowing and covering separately by local implements for sowing rabi jowar and safflower (Gurusamy and Patil, 1986).

By using tractor drawn cultivator cum seed planter, 91 per cent saving in lime of sowing besides saving of more than 42 man hour per ha were achieved (Anon. 1987).

Awadhwal et al., (1987) reported that the use of a wheel and tool carrier reduced labour input (56 - 75 per cent) for sowing and fertilizer applications when compared with traditional implements. Further the use of wheeled tool carrier resulted in 18 - 54 per cent reduced input of total Oxen - pair hour for all operations required for crop production.

By using tractor drawn cultivator seed planter and TNAU improved seed planer for sowing groundnut, 92.43 percent and 70.88 per cent of time could be saved over the conventional method of sowing behind the plough (Anon. 1988).

Senapathi et al., (1988) observed that manually Operated Implement Factory Seed Drill obtained an energy saving of 71 per cent when compared with broadcasting.

Surendra Singh et al., (1988) reported that the planting operation of a two row tractor mounted ridge-planter for winter maize saved more than 90 percent labour over the traditional method.

There was a saving of 92.47 per cent and 72.87 per cent in time by using the tractor drawn cultivator seed planter and TNAU
improved seed planter respectively over the conventional method of sowing groundnut crop behind the country plough. (Anon. 1989)

The animal drawn mechanical sowing has resulted in 49.19 per cent savings in energy in comparison with the traditional method of sowing wheat crop. (Sharma et al., 1989)

Senapathi et al., (1992) reported that Gujarat State Fertilizer Corporation Seed cum Fertilizer Drill had the best performance on the field for sowing finger millet as it had the highest performance index value of 0.613 when compared with other seeding devices.

The amount of labour required for the planting operation using the traditional method was greatly reduced with the use of animal drawn plough-seeder. The reduction recorded 83 per cent and 50 per cent in the case of sorghum and groundnut respectively. (Rahama and Hussein., 1993)

2.1.3 Cost saving:

Singh (1971) reported that using a ferli-seed drill for wheat crop reduced the cost of sowing by roughly about one-fifth of the conventional method.

Rastogi and Vinod Kumar (1974) observed that an average increase of Rs.445/ha in net profit was obtained by using hand seed drill for bajra sowing as against sowing behind the plough.

Awadhwal et al., (1987) reported that the use of a wheeled tool carrier saved the cost (23-39 per cent) of sowing and fertilizer application when compared with the traditional implements.

The cost of operation using the TNAU improved seed planter was found to be Rs.95.06/ha and hence there was a saving of Rs. 189.74/ha when compared with the cost of operation for sowing behind the country plough (Rs.284.38/ha) (Anon.1988).
Suremlra Singh et al. (1988) reported that winter maize planting operation with a two row tractor mounted ridge-planter saved planting cost of Rs. 238.40 / ha over the traditional method (Rs.444.90 / ha).

There was a saving of Rs.150.11 / ha and Rs. 197.27 / ha in cost of operation by using the tractor drawn cultivator seed planter and TNAU improved seed planter respectively over conventional method of sowing behind the country plough (Rs.287.50 / ha ) (Anon.1989).

Sharma et al., (1989) concluded that using the animal drawn mechanical sowing has resulted in 49 per cent savings in the cost of operation in comparison with the traditional method of sowing wheat crop. The overall benefit was Rs.671.75 / ha.

Shridar et al., (1992) revealed that there was a saving of 37.83 per cent in the cost of sowing as against the country plough sowing for groundnut crop.

2.1.4 Field capacity and draft requirement:

Srivastava and Dubey (1985) reported that the draft of a three row animal drawn seed-cum-fertilizer drill cum two row planter was in the 45-65 Kg range depending upon the soil type and moisture content. The field capacity of the machine ranged from 0.1 - 0.25 ha/h depending on the row spacing.

Surendra singh et al., (1985) developed a two row ridge planter for planting winter maize. The average seed to seed distance was found to be 19.8 cm row to row spacing was 60 cm and average ridge height 25 cm. The capacity of the planter was 0.18 ha/h at the forward speed of 2.5 Kmph.

In an hour one acre was sown with TMV-7 and JL-24 groundnut varieties using tractor drawn seed planter at TANCOF Farm, Neyveli (Anon. 1986)
Gurusamy and Patil (1986) developed a low cost multipurpose implement with seeding cmn covering attachment, for sowing rabi jowar and safflower crops. The average values of effective field capacity and draft of the implement, while sowing were found as 2.15 ha/day and 60.02 kgf respectively with field efficiency of 77.12 per cent, whereas it was found 2.02 ha/day, 55.12 kgf and 72.15 per cent by using local seed-cum-fertilizer drill and covering separately.

Surendra Singh et al., (1987) reported that the capacity of the seed drill attachment to the tool carrier designed by ICRISAT increased (0.3 ha/h) as compared with the conventional seed drill (0.075 ha/h) and improved seed drill (0.15 ha/h).

It was found that an area of 4.33 ha/day and 1.12 ha-day was covered by using tractor drawn cultivator seed planter and TNAU improved seed planter respectively as compared with 0.32 ha/day by sowing behind country plough. (Anon. 1988)

Surendra sindi el al^ (1988) reported that the average field capacity of a 2 row tractor mounted ridge - planter for winter maize was 0.24 ha/h at the forward speed of 2.25 Kmph.

The coverage of the TNAU improved seed planter was found to be 1.18 ha/day as against the coverage of 0.32 ha/day by country plough for sowing TMV-2 groundnut at farmers fields. (Anon. 1989)

The Punjab Agricultural University developed a tractor drawn seed planter covering 7 to 13 rows of sowing with a width of 1.4 to 2.8 m using a 20 - 40 IIP tractor. The field capacity of the planter was 4 -6 ha/day. (Gill. 1991)

Varshney et al., (1991) reported that the field capacity of the power-tiller drawn seed drill was about 55 percent, higher for wheat and 24 percent higher for Bengalgram than that of CIAE 3 row animal drawn seed-cum fertilizer drill.
Shridhar et al., (1992) reported that the field capacity of the tractor drawn cidiivalor cum seed planter was about 0.45 ha/h for sowing VRI-2 variety of groundnut when compared with the conventional method of sowing behind the plough (0.03 ha/h).

Awadhwal and Babu (1994) have developed a multi-row bullock drawn planter and tested it in field conditions. They have reported that the lime required to sow groundnut in 1 ha was 4-6 hours with draft requirement varying between 70 and 80 Kgf depending upon soil conditions.

2.1.5 Plant population and seed germination:

Rastogi and Vinodkumar (1974) found that by using hand seed chill for bajra sowing an average increase in plant population about 26.47 percent was obtained over the local method.

Sirohi (1980) reported that the germination of seed was uniform and was two days faster with the use of seed drill as compared with the local method of sowing.

Sharma et al., (1983) found that the highest average germination (23.83 seedling/sqm) was observed with single row seed-cum-fertilizer drill followed by tractor drawn seed-cum-fertilizer drill (13.65 seedling/sqm) and three row bullock drawn seed-cum-fertilizer drill (12.3 seedling/sqm) respectively. The lowest germination was recorded in the single row cotton drill (3.76 seedling/sqm).

It was noted that the actual plant population was recorded 27 in the fields where TMV-7 and fl-24 groundnut varieties were sown by using tractor drawn seed planter at TANCOF Farm, Neyveli. (Anon. 1986)

The performance trials conducted with tractor drawn seed planter and with bullock drawn TNAU improved seed planter revealed
an increase in plant population of 16.12 and 18.66 per cent respectively when compared with sowing TMV-12, groundnut behind the country plough at farmers fields. (Anon. 1988)

Choudhary (1988) reported 65 per cent and 360 per cent belter plant establishment with inverted 'T' seeder in maize and niung bean respectively than seed dibbling / covering by hand.

Shridhar et. al., (1992) reported dial 91 per cent germination of crop and 30 plants per square metre were found by using tractor drawn .seed plainer whereas 82 per cent germination of crop and 23 plants per square metre were found by using country plough.

2.2- Specification of seed drills:

- Sowing can be divided into two main phases.

- The uniform feed of seeds from the grain hopper to openers and

- the preparation of furrows, the placement, of seeds in them and covering of the furrows with soil to the same depth.

Based on these phases, Bernacki, et al., (1972) stated the agronomic specifications of machines for sowing as follows :

- Distribution of seeds on the area sown must he uniform.

- The metering mechanisms of die seed drills must drop the seeds uniformly. "The average non-uniformity between separate mechanisms must not exceed 3 per cent for cereals and 4 per cent for leguminous crops.

- The amount of seeds in each row must be the same and must correspond to the adopted seed rate. Deviation of overall sowing from the seed rate must not he greater than + / - 3 per cent.

During sowing, seeds must not be damaged in the metering mechanisms, openers and other parts of the seed drill.
Furrow openers must create a slightly compressed furrow bottom and the furrow depth must be constant. Seeds are laid on the compressed bottom and covered with wet soil. Permissible deviations from the given depth of drilling are +/- 0.5, +/-0.7 and 1.0 cm for sowing depths 3-4, 4-5 and 6-8 cm.

Square-pocket planters must sow the same amount of seeds in nests. The percentage damage of seeds should not exceed 1.5 percent. Deviation of nest centers from the axial line, perpendicular to the direction of motion of the unit, must not be greater than +/- 5cm; in the longitudinal direction it must not be greater than +/- 2cm and in the joining rows it must not be greater than +/- 5cm.

During sugar beet sowing, single grain seed drills must guarantee the linearity of drill rows and maintain a distance between single seeds of 3,5 (or) 8cm over not less than 80 percent of the whole sowing area. The amount of blanks must not exceed 2 per cent and seedbreakage must not exceed 0.5 per cent.

Hansen et.al, (1962) and Bernacki (1072) listed out the operational requirements of a combined drill as follows:

The number of seeds placed simultaneously in particular rows should be roughly the same over each meter of row length. This criterion should be met for various kinds of seeds and fertilizers too and at various seeding and fertilizer application rates.

- There should be a provision of changing seed rate from 6-300 Kg/ha.

- Metering of the required seeding and fertilizer application rate should be reliable and easy to adjust.

- Provision for changing row spacing between seeds and both vertical and horizontal distance between seeds and fertilizer deposition in soil.
- Placing of seeds at an appropriate depth and covering; with soil layer.
- Seeds should not be injured by the seed metering and placement, devices.
- Insensibility of working elements of the distributors to corrosive action of fertilizer by employing suitable structural material such as fibre glass, stainless steel and metal coating.
- Easy removal of die fertilizer left in the box and easy access to clean the inside of the machine.
- Operating efficiency of the drill should not be dependent on its inclination when seeding undulated fields and should remain unrelated to the travel speed (4-8 Kmpli).

2.3 Factors which influence the improvement of seed drill design:

The design of agricultural machines involves the understanding of the variable field conditions and other factors which influence machinery performance, including environmental and human related factors. Machines should be operationally reliable and economically acceptable to the farmer. In the case of agricultural machinery design, the relevant scientific principles concerning soils, plants and plant, parts and other biological materials are also considered. Designers of farm machines must integrate analytical design and results of experimental investigations which are simple to fabricate, affordable, light in weight, easy to maintain, and require readily available and low-cost materials.

2.3.1 Seed metering devices:

A metering device draws seeds from hulk and delivers them at the desired rate in the seed tube for sowing. Seeds to be sown should be arranged according to the desired plant spacing. The device should not cause mechanical damage to the seed while in operation. Seed drills are provided with metering devices which determine a given volume of seed for random distribution along the row. The size and shape of seeds affect machine operation because of large variations in recommended seed rates for the crops.
Arthur Rjerkan (1947) found that the slippage on ground wheels, high planting speeds and non-uniform seed size were the causes of irregular planting. He suggested an average slippage value of 5 percent for rubber tyres and 15 per cent for steel wheels.

Roy Bainer (1947) reported that, the plate type planters should be provided with sufficient opportunity to enter into the plate cells. A rim speed of 33 rpm gave 100 per cent space fill. Small smooth tubes were found to be more useful. He also developed a laboratory apparatus for making greased board tests of planters:

Barrington (1948) studied the effects of various factors on seed metering and seed placement errors. These factors were summarized as,

- Variation in seed size and shape
- Planting speed
- Design of metering mechanism and dropping mechanism
- Design of seed hopper
- Level of seed in hopper and
- Condition of soil furrow at which seeds are dropped.

Autry and Schrolder (1953) give the design factors for high drop horizontal plate planters and studied the effect of cell shape and uniformity of seed size and accuracy of planting, dispersion at various heights of fall.

Snooker (1960) conducted laboratory trials on seed with fluted wheel, serrated wheel, centrifugal and precision seed drills dropping seeds onto a greased belt moving at 3 and 6 km ph. The space between the seeds were counted and measured. Field trials were run with the same drills at approximately 5, 7, 9 and 10 kg/ha of seed rate and data collected at the time of emergence and plant density. Subsequent mechanical thinning produced good results at lower seed rates.
Baczkowski (1962) conducted trials to study the effect on the performance of increasing the speed of drills with seed drills fitted with different types of feed mechanisms. He concluded that the conventional fluted roller mechanism sowed even less seeds at higher speeds and the star wheel performed the best.

Mekhaniz. (1964) conducted experiments on increasing the accuracy of hilling. Forward speed of drill, height from the point of ejection of seed to furrow bottom and distance travelled during flight of seeds were considered in a geometrical study of seed drilling with a plate type spacing drill and theoretical deductions were confirmed in thesis on a rig in winch graded seed was drilled from different heights and at various speeds onto seed beds of consolidated or loose soil.

Kenneth K. Banes (1966) found that the uniform size and shape for accurate metering, biological uniformity for ensuring uniform response and uniform seed bed are the three essential requirements for satisfactory precision planting.

Hilton (1979) discussed the design criteria for a row crop drill. He concluded that the metering wheel speed should be less than 200 min/s delivery speeds equal to ground speeds in the range of 1-3 m/s and the release should take place as close to the soil surface as possible and at 20' before bottom dead centre for a cell wheel mechanism. Based on these conclusions he developed an experimental drill and tested.

Redemacher (1981) conducted experiment on seed damage in grain augers and found that the damaging factors were sheering and jumping of seeds against the casing or wall.

Devnani et al., (1984) conducted a study on inter-row variation which occurred in a fluted roller (12 flutes at 50 mm diameter) at different exposed lengths of four row animal drawn seed-cum-fertilizer drill for wheat crop. The results indicated that the inter-row variation increases as the exposed length of flutes is, reduced from
25 to 10 mm. The seed rate variations are caused by varying seed characteristics, friction between seeds as well as between the seed and the *iced* cup and the dimensional accuracy of the fluted roller.

Patterson (1984) tested the performance of metering rollers using the sticky belt method. Of the five rollers tested, the spiral fluted roller (with 10 flutes) performed best.

Srivastava and Dubey (1985) conducted a test on fluted rollers fined on a 3 row animal drawn seed-cum-fertilizer drill for different crops. The observed seeding rates were within 3 per cent of the desired rates and germination value within 1 per cent.

Verma (1985) described the qualitative performance of cup_type metering device used on sowing equipment as

- Suitable for sensitive seeds.
- Nonpositive separate unit, required for different crops
- Difficult to control seed rate, which varies with speed of operation.
- Simple mechanism
- Moderate cost
- Skill in fabrication required.

Venna (1985) tested a tractor mounted seed-cum-fertilizer drill at different seeding rates and speeds of operation for fluted tollers and for adjustable opening with agitator type metering devices. For fluted rollers the seeding rate varied with the speed of travel. Inter row variation was high for a low seeding rate and low for a high seeding rate. For stationery opening type devices, the seeding rate decreased with increasing speeds of travel. In case of fluted rollers, the maximum variation between rows ranged from -7 to +9 per cent whereas in the orifice-type, the maximum variation ranged from -64 to +26.7 per cent.
McPhee (1986) conducted trials in the laboratory to determine the influence of meter type and operating speed on the levels of damage inflicted on peanut seed during the sowing operation, using seven planters. Damage was found to be less than previously thought. While 5 drills showed statistically significant levels of damage, most are capable of operating at reasonable field speeds (7-10 kmph) before damage to seed becomes a serious limiting factor. The performance of some drills is limited by their inability to deliver the correct quantity of seed at higher speeds.

Morris (1988) conducted a study on the performance characteristics of metering devices in terms of seed size (seeds/kg), metering speed (seeds/sec) and maximum throughput of the devices per meter (g/s). He found that, the coefficient of variation (CV) of spacing between consecutive seeds, values below 60 percent indicated that the metering device performance is good.

Morris (1988) has reported seed metering requirements for common crops: (Appendix - 1).

Bausal et. al., (1989) developed a roller type positive feed mechanism for seed metering which is very simple in construction, and inexpensive to make in small workshops and has potential for use in low-cost seed drill.

The planting requirements of important crops (Appendix - II) vary widely from place to place and are based upon agronomic requirements of the crop. The variation is also due to differences in agro-climatic conditions and level of soil fertility (RNAM, 1991).

Afzal Tabassum and Abdul Shakoor Khan (1992) have developed a test rig for performance evaluation of seed metering devices. Regularity of seed spacing of wheat, paddy, millet, and rape/mustard were evaluated at speeds of 3.7, 4.5 and 5.4 Kmhp. A speed of 4.5 Kmhp with universal seed wheel metering unit was found suitable for all crops except millet. In the case of sponge feed metering unit,
a speed of 3.7 Kmph was found suitable for wheat and paddy. Whereas, millet and rape/mustard distribution was found better at a speed of 4.5 Kmph.

2.3.2 Furrow openers

Seed drills are provided with furrow openers for placement of seeds at uniform depths and spacing. The depth at which seed is placed in the soil depends on the crop species and the soil moisture level. In dry areas, seeding depth depends on the rate at which the moisture drying front descends in the soil. This rate depends on the evaporation of surface soil water and the rate at which the seedlings grow or emerge. Furrow openers should form a neat groove in the moist soil with minimum soil disturbance to avoid mixing of the top dry soil with the underlying moist soil at seed level. Excessive moisture in the soil causes a smearing action reducing the growth of seedlings. The soil aggregate size is determined by the degree of seed bed preparation and the crop residue; the proper aggregate size avoids clogging of furrow openers.

Bera\'ncki et al, (1972) described a disc opener which slides easily over possible obstacles encountered on its path such as hard lumps of earth, garbage, fragments of plants etc and it is also free from choking up by wet soil.

Billy Goocharan et al, (1974) studied that vertical forces on some furrow openers and depth control devices could be pressed quantitatively and a correlation could be obtained.

Smith and Wilkes (1977) reported that hoe type opener is suitable for high tractor speeds and for thrashy land.

John Morrison and Frank Abrams (1978) designed a new furrow opener and used it in combination with appropriate articulating frames for conservation tillage planters. Previous studies have shown that the rolling double disc furrow openers have been proven successfully.
Rogers (1979) tested 10 commercial furrow openers in two soils at two moisture levels for seeding depths of 3.0 and 7.0 cm with compaction levels of land 3 Kg/sqcm and at speeds of 6.9, 10.4 and 13.6 kmph. The studies showed that both the draft and vertical forces on the opener increases with speed as the opener depth increases from 3.0 to 7.0 cm. Vertical and draft, forces increase from 50 to 100 percent as speed increases from 6.9 to 13.6 kmph and the seed cover diminishes between 10 to 40 per cent. The distance over which the soil is scattered increases by 60 to 100 per cent, with a speed between 6.9 and 10.4 kmph and by 10 to 50 per cent, between 10.4 and 13.6 kmph. The greater the opener depth is the greater the amount of soil scattered.

The openers tested, performed satisfactorily for all moisture levels and compaction conditions in the sandy soil. In the clay soil the performance of the furrow openers found satisfactory for the low moisture level but problems were encountered at higher moisture levels.

Wilkins et al., (1983) studied six different: grain drill openers including deep furrow, disc and hoc-type for field testing in a seed bed where moisture was limited. Opener type significantly affected seed distribution, soil moisture content and bulk density in the seed bed which in turn affected wheat seedling emergence. The best emergence was produced with a modified deep furrow opener that, placed over 70 percent of the seeds in contact with soil containing more than the limited moisture content.

Sharma et al, (1984) developed a single row drill using double disc furrow opener to accomplish sowing of wheat without, field preparation. Moisture depletion during stress periods was high in this no-tillage treatment. The no-tillage system required the least energy and cost of production while the requirements were about 1.5 times higher in the conventional system.

Shukla et al., (1984) discussed the major problems encountered
while using drills, like culling of straw accumulation of straw on the tynes, formation of clods, greater power requirement and uneven dropping of seeds due to ground wheel not touching the ground. To overcome these problems, a coulter attachment was developed to the drills. Provision was made to vary the disc angle from 0 to 23 degrees with this attachment there was reduction in clod size and no accumulation of straw on the tynes. Also the draft requirement was

Hoe or reversible shovel type furrow openers are used in the animal drawn drills due to simplicity of construction, low cost, low draft and precision placement of seed and fertilizer (Tandon et. al, 1984).

Townsend (1984) studied different furrow openers for proper seed and fertilizer placement in no-till and he carried out the tests with a prototype and reported that the fertilizer and seed were placed successfully in the furrow separated by a layer or soil approximately 18mm thick and the maximum average power required to rotate the disc at 540 rev / min at a forward speed of 5.2 kmph was 2.6 kW, cutting a 50mm deep slot in soil that had been compacted by combine wheels.

Aziz Ozmeri (1986) investigated about the depth of operation, seeding depth and seed distribution capabilities of four different types of furrow openers viz., suffolk coulter, hoe, single disc and double disc type. It was concluded that

- the depth of seeding was always less than the depth of operation for all tested openers.

- the opener's working depth had more effect on seed space distribution than forward speed or soil cover especially of the single disc-type opener.

- hoe, double disc, single disc/suffolk coulter were suitable for deep, medium and shallow depth of seeding respectively.
Lawrence and Dyc (1990) conducted studies on seed from 45 strains of grass sown with 2 drills fitted with different furrow openers and depth control devices. At the 2.5 cm depth the large-small disc opener assembly gave superior forage establishment compared to that obtained with the standard double disc assembly. A comparison between opener-depth control assembly set to seed at 2.5 cm depth with tin: large-small assembly set at 6.25 cm depth confirmed the value of shallow seeding of forage crops to overcome establishment problems.

The draft values of 2-row and 3-row machines evaluated at a number of soil types in India ranged from 60 kgf to 100 kgf. For light soils, the drab is 20 kgf per furrow and for heavy soils, draft is 30 kgf to 35 kgf per furrow opener, on the average (RNAM, 1991).

Tajuddin et al. (1901) tested hoe, shoe, wedge, single disc and double disc types of furrow openers systematically in the field and their performances were compared. The performance of the single disc furrow opener was better having the highest performance index and the lowest unit draft (10.84 kPa). The average draft and power of the country seed drill (gorru) fitted with three single disc furrow openers were 131.56 N and 56.57 W as against 471.65 N and 183.94 W respectively for the wedge type openers which are used at present. In general addition of dead weight reduced the performance index value of the furrow openers.

2.3.3 Covering and compacting devices:

Plant, stand is affected by the compaction of soil over the seeds. The emergence of seedlings depends upon the soil moisture level at the seed depth and the resistance of the top soil against growth of the seedlings. Therefore, the seeds should be placed at uniform depths having loose and uniform contact with the soil. Under fast drying conditions sufficient loose soil should be retained to prevent moisture loss and avoid crust formation. Soil compaction after the seed is placed in the furrow has shown better plant emergence.
Laboratory studies of compacting devices on beans, maize and sugar beet in sandy, clay, loam soil conducted by Morrisson et al, (1988) indicated that the pressure of 34-60 kPa applied to the soil sulfate after planting suppressed seedling emergence whereas pressure of 3-4 kPa did not. Pressure applied at the seed level of 34-69 kPa on the soil improved emergence when adequate moisture was available immediately below the seed level. It was concluded that for better emergence, the soil should be packed below seed level, and the seed should be pressed into compacted soil and lien covered with loose soil.

Tessier et al, (1989) investigated the effects of no-tillage furrow opener design on furrow compaction, soil water potential, temperature, emergence rate and stand establishment of spring and winter wheat. Hoe openers encouraged more soil disturbance than disc openers but gave consistent furrow compaction with 45 mm wide press wheels. Disc openers minimized soil disturbance and generally maintained a moisture seed zone but soil-seed contact may not always be enhanced by a 45 mm press wheel which then causes lower wheat emergence.

2.4. Animal draft power:

The major draft power sources used in Indian agriculture are bullocks although some other animals like buffaloes and camels are also used. On the basis of 1991 estimates, the availability of power on Indian farms is about 0.55 hp/ha of cultivated area. The contribution of draft animal is about 52 percent and the rest comes from tractors and power tillers. Earlier studies have shown that the use of adequate power results in timely operations, increased cropping intensity and better quality of field work in terms of crop yield. It is observed that animal's work output depends on various factors such as the body size, their bread, draft, duration of work, field conditions and climate.

Joshi and Phillips (1953) ar tel Kama (1957) reported that for various Indian and Pakistani breeds of bullocks (Bos indicus), the
average body weight varies from 320 to 640 Kg, height (up to withers) from 1.6 to 1.9 m and length (shoulder point to pin bone) front 1.7 to 2.2 m

Studies of Mukharjee et. al, (1961), Anand and Sunderesan (1974) and Devadattatn (1974) show that the pulse rate, respiration rate and body temperature of Haryana bullocks vary from 41 to 56 per minute, 12 to 35 per minute and 55.1 to 55.6 deg C, respectively. They found that the pulse and respiration rates increased during work, the increase was rapid in the first hour of work, and slower thereafter. The body temperature, however, increased steadily with the duration of work.

Yusuf (1936) reported that the bullocks draft capacity was 10% of their body weight in 6 hour working day.

Singh et al., (1968) studied Haryana bullocks during different, agricultural operations, such as disc-ploughing, harrowing and tillage and the horse power developed was 0.8, 0.97 and 0.94 respectively.

ICAR (1969) reported that bullocks draft capacity varied from 8 to 20 per cent of their body weight. It also slated that, while ploughing, a pair of bullocks developed 0.2 to 1.4 kW (lower with a navel speed of 2.7 to 2.9) kmph.

FAO (1972) study stated that bullocks draft capacity varies from 10 to 14 percent of their body weight at an average speed of 2.3 to 2.7 kmph

Singh and Chanreller (1975) rated the bullocks in North India with average power of 0.2 to 0.5 kW

Cheema and junjua (1976) while studying the performance of bullocks, concluded that the optimum draft for a Haryana bullock varied from 12 to 15 percent of its body weight. They found that, a bullock on an average developed 0.5 kW and moved at an average speed of 3.26 Kmph.
Maurya and fmvadaitam (1978) found that the draft capacity of bullocks varied from 7.5 to 24.5 percent of their body weight, whereas the horse power varied from 0.5 to 1.85 per pair of bullocks. The maximum pull the bullocks could exert varied from 49.5 to 60.5 percent of their body weight. The variation in the draft was mainly due to their breed, type of harness, duration of test and atmospheric condition during the test period.

Premi (1981) described the experiments carried out on four pairs of Halilkar bullocks spreading over winter, summer and rainy season. It was observed that bullocks could pull maximum draft of 13 to 16 percent of their body weight for six hours. The average speed, power and work output of a pair of bullocks in a six-hour working day were 3 kmph, 0.91 hp and 5.23 hp hours respectively. The bullocks performed better in the cool climate than in the hot and humid climates.

Rao and Upadhyay (1982) carried out the study for evaluating the efficiency of the bullocks, specially crossbred bullocks for various agriculture operations (e.g.) ploughing. The experiments were carried out in summer, rainy and winter seasons. The results showed that crossbred bullocks experience less difficulty in carrying the conventional ploughs during agricultural operations, without rest at different intervals of time during summer and rainy season and that it is possible to plough an area of about 480 sqm/h and 4125 sqm/h respectively.

Bola Rashina and Igbeka (1986) classified the use of animal draught as the intermediate stage of mechanization. They examined the advantages and problems of introducing animal draught in the agriculture of a developing country. The net return from 1 ha of groundnut (peanut) farm using animal draught cultivation was 35.7 percent higher than the partial motorized power-operated cultivation and about 52 percent higher than that of entirely manual cultivation. Some of the problems of introducing draught animals include ecological factors like inability of the annuals to survive in
tsetse fly infested parts of the country and shortage of pasture during the dry season.

Sahu (1986) highlighted the status of power available on agricultural farms in the North Eastern Hill Region of India with special reference to draught animals. Though potentially animal power contribution is 01 percent of the total available farm power in this region, it is discouraging to note that draught animals remain mostly unutilized or underutilized contributing only 11 percent of the total requirement. Some possible solutions have been discussed to introduce systems for greater usage of animal power in agriculture in the hilly regions which traditionally depends upon manpower.

In India more than 80 million draft animals are available for various farm operations, which is equivalent to nearly 30 percent of the total power available for agriculture (Sharma et al., 1987).

Gajendra Singh et al., (1989) conducted a study to investigate the performance of bullocks in terms of speed and power developed as a function of their body size, duration of work, draft load and climate. At increased draft load, the speed decreased but power output increased. The speed and power output increased with an increase in body weight. The increase in power rating was 0.03 kW for an increase of 100 kg body weight per animal. In 6 hours, the speed and power developed declined to about three-fourths of those at the start of the work. It was found that the bullocks could pull maximum draft of 13 to 16 percent of their body weight for 6 hours. Their average speed and power in a 6 hour working day were 3 Kmph and 0.08 kW per pair, respectively.

The bullocks’ performance was better in warm climate than in hot or warm and humid climates. The respiration and pulse rates of bullocks increased during work. The increase was rapid in the first hour of work and thereafter, it was slow.

Thakur et al., (1989) studied physiological responses of operators and animals (Murrah buffaloes) during the summer in
rnorning (8-11 am) and afternoon (2-5 pm) periods under field conditions while using a walking type mould board plough 3 tyne cultivator and riding type disc harrow cum puddler. The respiration rate of the operator increased initially but reached steady-state earlier than pulse rate. The respiration rate and rectal temperature of hukaloes increased with the increase in air temperature and decrease in relative humidity but pulse rate increased even after the air temperature showed a declining trend. Ploughing in the afternoon (2-5 pm) with temp of 41.5 deg C during the first hour showed an increase in respiration rate to approximately 52 per cent over ploughing in the morning (8-11 am) with an average atmospheric temperature of 30.75 deg C.

The response of the operator with a riding type harrow remained constant throughout the working period of 3 h and he felt more comfortable. The speed of buffaloes decreased significantly by 7-15 percent after 3 h of work, depending upon implement draught and environmental conditions. For maximum work output, buffaloes should be used either during early morning or late evening periods.

Misra and Singh (1994) found that a pair of bullocks with indigenous implements can control 1.5ha area and a pair of bullocks with improved implements can control 20ha area for the best production.