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Mechanisation of Cotton Production in India

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MECHANISATION OF COTTON PRODUCTION IN INDIA

Introduction

The Green Revolution succeeded in India in raising the farmer's income and yield of major crops because of introduction of high yielding varieties and wide use of synthetic fertilizers and pesticides. Though, this reflects the potential of our agriculture, it is not clear how long it will meet the growing needs of feed our evergrowing population. The problem would be difficult to tackle if we continue to depend only on traditional farming. In the post green revolution period, agriculture production once again has become stagnant and is not able to keep pace with the burgeoning population. The agricultural technology available in 1940's could not have met the demand of the food for today's world population in spite of the revolution. It is just difficult to assume that food requirement of the population by 2020 AD will be supplied by the technology of today. The transformation of India in the last century from a food deficient into a food surplus country shows our achievement that holds as much significance as it's satellite launching and nuclear capabilities. As the country undertakes initiatives now to advance from the status of food security through newer and emerging technologies, the farmer in the field is poised to reap quantum agricultural grains through advanced farming. To meet the forthcoming our agricultural productivity like other countries of the world.

'Cotton' the white gold is one of the most important commercial; crops playing a key role in the economical, political and social affairs of the country. India, today is the third largest producer of cotton in the world. About one third of total crop is irrigated and rest is rainfed. The yield of crop is 307 kg/ha as compared to 783 kg/ha in USA, 659 kg/ha in China and 988 kg/ha in Egypt. Our production levels of this crop satisfactory increased five folds since independence. The current yields tend to linger on lower averages, which has been a matter of concern and a national challenge.

The low yields of cotton are attributed to inadequate inputs, untimely field operation, lack of irrigation (70 % area under rainfed conditions) and inefficient crop production technologies. The land preparation aspect is not given a due consideration in cotton cultivation. The soil and water conservation measures for rainfed crops are usually overlooked. In dryland areas of central India, cotton farmers still use traditional farm implements that have low field capacity and demand lot of energy. Several operations like planting, weeding and picking are labour intensive and during these operations shortage of labour frequently occurs. The delay in completion of operations leads to loss of yield. The intercultural machinery operated by tractors is rarely used. The possibilities of mechanical picking need to be assessed. Similarly the custom hiring system for farm implements requires promotion in rural areas.

Farm mechanization is essentially a judicious mix of resources, implements, machines, and power sources. It involves injecting extra capital into the farming system with a view to increasing labour capacity to do work, defined in terms of quality and / or quality of output per worker. The ability of Agricultural Engineering technologies to increase yields must be attributed to improving the effectiveness of other production technologies, whose full potential can only be realized using advanced machinery. In other words, there does not exist any direct causal relationship between the yields and levels of farm power utilized. But, if mechanization does not keep pace with progress in other agro-technologies, then it can become a yield-limiting factor.

The flight of the talented youth from rural to urban areas is an expression of the perceived poor development prospects in the rural environments. It has been amply demonstrated that the utilization of machines requires a supporting infrastructure offering interesting technical employment possibilities as opposed to the daily manual grind and drudgery associated with subsistence farming. Mechanization of farming operation is the only way of reducing drudgery. This will release women and children particularly from the tedious work of many farming operations to spend their time more productively on other activities. Mechnisation can generate increased ventures, which manifest themselves in a variety of interrelated ways. More area can be brought under cultivation, as capacity to do more work in the available time becomes a possibility. New crop and livestock systems can be practiced as labour output increases because of machanisation, off farm employment opportunities are generated in the servicing sector i.e. manufacturers, dealers, repair workshops of agricultural machinery. We also should not forget that the rural market offers as extraordinary opportunity and no large industry can afford to ignore it. A great opportunity therefore lies in setting up integrated agro industrial complexes at the villages which will integrate best of farming practices, much higher and stable returns for farm products and related activities and value added chains. Our farmers have demonstrated their readiness to adopt new technologies, provided it is economically viable and appropriate. We have proven to the world that the productivity can be improved several times by adopting and transferring technologies at the farm level. Where mechanization is substituted for hired farm labour, cost savings may be apparent to the employer. There is a sense of pride in owing and using machinery.

Mechanization is thus a labour augmenting technology increasing the output per worker rather than output per unit of land. The benefits of mechanization have been greatest where labour is scarce and therefore expensive and /or land is plentiful. This characteristic of mechanization has important implication for its role and impact in the small holder system, where in majority of the cases land, capital and management are limited and labour is generally abundant. All over the world machinery proves one of the most important inputs in cotton production, because of the obvious benefits as discussed above.

1. Land Grading

This process is necessary to provide a more suitable surface to control the flow of water to check soil erosion, proper drainage and to facilitate use of seeders and planters. Irrigated areas benefit greatly from land leveling as uniform application of water to the crop adds to yield. Rainfed areas benefit from moisture conservation, reduced soil erosion and surface drainage. Land levelling operations may be grouped in three phases.

1.1 Rough Grading:

Removal of abrupt irregularities such as mounds and dunes, and filling pits, depressions and gullies.

1.2 Land Levelling:

Requires moving large quantities of earth over considerable distances. Tractor drawn bulldozers are suitable in cutting and pushing earth to short distance of 25 meters. Tractor drown scrappers (terracer blade and heavy carrier type scrappers) are ideal for long distance haulage. Wheeled scrapers and leveller blades are used for medium leveling jobs. Scoop and Buck scrapper are animal drawn. Scoop is used to haul earth for long distance. Buck scrapper is an efficient implement particularly for jobs inn small and medium fields, with haul distance less than 50m.

1.3 Land Smoothing:

Leveling operation leaves an irregular surface due to dumping of soil loads. These are removed by land smoothing operations. It is often done prior to seeding as a regular land preparation activity. Equipment used are planes, levellers and floats. Land plane and levellers are used for medium size fields. Wooden float is used with animal power. Wooden U leveller is a useful animal drawn implement for small fields.

2. Land preparation :

A good tilth is essential before sowing. Deep ploughing (25 to 30 cm) is recommended ever 2-3 years following by 3-4 harrowings and levelling.

2. Tillage Equipments

Tillage is the mechanical manipulation of soil to provide favourable conditions for proper crop growth. Soil tillage consist of breaking the compact surface of earth to roots of the crops to penetrate and spread into the soil. Tillage adds more humus and fertility to soil properly. Water holding capacity of the soil is increased thus reducing the soil erosion. The machinery required for tillage includes power units (human, animal or mechanical) and the proper tillage tool. Self- propelled tillage tools have also been developed such as rotary tillers and oscillating tillage tools.

A: Primary tillage:

It consists of deep opening and loosening of soil to prepare seedbed. Primary tillage implements include different types of mouldborad plough, disc plough, subsoil plough and chisel ploughs.

B: Secondary tillage:

Tillage operation following primary tillage that are performed to create proper soil tilth for seeding and planting are secondary tillage operations. Secondary tillage operations pulverize the soil destroying the grasses and weeds in the field. It brakes the big clods to make the field surface uniform and leveled. Implements used for secondary tillage include different types of cultivators, harrows, levellers, rollers etc.

Bulletins on Cotton Production Technologies would provide sufficient information to the reader to select the best cotton production practices under his conditions, and all of the inputs necessary for maximization of profit. It is not always as easy thing to do, though, as there are factors which can not be predicated accurately or controlled such as rainfall. Having though through this entire system of operation for the year the grower should then determine what must be done to the soil in his field to prepare for planting, keeping in mind the succeeding cultural practices and harvest. After he has decided what changes need to be made to the soil for planting and meeting the specific tillage objectives, he can then select the equipment best suited to make these changes. A wide array of tillage tools exist with different functions, out of which proper ones can be selected for meeting his specific field and soil conditions.

Tillage, per se, does not control plant growth. It can only affect some of the factors that control growth like soil fertility, available water, temperature, oxygen availability etc. For example subsoiling may result in increased cotton production. This would be attributed to the additional water made available to the crop because of the influence of subsoiler.

The cotton plant forms a deep and extensive network of roots hence concentrated tillage is essential for sound growth. The heavier the soil selected the greater the importance of adequate aeration, tilth and mould. Light and medium heavy soils are preferred and tillage is less deep. Therefore traditional and simple methods are still practiced in many regions and hoes are still in use although ploughing is more general. In Vidarbha local plough (Balram plough) equipped with wooden shares and drawn by bullocks is generally used. Mould board ploughs or disc ploughs drawn by tractors till large area.

TYPES OF PLOUGH

The details of commercially available farm implements used for seedbed preparation in cotton crop are given in Table 1. Different types of plough are used at different places. They may be classified as:

1. Indigenous plough
2. Mouldboard plough
3. Disc plough
4. Chisel plough
5. Subsoiler
6. Rotary plough

Table 1: Commercially available farm implements used for seedbed preparation in cotton crop

S.No	Name	Brief specifications and performance details	
A Tractor operated			
1	Mould board plough (mounted)	No. of bottoms	2-3
		plough bottom size, mm	300
		Dimensions, mm	(1778-2362) x (889-1194)x (889-1194)
		Field capacity, ha/h	0.2
2	Disc plough (mounted)	Field capacity, ha/h	0.1-0.4
		Disc size, mm	660-700
		No. of discs	2-3
		Width, mm	991-1118
		Weight, kg	236-320
3	Trailed disc harrow	No. of discs	8-24
		Diameter of discs, mm	457-660
		Weight, kg	350-700
		No. of gangs	2-4
		Pitch, mm	228-280
		Field capacity, ha/h	0.5-1.0
4	Cultivator/Tiller	No. of tines	7,9,11,13,15
		Working width, mm	1370-3070
		Weight, kg	142-345
		Working depth, mm	150-175
		Field capacity, ha/h	0.5-1.8
5	Duckfoot cultivator	Dimension (LxWxH)m	2.25x0.6x0.06
		No. of sweeps	7
		Weight , kg	250
		Field capacity, ha/h	0.7-1.5
		Field efficiency, %	75
6	Rotavator	No. of cutting blades	36-60
		Working width, mm	1500-2500
		Cutting depth, mm	150-200
		Weight, kg	300-500
		Field capacity, ha/h	0.25-0.38
B Bullock operated			
1	Mould board plough	Cutting width, mm	100,125,150,200
		Weight, kg	6.5-12
		Field capacity, ha/day	0.2-0.25
2	Disc harrow	No of discs	4,6,8
		Disc diameter, mm	400-450
		No of gangs	1-2
		Width of cut, mm	800-1200
		Depth of cut, mm	50-120
		Field capacity, ha/day	1.5-1.75
		Weight, kg	80-120

3	Blade harrow (bakhar)	Cutting width, mm	500-600
		Shape of blade	Straight or V shaped
		Weight of blade, kg	4-5
		Weight of implement, kg	25-30
		Field capacity, ha/day	0.5-0.6

2.1 Indigenous plough

Indigenous plough is most commonly used in this country. The shape and size of the plough varies with places and regions due to variation in soil types and tillage requirements. The main parts of the plough are body, share, shoe, beam and handle.

2.2 Mouldboard plough

A mouldboard plough is very common implement used for primary tillage
operation. It is adapted to the breaking of many types of soils and is well suited for turning under and covering crop residues, weeds and pulverizing the soil in one operation. It is not recommended for dryland agriculture where conservation of moisture is important. It also leaves the surface uneven and disturbed along with dead furrows (ditches) and back furrows (ridges). However this can be avoided by the use of two – way plough. For certain field conditions, a number of attachments are used. The coulter is a sharp flat disc or knife blade that cuts through the trash causing reduction in draft. A jointer is a miniature MB ahead of plough share used to plough and cover the residue escaping coverage into three bottoms. Condition of the plough bottom and correct hitching of the plough to the power unit are important factors affecting performance. It is also necessary to make proper adjustments; vertical suction for proper penetration and horizontal suction for proper width of cut before the operation of plough. Proper setting of gauge wheel is necessary for proper depth of operation.

The mouldboard is that part of the plough that receives the furrow slice from the share. It lifts, turns and brakes the furrow slice. To suit different soil conditions and crop requirement, mouldboard has been designed in different shapes. The mouldboard is of the following types (Fig.3.3):

1. general purpose
2. Stubble
3. Sob or breaker
4. Salt

1. **General purpose:** It is a mouldboard having medium curvature lying between stubble and sod. It turns the well- defined furrow slice and pulverizes the soil thoroughly.
2. **Stubble types:** It is a short but broader with a relatively abrupt curvature which lifts, breaks and turns the furrow slice used in stubble soils. This types of mouldboard is not suitable for lands fill of grasses.
3. **Sod or breaker type:** It is used in tough soil of grasses. It turns over thickly covered soil. This is very useful where complete inversion of soil is required. This type has been designed for use in Sod Soils.
4. **Slat type:** This type of mouldboard is often used, where the soil is sticky, because the soild mouldboard does not scour well in sticky soils.

Animal drawn M.B.Ploughs are of two types i.e. fixed type or one way plough and other is Reversible or two-way plough. One way plough throws the furrow slice to the right or left side of direction of travel as required. Such ploughs have two sets of opposed bottoms. In such ploughs all the furrow can be turned towards the same side of the field by using one bottom for one direction of travel and the other bottom on the return trip.

2.3 Disk implements

Disc implements are mounted on ploughs, harrows, stubble breakers, seed drills and other machines. Unlike plough shares they are less choked by fibrous plant remains (weeds, stubble, and roots) and are better suitable to crush dry, parched soil. Accordingly disc ploughs are used to cultivate dry and hard soils to a depth of 25 to 30 cm; disc type stubble breakers are used mainly to break stubble by shallow ploughing to a depth of 5 to 8 cm. A common feature of these implements is the spherical or plane shape of the disc. Spherical discs are used on soil working or cultivating machines. This cutting edge is either continuous or noticed. Discs with notched cutting edges are used on heavy harrows used for final dressing of the soil after it is ploughed.

The principal geometric parameters which govern the nature of interaction between the disc and soil are the diameter D, radius of curvature R, the setting angle of the disc with respect to direction of motion and the inclination of the axis of disc with respect to horizontal plane. The diameter of disc greatly influences the depth of ploughing. With increase of disc diameter, the vertical component of the reaction sharply increases due to which the capacity to plough deep is adversely affected. Hence an additional load has to be provided for the disc to penetrate the soil deeper. The following relationship exists between the depth of ploughing and the diameter of the disc.

$D = k\,a$

Where k is a coefficient equal to 3 to 3.5 for ploughs, 5 to 6 for stubble breaker and 4 to 6 for harrows.

The radius of the curvature governs the crushing ability of the disc. The smaller the radius, the more intensely the soil is crushed and turned over. The angle of attack determines the lateral displacements, overturn and crushing of the soil layer. These parameters increase with increasing angle of attack determines the lateral displacements, overturn and crushing of the soil layer. These parameters increase with increasing angle of attack. It similarly influences the cutting and removal of the weeds and the adhesion of the soil to disc surface. Amounts of soil adhering to surface of disc increases with increasing attack angle. The cutting edge is sharpened from the convex side of the disc. Angle of cutting edge is in between 10 to 25^{o}

DISC PLOUGH

Sometimes called as standard disc plough. It consists of a series of individually mounted inclined concave disc blades on a frame. Which may support it as in the case of trailed type of disc plough. It is most suitable for conditions under which mould board plough does not work satisfactorily. A disc plough can be operated in hard dry soil where a mould board plough may not penetrate, in sticky soil where mould board will not scour, in stray or stumpy fields, in soil containing heavy roots, in soils such as peat lands and in abrasive soils. It is also suitable for deep ploughing.

A trailed type of disc plough is heavily constructed and entirely carried upon three wheels i.e. land wheel, front and rear furrow wheels. The furrow wheels are set normal to the furrow walls and the land wheel vertical. The wheels not only carry the load of the plough but also the side thrust of cutting and turning the furrows. These wheels are adjustable so that the plough disc will cut the desired depth of furrow depending on the soil and the condition of the ploughing. The standard of the front furrow wheel must always be so adjusted that the width of cut of front disc is same as that of the others. For hard dry ploughing a narrow cut is desirable, while for mellow ploughing a wider cut may be used to cut all weed growth and turn a uniform furrow. The front wheel should run straight ahead. The land wheel should run straight ahead with the rear furrow wheel leading to the ploughing to assist in carrying some of the side draft. It also helps steering on the corners.

Disc plough will operate effectively even after a considerable part of the disc blades have been worn off, provided sufficient weight is available to cause them to penetrate to the desired depth. Thus they can be used effectively in hand and extremely abrasive soils. The disc plough is less sensitive to adjustments than is the mould board plough, thus does not require as much skill to keep it functioning. It does not cover crop residue as well as the mould board plough and normally requires about 10% more draft.

Disc plough leaves the soil surface rougher than a mould board plough. This may be disadvantageous if planting is to follow or advantageous if land is to be left fallow. Because a rough surface increases water infiltration while retarding wind erosion.

2.4 Chisel plough

It is plough used to cut through hard soils by means of a number of narrow tynes. It is used before using the regular plough, for breaking hard layers of soil just below the regular ploughing depth. This layer of soil, which is, called hard pan or plough sole is very tough and hard. Brief specification and performance results of Animal drawn Chisel plough for deep tillage is given in Table 2.

Table 2. Breif specification and performance results of Animal drawn Chisel plough for deep tillage

S. No.	Variable specifications	Values
1	Dimensions (length x widthx height) m	1.15 x 0.38 x 1.05
2	Weight, kg	50
3	Radius of curvature of tyne, mm	370
4	No of tyne	one
5	Power source bullocks	Pair of heavy
	Performance results	
1	Width of cut , mm	40
2	Space between successive passes, mm	900
3	Depth of cut , mm	300
4	Operating speed, km/h	2.1
5	Field capacity, ha/h	0.2
6	Draft, N 1200	

It is a myth that subsoiling should be done only when the soil is dry to get more shattering. Very compact soils will shatter just as well when the soil is moist and the power requirement is much less. Chisels are shaped the same as subsoiler but the depth of operation is less and normally they are spaced closer together. Usually if depth of operation is less than 40 cm it is called chiseling.

2.5 Subsoiler

It is plough designed to penetrate the soil to depths more than those achieved during normal ploughing operation. Usually the plough depth may be 40 cm or more. It helps in breaking up of hard pan helping to drain heavy soil, stimulating deep- rooted growth to help crops withstand in drought conditions and aeration of soil.

B: Secondary Tillage

The secondary tillage implements include different types of harrow, cultivators, levelers, clod crushers and similar implements. These operations are generally done on the surface soil of the farm. Secondary tillage operations do not cause much soil inversion and shifting of soil from one place to another. These operations consume less power per unit area compared to primary tillage operations. The main objectives of secondary tillage operations are:

1. To pulverize the soil of the seed beds
2. To destroy grasses and weeds in the field
3. To cut crop residues and mix them with top soil of the field

4. To break the big clods and to make the field surface uniform and leveled.
   Secondary tillage implements mat be tractor drawn or bullock drawn implements.

HARROWS

There are several types harrows used in India such as:

1. Disc harrow
2. Spring tooth harrow
3. Spike tooth harrow
4. Blade harrow
5. Guntaka
6. Triangular harrow

2.6 Disc Harrows:

Disc harrows are used for as great variety of purposes, such as preparation of seedbeds, covering of seeds, destruction of weeds, aeration of pastures etc. Disc harrows are suitable for most fields. The discs are mounted on an axle named arbor bolt. Thus framed gang is given an angle, due to which it cuts the slice of the soil. There are usually three types of disc harrows, namely, single acting, tandem and offset.

The single acting disc harrow has disc blades on two shafts. The shafts are angled in opposite direction so that the soil is thrown out and the soil forces on the two- gangs of discs are balanced. Tandem disc harrows are made up of two sets of single acting discs, one set throwing out and other throwing in. The offset disc harrow is made up of a set of discs on each of two straight axles. One set follows the other, both throwing soil to opposite direction. The soil action resulting from a blade of disc harrow is the same as that of a vertical disc plough.

The disc harrow is often used as a primary tillage tool to prepare a sandy land for cotton. The soil is disked once or more and then planted. Disc harrow also used for controlling weeds on fallow land, cutting up and mixing with soil crop residues such as cotton stalks and cover crops. They are used to pulverize and smooth the soil after ploughing. Disc harrow is an effective tool in compacting the soil immediately below its operating depth. The disc harrow needs a considerable amount of weight on it in ground. The weight is carried on a small axle of the disc. Repeated operation of the discs over a piece of land will leave a compacted layer just below the depth of operation. This layer if not broken off, may cause shallow rooting of the cotton plants.

Spring tooth harrow is used in the soil where obstructions like stones; roots and weeds are hidden below the ground surface. Spike tooth harrow is used to break clods, stir the soil, uproot the weeds, level the ground, break the soil crust and cover the seeds. Blade harrow (Bakher) is used to prepare seed beds mostly in clayey soils. It works like a sweep, which moves into the top surface of the soil without inverting the soil.

2.7 Cultivator

Cultivator is used for inter cultivation with laterally adjustable tines or discs to work between crop rows. This can be used for seedbed preparation and for sowing with seeding attachment. The cultivator can be disc cultivator, rotary or tine cultivator. A cultivator performs functions intermediate between those of plough and the harrow. It may be tractor drawn or bullock drawn.

2.8 Rotavator

The rotating tines are mounted on a shaft, which is driven by a tractor or any engine. These tines take the incremental bites of the soil. The soil thus lifted with impact and shear is rotated along with tines and is them thrown backward. This operation makes the soil well pulverized at a certain forward rotational speed. There are many types of such tines available for varying field conditions.

It is reported that a single stroke of rotavator does the job equivalent to one ploughing and two harrowings simultaneously. Tillage operation is done based on the principal of minimum tillage and has been found very suitable for sandy loam and alluvial soils. Rotavator at lower speeds and with more number of tines is also used for interculturing purpose. Table 3. Presents the results of feasibility trials of tractor operated rotavator for seedbed preparation in case of cotton crop.

Table 3. Results of feasibility trials of tractor operated rotavator for seedbed preparation in case of cotton crop.

S. No.	Variables	Performance characteristics	
		Light soil	Heavy soil
1	Effective width,m	1.35	1.30
2	Forward speed, km/h	3.86 to 3.97	3.86 to 3.97
3	Field capacity, ha/h	0.37	0.34
4	Field efficiency, %	65.66	62.64
5	Wheel slip, %	-2.08	-2.29
6	Fuel consumption, l/ha	8.90	9.05
7	Mean soil clod diameter,mm		
	a. first pass	17.53	20.39
	b. second pass	11.86	17.08
8	Soil inversion, %	91.95	82.54
9	Cost per ha,Rs.	572.0	624.0
10	Cost of land preparation by Tractoe operated blade harrow, Rs./ha		
	a. 2 passes	750	750
	b. 3 passes	1125	1125

Source: Progress report, 1998-99. Akola centre, AICRP on Farm implement and Machinery, Dr.Punjab Rao Deshmukh Krishi Vidyapeeth, Akola.

3. SOWING EQUIPMENTS

3.1 Preparation of field

Preparation of field prior to sowing ensures a porous soil friable and sufficiently aerated. This is done by harrowing once or several times or in case of smallholdings by frequent manual hoeing. The black soil of Vidarbha is prepared for sowing rainfed cotton by harrowing the field 3 or 4 times with blade harrow. The lands are given a deep ploughing only once in 4 to 5 years to remove perennial weeds and to improve drainage property of soil. For irrigated cotton crops the soil is first given one ploughing immediately after the removal of crop. Later on, 3-4 harrowings are given to bring the desired tilth for cotton. The compost of farmyard manure is mixed in the field prior to last harrowing. The weeds are collected and destroyed by burning.

With improved methods of seedbed preparation and consequent increased costs planting accuracy is necessary not only for a desired crop stand but also for saving the very costly seeds. Cotton sowing and established of uniform as well as desired plant population in field are one of the difficult operations in cotton cultivation. Studies at HAU revealed that plant population at farmer's field was too short (35,950- 40660) of the recommended number of 55,000 plants/ha. Mainly due to low seed rates, use of poor quality fuzzy seed and inefficient sowing machinery. (Single row cotton drill and sowing behind the plough by Pora method) Fuzzy seed pose two problems, which need attention. Firstly separating defective, immature, and damaged seed is not feasible and secondly fuzzy seed does not flow freely in seeding tubes. Thus delinted seed is suitable for machine planting. The free flowing characteristic of delinted seed makes them desirable for precision planting. This characteristic will become more important as more high-speed planters are developed and used for cotton. Delinted seed can be metered more accurately which is highly desirable when planting to a stand.

Sufficient research work has been done on the delinting process and development of acid delinters. HAU has developed several models of acid delinters. They can be classified as small, medium and commercial grade acid delinters. The grading of delinted seed can be accomplished by physical sizing or by weight. Cotton planting development has been hampered by the non-uniformity in size and shape of cottonseed. The development of a precision – metering device for planters to select and drop the cottonseed into a furrow is impractical unless the seeds are uniform in size and shape. Alongwith the uniformity in the physical characteristics, the seed must be of uniform quality to permit the use of precision placement. Field and laboratory studies have shown that the highest germination, emergence and yield were obtained from seed sizes in the intermediate classes. Grading seed according to weight has also resulted in germination increases from 80 to 90% by removing the light seeds, which represented 25 % of the initial samples. Other methods result in added cost to the planting seed. However, this cost can be offset since less seed will be required for planting and such treatments increase the reliability of the planting operation.

3.2 Seed Drills and Planters:

Mechanical sowing equipment can broadly be classified as drills and precision planters. In seed drills, seed flows continuously and randomly in furrows whereas, in precision planting seed to seed distance in rows is also checked. On drills, metering of seeds is achieved by one of the commonly available mechanisms like fluted rollers, vertical rotors with cells on edges or gravity systems with adjustable opening and rubber rollers. In case of precision planters, vertical rotors with cells or the horizontal seed plates are used for seed metering. Now – a – days combination of seed and fertilizer placement equipment has gained popularity and seed –cum- fertilizers drills and planters are available. These machines are provided with two separate boxes for seed and fertilizers. Main fertilizer metering systems used are Gravity type and rotor with cells. Table 6. Gives brief Specifications are Performance Results of Seed drill and Planter developed and found suitable for cotton crop.

Table 6.Brief Specifications and Performance Results of Seed drill and Planter developed and suitable for cotton crop.

S. No.	Seeder / Planter	Brief Specifications and Performance Details	
1	Bullock operated cotton planter for vertisols (CICR Design)	Dimensions (lxwxh) mm	700x300x900
		Weight,kg	50
		Number of row	2
		Seed metering mechanism	Cup feed type
		Furrow openers	Shoe type
		Field capacity, ha/h	0.5-0.6
		Cleaning device for Drive wheel	Tapping mechanism
2	Animal drawn seed cum Fertilizer drill (HAU Design)	Dimensions (lxwxh)m	1.25 x 1.15 x 0.65
		Weight,kg	90
		Number of row (when used for cotton)	2
		Seed metering mechanism	Fluted rollers with 12 flutes
		Furrow openers	shoe type
		Power source	a pair of bullock

		Width of coverage,mm	900 (max)
		Field capacity, ha/h	0.15-0.20
		Draft, N	500-600
3	Bullock operated cotton planter (HAU design)	*Dimensions (lxwxh)m*	*1.5x 1.9 x 0.85*
		Number of rows	*3*
		Row to row spacing	*600 mm*
		Width of coverage, mm	*1800*
		Field capacity, ha/h	*0.5-0.6*
		Draft, N	500
4	Animal drawn planter (TNAU design)	Dimensions (lxwxh)m	1.2 x 1.08 x 0.94
		Weight, kg	60
		Number of row	3
		Seed metering	Cup feed type
		Furrow openers	Shoe type
		Power source	A pair of bullock
		Width of coverage, mm	900
		Depth of placement, mm	30-40
		Field capacity, ha/h	0.19
		Draft, N	600
5	Tractor mounted seed Fertilizer drill cum planter (PAU design)	Dimensions (lxwxh)m	2.35 x 1.12 x 0.97
		Weight, kg	220
		Number of row	6 max
		Seed metering	Inclined plate
		Furrow openers	Reversible shovel
		Power source	25 hp tractor & Above
		Seed rate (cotton)	20 kg/ha
		Width of coverage, mm	1800
		Depth of placement, mm	30-50
		Field capacity, ha/h	0.30
		Fuel consumption, l/h	3.0

Speed of the seed plates and number of cells per per plate will decide the seed rate. It is usually determined by the quality of seed and desired plant spacing. The thickness and the design of seed plates and cell dimensions should be selected according to the type of seed used, i.e., gin-run, machine delinted, or acid delinted seed. Calibration of the planter for the desired seed rate for each variety is a must. Tests have shown that seed rate decreases as the ground speed or seed plate speed increases. A decrease in cell fill efficiency occurs as the speed increases.

Next important criterion to seed rate is the uniformity of the spacing along the rows especially where machine harvesting is required. Distribution of seed is also influenced to some extent by the shape of the seed tube. Study has revealed that path of free fall of the seed after it left the seed plate was nearly that of a parabola. Seed tube restricts the free fall of seed or causing seed to bounce from the walls, can cause uneven distribution along the seed furrow.

Furrow openers are used to open a seed trench or furrow. Research has shown that seed furrow should be uniform in width and depth for uniform placement of the seed. Seed furrow should be firm and formed with minimum disturbance is increased, the germination and total emergence decreases. Studies on application of fertilizers in same operation have shown that when soil is disturbed under the seed and the cotton seed are planted in the loose soil, germination and total numbers of seedlings emerged is reduced. This effect increases as the depth of disturbed soil increases. The total emergence was uniform for several depths of placements for the fertilizer. Furrow openers are available in various sizes and shapes. They can be classified into three general categories, viz. Chisel type furrow opener, runner type opener and double disc furrow opener.

Chisel type furrow opener consist of narrow shovel to form the furrow. Chisel openers function well in rough, cloddy soils, where others do not penetrate properly. A narrow furrow opener with extended shields has been found more efficient. The width of such an opener and shield would be about half the standard i.e. 2.5 cm. Clearly defined seed furrow is difficult to form with wide chisel type furrow openers. Although the seed boot or dirt shields may prevent loose soil from falling below the seed, the bottom of the furrow in heavy clay soil is uneven causing non-uniform depth and lateral placement of seed.

Runner type opener is probably the most commonly used furrow opener for planting cotton. Among the two basic types curved runner and stub runner, the former is more popular. Stub runner permits a more compact planter unit than curved runner due to overall length of the latter. Runner opener is extensively used in sandy and sandy loam soils. Gauge shoes or runner wings are used to control the depth of seed furrow and planting. Under dry planting condition standard runner does not function well as it often allows loose soil to fall into the seed furrow ahead of the seed. The opener often forms a loose granular surface at the bottom of the furrow. A modification that has improved the seed contact with the moist firm soil is adding a piece of angle iron in front of the seed opening and directly behind the knife-edge of the opener. The width of opener was decreased for standard 5 cm to 2.5 cm. the sides of dirt shields were extended about 10cm behind the seed tube to prevent loose soil from falling under the seed. This modification results in a narrow V shaped seed furrow, which permits a more positive relationship between the seed and the soil. The V shaped furrow also minimizes lateral displacement of the seed since the seed are funneled down into the narrow trench.

Double disc furrow opener devices are successfully used in trashy and cloddy soils. It opens a clean positive type of furrow under adverse conditions. The seed may not fall to the maximum depth of the furrow, but they establish a fine contact in the soil by wedging in the “V” shaped groove made by the discs, thereby enhancing germination. Positive depth controlled mechanisms are required with disc openers as they tend to penetrate according to fineness of soil. Depth bands mounted on the sides of the discs have proven satisfactory; however the principal problem is that the depth of planting can not be readily changed.

Planting depth is decided by the ability of the soil to retain sufficient moisture in the seed zone during the germination and emergence period. Shallower depths between 2.5 to 5.0 cm have been found to be most desirable. In heavy soils, it is difficult to recompact the loose, granular covering soils to prevent the loss of moisture. The lighter, sandy soils compact easily after being disturbed. Therefore, it is often necessary to plant deeper in heavy soils than sandy soils.

A high precise tractor drawn pneumatic planter has been developed by CIAE and tested for planting small to bold seeds of cereals, pulses and oilseeds. Single seed is metered which reduces the seed rate. It can plant 4-5 ha/day, weights 225 kg. And requires minimum 35 hp tractor to operate.

4. Weeding and Interculturing

Weeding operations are one of the most important bottlenecks occurring in cotton production, particularly where mechanization of the cultivation operation has allowed an increased area of land to be planted. The high temperature and rainfall experienced in many areas cause rapid growth, not only of the planted crop but also of the weeds, which can quickly choke the former unless controlled. The use of chemicals for weed control has some advantages but these are probably reduced in the small holder situation, where the problem of safety and high cost of chemicals becomes more significant. When chemicals can be used safely and effectively as in a well organized no till system; they will probably offer a useful solution to weed control problem in a number of situations. Otherwise a mechanical system is required. This can make a very high demand on labour availability and lack of the ability to control weeds effectively may significantly reduce the gains, otherwise weeds from planting increased areas or using improved seed varieties.

Tools and equipment needed for other crops may be used for cotton crop also. Weeding is usually done manually by khurpi or sickle by small farmers or by blade harrow. Farmers owing tractors use cultivators. However due to height of cotton crop, high clearance machines specially developed for cotton crop are used. Bullock drawn blade harrow gave a better performance compared to bullock drawn three-tine cultivator. Shovel type hoe was found suitable for bullock drawn weeders for cotton crop. Giving an effective field capacity of 0.17 ha/h. however first hoeing operation has to be done by a blade hoe.

A tractor operated high clearance cultivator using full and one half sweeps was developed at HAU Hissar. It has a field capacity of 1.5 ha/h and found to give good result. Different types of shovels can be used depending on local conditions. Lister plough (fig.) may be used at later stages of plant growth. Ridger plough can be used for row crop cultivation and earthling up at later stages of interculturing for better yields. Several models of wheel hoes and bullock drawn harrow are commercially available. The technical details of a few of these units are given in table 7 & 8.

The black soils of central India pose a special problem. It becomes very sticky when wet and hard when dry. There is narrow range of soil moisture condition when weeding can be carried out. On many occasions only one or two days are available for weeding. Hand operated wheel hoes and bullock drawn weeding tools are sometimes not sufficient to complete the job. Tractor drawn high clearance weeder will not be feasible as soil is sticky and tractor can not enter the field. Therefore there is an urgent need to develop a high capacity lightweight weeder suitable for black soils.

Table 5. Brief Specifications and Performance details of manual, bullock drawn and tractor operated weeding tools and implements developed for weeding and interculture in cotton

S. No	Weeding tool/ Implement	Brief Specifications and Performance Details	
1	V Blade hoe (Manual)	Length of handle, mm	1500
		Weight, kg	2.0-2.5
		Features	Either single or 3 V Shaped blades Attached to single Ferrule
		Labour required	1 person
		Field capacity, ha/h	0.0004
2	Wheel hand hoe (Manual)	Dimensions (lxwxh) m	1.3x 0.5 x 0.9
		Wheel diameter, mm	300-400
		Features	Single wheel, V Shaped or straight Cutting blades
		Labour required	1person
		Field capacity,ha/h	0.05-0.07
3	Blade hoe (animal drawn)	Dimensions (lxwxh) m	0.78 x 0.31 x 0.92
		Weight, kg	11
		Labour required	1 person
		Width of coverage, mm	250
		Draft, N	500
		Field capacity, ha/h	0.08
4	Animal operated sweeps (TNAU design)	Dimensions (l x w x h) m	3.0 x (0.22-0.40)x 1.05
		Weight, kg	12

		Width of coverage, mm	300.
		Field capacity, ha/h	0.125
		Draft, kg	30-36
5	Tractor operated High Cleance Cultivator (HAU design)	Dimensions (lxwxh) m	2.3 x 1.25 x 0.5
		Weight, kg	150
		Weeding tool	Full sweep, half sweep Or shovel as per Requirement
		Ground clearance,mm	500
		Power source	25-35 hp Tractor
		Field capacity, ha/h	1.5
6	Ridger (Bullock operated)	Dimensions (l x w x h)m	(0.45-0.78)x (0.42 -0.69)x (0.44-0.50)
		Weight, kg	15-25
		Number of rows	1
		Field capacity, ha/h	0.05-0.07
		Field efficiency, %	75
		Power source	Medium to heavy Pair of bullock
7	Ridger (tractor operated)	Dimensions (l x w x h)m	(1.6-1.9)x1.1x1.1
		Weight, kg	145-285
		Working depth	250
		Width of each ridger, mm	450-600
		Power source	25-35 hp tractor
		Number of rows	3
		Field capacity, ha/h	0.35-0.75
		Field efficiency, %	80

Table 6. Brief Specifications and Performance details of weeders developed for different crops.

S. No.	Weeder Name	Brief specification	
	A. Manual weeders		
1	CIAE three tyne hand cultivator	Dimensions (l x w x h) mm	1770x230x178
		Weight (without handle)	1.8 kg
		Width of coverage, mm	230
		Work capacity, ha/h	0.024
		Labour requirement	I person
2	Twin wheel hoe (CIAE design)	Overall width, mm	175
		Width of blade, mm	110
		Wheel diameter, mm	150
		No. of wheels Weight, kg	2 8.0
		Field capacity, ha/day	0.1
3	Wheel hand hoe (HAU design)	Dimensions (l x w x h)mm	1250x400x(700-950)
		Weight, kg	12

		Width of coverage, mm	90-150
		Field capacity, ha/h	0.05
		Labour requirement	I person
		Suitable for	Sandy and loamy Soil
4	CRRI wheel hoe	Dimensions (l x w x h)mm	1650x400x950
		Weight, kg	6
		Width of cut, mm	150
		Depth of cut, mm	40
		Field capacity, ha/h	0.015
		Labour requirement	I person
5	Wheel hoe with bicycle Wheel rim and sweep Type blade (APU design)	Length, mm	1150
		Blade width, mm	110
		Wheel diameter, mm	650
		Weight, kg	7
		Field capacity, ha/h	0.07-0.09
	B. Bullock Operated weeders		
1	Blade hoe (HAU design)	Dimensions (l x w x h) mm	2800x300x1100
		Weight,kg	20
		Width of coverage, mm	150-300
		Field capacity, ha/h	0.13
		Labour requirement	I person
		Suitable for	Light soil
2	Hoe (Gujarat Agril. Univ. Design)	Dimensions (l x w x h) mm	3000x(225-400)x 1050
		Weight,kg	12
		Width of coverage, mm	225-400
		Field capacity, ha/h	0.2
		Draft, kg	27
		Suitable for	Light and medium Soil
3	Serrated blade hoe (Akola design)	Dimensions (l x w x h) mm	3100x350x900
		Dimensions (l x w x h) mmWidth of coverage, mm	4000x1650x920300
		Field capacity, ha/h	0.125
		Draft, kg	25
4	TNAU sweep	Dimensions (l*w*h) mm	4000*1650*920
		Weight,kg	38
		Width of coverage, mm	1620
		Field capacity, ha/h	0.2-0.3
		Draft, kg	30-36
		Suitable for	All soil type

The cultivator sweeps must be placed so that the cutting edge lies in the horizontal plane. With such a setting a uniform furrow beds as well as satisfactory removal of weeds is obtained. The provision of pointed heel on the inclined cultivator sweep improves its ability to plough deep. However the furrow bed and field surface tend to be uneven. At higher speeds, the soil thrown off increases in magnitude. When heel isinclined upwards, the ploughing is shallow and resistance to motion of the cultivators sweep increases. The operating condition of the harrows and the teeth of the cultivator are governed by the depth of ploughing and the speed with which the implement moves. For most implements an increase in speed leads to shallower ploughing of the soil.

Speed of ploughing has significant effect on other factors as well which affect the quality of soil penetration, such as loosening of the upper soil layer, cutting roots of pervious crops, covering and ploughing in of weeds, leveling of the finished surface of the field, displacement of soil layer etc. implements working on the soil surface at 7-9 km/h loosen the soil better and give an increase in the quantity of clods or lumps of soil of optimal size. (2 to 2.5 cm diameter). Cutting, pulling out and ploughing in roots and weeds, in most cases, improves with an increase in speed of operation. For inter crop cultivation, the quantity of roots left untouched within the working zone of implement decreases. Simultaneously, a large amount of current crop is also ploughed into the soil since more of these plants are dug up and thrown off by the implement.

5. Plant Protection Equipment

Plant protection is one of the major farm operations for cotton crop. Pesticide application for cotton crop accounts for more than 50 % of total pesticide used for agriculture in the country. Sprayers are used for applying insecticides, pesticides, herbicides, fungicides and plant growth regulators. Many types of sprayers and dusters are available in different sizes for plant protection work. The sprayers should produce a steady stream of spray materials in the desired fineness of the particle so that the plants to be treated may be covered uniformly. The sprayer should deliver the liquid at sufficient pressure so that it reaches all the foliage and spreads entirely over the sprayed surface.

Several sprayers have been developed by research institutes which are suitable to cotton crop are:

a. Wide swath sprayer boom for tall crops (IISR)
b. High crop sprayer (GBPUAT)
c. Self propelled high clearance sprayer for cotton (PAU)

6.1 Knapsack Sprayers

Most commonly used sprayers on cotton farms are Lever Operated and Power knapsack sprayers. A lever operated sprayer consists of a tank which will stand erect on the ground and when in use, fit comfortably on operator’s back like a knapsack, a hand operated pump, a pressure chamber and a lance with an on/off tap or trigger valve and one or more nozzles. Droplets in the volume medium range of 120-300 micron with 20-50 droplets/cm^2 of leaf were found effective for cotton pest control. Maintaining a constant pressure while spraying improves the production of uniform size droplets. This can be achieved automatically by incorporating a pressure management valve in the lance. It is possible to reduce upto 60% cost of spraying with this equipment if improved methods of spraying are followed. Power sprayers can be used for quick application of pesticides in dust and liquid form. These sprayers are fitted with two-stroke petrol/kerosene engine of 1 to 1.5 hp. These knapsack sprayers are very effective at the early stage of crop growth. They pose severe problem at later stage of crop growth since movement of operator as well as handling of lances for spraying becomes difficult. Brushing against the treated foliage contaminates the operator. The performance of power sprayer is better due to higher pressure generated by engine and pump and thereby a strong blast of air strikes at higher velocity and shakes the plants. Power mist blowers spray even the undersides of leaves. The field capacity of LOK sprayer varies from 0.4 to 0.5 ha/day while the field capacity of power sprayer varies from 4.0to 5.0 ha/day. A motorized knapsack fitted with a restrictor to give an ULV discharge of Endosulfan at 19ml/min with a blower speed of 4800 rpm was found most effective. A maximum deposit of 60.27% could be achieved within a radius of 3m.

6.2 Advances in Small Sprayers

Controlled Droplet Applicator or CDA sprayers are a recent entry in the cotton arena. In India they are also marketed as Heli sprayers. It ensures correct droplet size for a given target with the uniformity of droplet size, using minimum volume and dose to achieve effective control. A most promising method of controlling size of droplets within a fairly narrow range is by using spinning discs or cups, with which droplet size can be adjusted by varying their rotational speed. These nozzles only operate efficiently when the volume of spray applied is restricted to prevent flooding the nozzle. The droplet size is typically 100 µm which is optimum for cotton pests. Lightweight, with a dc motor to drive the rotating disc, these sprayers carry a liquid reservoir and a power supply in the form of rechargeable batteries. Fully charged batteries can run to cover an area of 10 hectare. These sprayers are gaining popularity because of their lightweight and generation of very small uniform size droplets. The cotton farmers of Dhar district of Madhya Pradesh have achieved a saving of 20-30% chemicals. The mist blower deposits the largest amount of spray on lower surface of middle portion of cotton plant whereas, the heli sprayer deposits the largest amount of spray on the lower surface of lower portion of cotton plants. Study on the efficacy of high volume, low volume and ultra low volume sprayers on control of cotton insect pests found that the fog air sprayer gave the lowest bad kapas content, highest droplet density and good plant coverage. Low volume sprayers are found better than the high volume sprayers for controlling cotton insect pests.

6.3 Tractor Operated Sprayers

These sprayers are tractor PTO operated and are used during early stages of cotton crop. A boom of 6.5m long is fitted with nozzles. The boom can be raised to a height of 30-300 cm and swath width ranges upto 12.1 m. An increase of yield 25-29% is reported inspite of two rows of cotton getting trampled over by the wheels of tractor particularly at later stages of crop growth. To save the crop from being damaged by the tyers, while spraying, shields or fenders can be fitted.

Self Propelled High Clearance Sprayer for cotton

Recently a self-propelled high clearance sprayer for pesticide application in cotton has been developed at PAU Ludhiana. It is operated by 20 hp engine having a ground clearance of 120cm. swath width is 10.8 m. Machine wheel track is 135 cm, accommodating two rows of cotton crop under the chassis. The boom is fitted with 15-18 nozzles and its height can be varied from 31.5 to 168.5cm. the capacity of machine is 1.6 to 2.0 ha/hr with 200-250 l/ha application rate. Tank capacity is 1000 liters. Labour requirement for the operation of this machine 1.5 man-hr/ha.

7. Harvesting

In India most of the cotton, whether rainfed or irrigated, is hand picked by human labour. About 1560 man-hr are required per hectare for picking by this method. A grown up person can pick about 20-70 kg of seed cotton per day, compared to average picks of over 1000kg by an average single row spindle type picker. Manual cotton picking is not only a tedious and laborious work but also costlier. In recent years labour shortages during peak periods of cotton production, have been quite frequent and widespread.

Because of the staggered blooming characterizes of cotton varieties in India, mechanical pickers were not considered suitable for our conditions. Barring a few instances, this area of research and development was not given much attention and a holistic approach has been lacking. But as the biological scientists are gearing up to develop plant types/ varieties amenable to mechanical picking, it is necessary that development/identification of a mechanical picker suitable for Indian conditions is given due consideration to coincide with the advent of such plant types.

Although cotton is entirely hand picked in our country, it still contains about 7% trash, mainly due to deficiencies in labour practice, storage and transportation. Comparing internationally, the trash content in cotton is 2.3-3.2% in USA, 2.3% in Mexico; 2.4% in Egypt and 4.1% in the erstwhile USSR, where most of the cotton is picked mechanically. Due to scarcity of labour, mechanization of cotton harvesting got importance in other countries. In USA only a few bales were harvested with picking machines in 1942. The share of mechanical harvesting of cotton rose from 25% in 1953 to 75% in 1963. At present almost all cotton produced is mechanically harvested in USA. With a similar situation now arising in India, it is expected that the use of mechanical pickers will be useful in minimizing drudgery involved in hand picking as well as enhancing production of cleaner grade of seed cotton. The mechanical cotton picking system will also be helpful in achieving timeliness of operation for the next crop.

8. Micro Irrigation System

Water resources are progressively getting exhausted and competition for available water between agriculture, domestic and industrial sectors is increasing day by day. Drip and other micro irrigation technologies are some methods promoted in agricultural front, to ensure proper use of water irrigation facilities.

In the traditional irrigation methods lot of water is wasted as more than the required water was released. Moreover, as all of it is released at the same time it usually flows away without reaching the roots of the plants. The modern method of drip irrigation came into existence blessed with several advantages of water and fertilizer saving, increase in the productivity with better quality. Reduction in inputs of labour and plant protection, use of saline water and saline soils, low energy with minimum maintenance, minimum expenditure on layouts, application of water under adverse conditions of high winds, extreme high or low temperatures or other natural calamities are some of the attributes of drip irrigation system. In the Drip irrigation system only required amount of water is released and it reaches the roots as well. So it serves the purpose more properly and saves water at the same time. The most outstanding feature of drip irrigation system is that it is not at all location, crop and water quality/ structure specific. It can be used with advantage in undulated, hilly and problematic areas.

Drip irrigation is considered to be most efficient method of irrigation. Irrigation efficiency is more than 90 percent. It saves 60 percent of water as compared to surface irrigation. As the deep percolation losses are prevented, there is efficient use of fertilizers. Only limitation for adoption of this system in India would essentially need initial financial and extension support from the government. The subsidy schemes introduced in India have gone a long way in popularizing the concept.

Drip irrigation system for any crop can be automated using computer. Number of irrigation software are available in market. Considering the importance of DIS, two universities viz. Marathwada Agricultural University, Parbhani and Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola have demonstrated the application of computerized drip irrigation system for cotton production on large area (100 ha). Various other universities and research centres in India conducted the experiments on drip irrigation for cotton. The results reveal that there is a 20 to 30% increase in productivity of cotton.

Components of Drip Irrigation System

1. Pump and motor:

Various types of pumps are motors are available in market. The type of pump and motor can be selected depending upon the water requirement and area to be irrigated. Volute centrifugal pumps operated by engines or electric motors are commonly used. The water pressure required to be developed by the pump should be sufficient to maintain the desired pressure at the laterals. Generally 3hp motor is sufficient for small farmers.

2. Filters:

The filter is the heart of the drip irrigation system, its aim is to minimize or prevent emmiter clogging. The type of filtration needed depends on water quality and on emmiter type. Each type of filter is effective for a particular size and type of suspended material, for a specific flow rate, and has a characteristic capacity of sediment collection.

a) centrifugal sand separators:

These filters are effective in filtering sand, fine gravel and other high-density materials.

b) Gravel filters:

These filters are effective against light suspended material, such as algae and other organic material, fine sand and silt particles. This type of filtration is essential for irrigation water reservoirs in which algae may develop. Reversing the direction of flow and opening the cover cleans the filter. Pressure gauge is placed at the inlet and outlet of the gravel filter to indicate the condition of the filter. If the haed loss is more than 10m (nearly 1 kg/sq.cm.pressure) water, the filter needs cleaning. Automatic self-cleaning filters are also available.

c) Screen filters:

The filters are always installed as an additional safeguard against clogging. The screens are usually cylindrical and are made of non-corrosive metal or plastic material.

The head loss across the filter must be measured periodically. If the head loss is higher than the permissible value, according to manufacturer's specifications for the operational flow rate, the filter needs to be cleaned, during cleaning care should be taken that no foreign material enters the irrigation line.

3. Pipe lines:

A drip irrigation system consists essentially of a main line, submains, laterals and emitters. The main line delivers water to the submains, and the submains into the laterals. The emitters, which are attached to the laterals, distribute water for irrigation. The mains, submains and laterals are usually made of black PVC (Poly Vinyle Chloride) tubings. The emitters are also usually made of PVC material. PVC material is preferred for drip system as it can withstand saline irrigation water and is also not affected by chemical fertilizers.

4. Fertilizer tank:

A fertilizer tank is provided at the head of the drip irrigation system for applying fertilizers in solution directly to the field along with the irrigation water. The dry or liquid fertilizer is placed into the tank. The tank is connected to the main irrigation line by means of a by pass so that some of the irrigation water flows through the tank and dilutes the fertilizer solution.

5. Emitters:

Emitters or drippers are provided at regular intervals on the laterals. They allow the water to emit at very slow rates, usually in trickles. Many types of drippers are available in the market, each with its specific properties, some drippers are pressure compensating and self-cleaning. Drippers may be on line or in line.

6. Other components:

Other components include a valve, pressure regulator, pressure gauge and end caps.

Water requirement of cotton crop

The estimation of crop water requirement is one of the basic needs for crop planning on the farm. Crop water requirement varies with the kind of crop, degree of maturity, soil type and atmospheric conditions such as humidity, wind velocity, sunshine hours, temperature and rainfall.

Depth of water to be applied per day will mainly depend upon the daily consumptive use rate. It is computed from daily pan evaporation values. The depth of water to be applied is calculated by using the equation.

Etc = PE X PE X Kc

Where

Etc = Evapotranspiration of crop, mm/day
i.e. Net depth of water

PE = Pan evaporation, mm

PF = Pan factor (generally taken as 0.7)

Kc = Crop factor (depends on crop growth stage)
The value of Kc for cotton varies from 0.51 to 1.12
(WALMI, Aurangabad)

Volume of water to be applied per day per plant is calculated as:

Volume of water (lit./day/plant) = Etc X plant spacing X % shaded area

Experiments have shown that the water requirement for cottn crop using drip irrigation varies in between 500-700mm depending on climate and soil. The required amount of water is applied in the effective root zone. The soil moisture is always maintained in the range of 70 to 85% of field capacity.

Problems associated with Drip Irrigation System

The drip irrigation system has got following problems which one should consider before adoption of this system.

1. Emitter clogging
2. Soil salinity
3. Improper design
4. Initial investment

1. Emitter clogging:

This is the major problem associated with this system. For long life and efficient working of the system proper care and maintenance is must. Clogging may be physical, chemical or biological. Physical clogging includes sand, silt, clay and suspended inorganic particles, organic plant, animal and bacterial debris, which block the emitter. Dissolved chemicals in irrigation water like calcium carbonate and sodium salts form the chemical clogging. Due to microbial activities the growth of algae and fungi in irrigation water takes place which is responsible for biological clogging.

To overcome these problems the source of water should be kept clean. The gravel filter and sand filter should be washed periodically as per manufacturer's recommendations. The main and submain lines are flushed regularly. End caps of laterals are removed and laterals are flushed section by section. If the chemicals dissolved in irrigation water clog drippers, acid treatment is given. Hydrochloric acid (HCl-36%) introduced in the system for 10 minutes is found effective for removing $CaCO_3$ salts. The frequency of cleaning depends on the concentration of the salts. Regular addition of acid to water at suitable frequency prevents the clogging. To avoid biological clogging chlorination should be followed at least once in a year. Introduce chlorine of 1000 ppm into drip system for 24 hours or 10 ppm for 20 minutes.

2. Soil salinity

The quality of water is prime cause of soil salinity. But use of bad quality water is possible in drip system than surface method. In drip irrigation the salt accumulation in the wetted area is observed. However there is temporary accumulation of salts and it is leached during rainy season.

3. Design

The system should be designed properly considering soil type and soil slope, plants to be grown, pipe size, lateral length etc. for achieving uniform and optimum application of irrigation water. The drip material should be of better quality.

4. Initial investment

The initial investment in drip irrigation system is comparatively high. It can be minimized by changing the crop geometry i.e. following paired row planting technique. The initial cost can be recovered in sequential two years.

9. Glossary

Back furrow: It is a raised ridge, left at the centre of a strip of land when ploughing is started from centre to side.

Brake HorsePower (BHP): Horse power available at the crankshaft and is measured by suitable dynamometers.

Dead furrow: It is an open trench left in between two adjacent strips of land after finishing of ploughing work.

Disc angle: It is the angle at which the plane of the cutting edge of the disc is inclined to the direction of travel.
Draft: Horizontal component of pull exerted on implement.
Drawbar Horse Power: Horse Power actually available at the tractor drawbar for doing work.
Field efficiency: It is the ratio of effective field capacity and theoretical field capacity, usually expressed in percentages.
Horsepower: if the rate of doing work is equivalent to 75-kg meters per sec, it is said to be 1 h.p.
Power take-off: It is a shaft, usually splined externally to transmit rotational power to another machine or equipment.
Power: Rate of doing work, i.e. how much work can be done in a given unit of time such as minute or hour.
Press wheel: It is a wheel, which compacts the soil and covers seed in the furrow.
Tillage: It is the basic operation in farming. It is generally done to create a favorable condition for seed placement and plant growth. These operations include ploughing, harrowing and mechanical destruction of weeds and soil crust etc.
Primary tillage: Operations performed to open up any cultivable land with a view to prepare seedbed for growing crops. Mainly done with heavy implements like ploughs, harrow ploughs and sometime harrows only.
Secondary tillage: Lighter and finer operation performed on the soil after primary tillage, but before and after seed placement, are termed secondary tillage. Operations are generally restricted to surface soil only little inversion and shifting of soil takes place and consequently there is less power requirement per unit area. Implements include harrows, cultivators, sweeps, tillers etc.

Classification of implements based on source of Power:

1. **Hand operated Tools:** Operated by the muscle of human beings with a pulling, pushing or swinging motion. They can be considered as a projection of human hand. Because of limited power at his command man uses these tools foe small-scale jobs on smaller holdings. Working part of the hand tool is made of iron or steel and the handle is generally made of word. E.g. (1) handle type tools like spades shovels, hand hoe, kudali (narrow spade) etc. and (2) wheel type tools such as wheel hoes.
2. **Animal drawn implements:**
   a) Walking type
   b) Riding type

Walking type implements have no provision for the operator to sit. He has to walk behind the implement so as to control it and drive the animals. Generally he has to walk about 64 km to plough a hectare of land. All indigenous plough, cultivators, harrows and seed drills, fall into this category.

Riding type implements have seating provision for the operator and the frame in supported on two wheels. Due to additional load provided by the operators body weight, a pair of large size animals or by more than one pair draw either riding plough.

3. **Tractor drawn implements:** they are operated at higher speeds, cover a larger width and penetrate deeper than implements operated by animals. Tractor drawn implements may be either trailed semi-mounted or mounted types.

- **Trailed** implement is attached to tractor drawbar by a pin joint, main body of implement is supported on the ground. Easy attachment.
- **Semi-mounted** is rigidly attached to the tractor and has a rear wheel to support part of its weight. More time consuming attachment but control is easier.
- **Mounted** implement is attached to tractor as an integral part. It is hydraulically controlled and is kept raised during transport. Steered directly by the tractor hence requires minimum space for turning. Such an implement may be rear or front mounted or it may be mounted in the middle of the tractor body.

---- End of the report ---