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Mechanization in Cotton – An Overview

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Abstract

Cotton is an important cash crop for Indian farmers and plays an important role in the economy of the country. Maximizing production and productivity while minimizing the cost continues to be a great challenge in view of increasing demand for cotton on one hand and increasing labour shortage and cost on the otherhand. Hence, mechanization in cotton cultivation will play a key role in reducing the cost and time. It envisages use of various power sources and improved farm tools and equipment to reduce the drudgery of the human beings and draught animals, achieving precision and timeliness in efficient utilization of various inputs thus reduce the losses. It involves partial or full replacement of traditional human and animal energy by engine-driven equipment. It also enhances energy use efficiency and productivity. The various machinery that can be used for different agronomic operations during pre and post harvest crop period are discussed in the article.

Keywords:

Boom sprayer, cotton, inter cultivation, mechanization, multi crop shredder, picking machine

1. Introduction

Cotton is one of the most important commercial crops that plays a greater role in Indian Agricultural economy. The cotton production in India is plagued by inefficient labor operations, increasing labor wages and labor shortages. Most of the agronomic operations are being carried out manually by farmers. Many states in India especially industrialized ones like Gujarat, Maharashtra, Punjab and Andhra Pradesh, etc., are already facing acute labor shortage due to migration of labor to urban areas and also various employment generation schemes implemented by the government. Though the usage of mechanical power is on the increasing trend, it is mostly restricted to usage of improved hand tools, animal-drawn implements and some extent tractor-drawn machinery. Besides, non-adoption of modern agronomic practices, low level of mechanization can also be considered as responsible for low productivity in India (500 kg ha^{-1}) as compared to other major economies like Brazil (2027 kg ha^{-1}), China (1311 kg ha^{-1}), USA (900 kg ha^{-1}) (Anonymous, 2020). So, there is an ample scope for introduction and upscaling mechanization in the country so as to improve the productivity and profitability in the cotton sector.

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2. Scope and Opportunities for Mechanization in Cotton

2.1. Land preparation

Earlier farmers were using cattle drawn wooden ploughs and blades for various tillage operations. Of late, mouldboard plough or disc plough are being used for deep tillage in summer, which helps in breaking the hardpan, improving the infiltration and water holding capacity, exposing the troublesome weeds, pupae of pests and some of the soil-borne disease-causing organisms to the hot sun. Further, subsoil plough and chisel plough which helps in breaking and chiseling the subsoil and improve soil physical properties, are also available in the market, but, rarely used by farmers. Farmers also started using cultivators, harrows, levellers and rollers for performing secondary tillage with a view to improve soil tilth and control weeds. These days rotavator has become popular for preparing pulverization and good seedbed before sowing.

Deep tillage with MB plough

Deep tillage with disc plough

Secondary tillage with cultivator

Secondary tillage with rotavator

2.2. Sowing/Planting

Traditionally, depending on the spacing (90cmx60-90cm, 100cmx100cm or 120cmx45cm), farmers have been running a cattle drawn wooden marker in north-south and east-west directions followed by sowing the cotton seed at the intersecting points with women labour. In this method, inter as well as intra row spacing can be perfectly maintained. In few places, farmers are following behind the plough sowing in which case uniform intra row spacing can't be maintained. In view of limited sowing window due to larger rainfed area under cotton (>65%) and declining cattle population and manual labour, there is a dire need to mechanize the sowing operation. Seed drills and precision planters can serve the purpose. Tractor-drawn seed cum ferti drills which

perform both the sowing and basal fertilizer application have gained popularity in several crops like cotton, pigeon pea, groundnut, maize etc., Of late, a few advanced cotton planting machines *viz.,* Precision planters, zero till planter for cotton after wheat, vertical rotor precision planter and inclined plate planter as an attachment to happy seeder are available in the market.

Layout for cotton with cattle drawn marker

Manual sowing in cotton

Sowing and basal dose fertilizer application in cotton using seed cum ferti drill

Precision planter for cotton

2.3. Weeding and intercultivation

Traditionally, farmers have been controlling weeds through intercultivation by running the cattle-drawn blade in both directions followed by manual weeding aided by *khurpi* around the plant. However, with the decline in animal population, scarcity of skilled labour for running the cattle-drawn implements and shallow depth of inter cultivation, it is very important to mechanize inter cultivation operation in cotton with the following implements. The intra row space can be weeded using manually operated weed scrapers.

Tractor drawn cultivator: It tills the inter-row space and uproots the weeds. But, it requires a wider row space of a minimum of 120 cm. It covers two rows at a time.

Tractor drawn rotavator: It pulverizes and loosens the inter row space. It uproots and exposes the weeds to the sun. It also conserves moisture through the formation of dust mulch. It also requires a wider row spacing of a minimum of 120 cm and covers only one row at a time. It is mostly operated with mini tractor.

Tractor drawn blade:

Tractor-drawn twin-blade uproots the weeds in the inter-row space and exposes them to the sun. It can cover two rows at a time.

Tractor operated high clearance cultivator/Power tillers/ power weeders:

Tractor-drawn high clearance cultivator will be of great

use for mechanical inter cultivation in a fully grown cotton crop (> 1.0 m height). But, the non-availability of the machines at all places and high cost are the main problems. Further, small engine operated power tillers or power weeders can be used for mechanical inter cultivation till the completion of cotton crop even it is planted at ≥90cm row distance with high efficiency. Its' field capacity is 4.25 hr ha^{-1}.

Self-Propelled precision inter row cultivator:

This was developed by PDKV, Akola, Maharashtra. It is a sweep-type blade inter-row cultivator with a 5 HP diesel engine. It runs at a speed of 2.85 to 3.2 km hr^{-1} and with a field capacity of 0.25 to 0.3 ha hr^{-1}, 48 to 98% field efficiency and weeding efficiency of 85 to 86%.

Wick applicator:

Broad spectrum systemic herbicides can be applied with wick applicators to kill only weeds without harming the cotton plants.

Intercultivation in cotton with cattle drawn blade

Manual weeding around the cotton plant

Manual operated weed scrapers for intra row weeding

Closer view of manual operated weed scrapers

Intercultivation in cotton with tractor operated cultivator

Intercultivation in cotton with mini tractor operated rotavator

Tractor operated twin blade for intercultivation in cotton

Intercultivation in fully grown cotton with power tiller

2.4. Nutrient management

Till date, farmers are applying tank silt, organic manures and inorganic fertilizers manually. Nearly 4-5 labour for three hours are required for one tractor loading and unloading of manure and another 4-5 more labour to apply uniformly over the soil surface. The total labour and time depends on the quantity of manure to be applied per hectare. This is not only laborious but also time-consuming. Hence, JCB can be employed for loading the manure into the tractor or trucks and tractor-operated spinners or dozer can be used for spreading manure uniformly over the entire field to save huge quantity of labour and time. The employment of seed cum ferti drills which have provision for two separate boxes for seed and fertilizers, can help complete seeding and basal dose of inorganic fertilizer application simultaneously and costs only Rs. 2500-3000 ha^{-1} thus saving half of the cost for performing the twin operations as compared to manual method. Further, farmers are applying top dose of fertilizers on the soil surface at the plant base upon receipt of rains during monsoon season and/or they run the blade (danthi) which does both the inter cultivation and covering the fertilizer applied on the surface. So, in case of mechanization, simple tools can be employed for opening the hole at the base of the plant followed by dropping the fertilizer and covering the hole with a leg by labour. Else, manually applied fertilizer at the plant's base can also be covered by running tractor-drawn cultivator/twin-blade/rotavator. But, once the crop grows horizontally and vertically, power tillers can be employed for the same purpose.

2.5. Plant protection equipment

Conventionally, farmers have been using knapsack sprayers for spraying pesticides and water-soluble fertilizer. It requires 7.5-10.0 hours ha^{-1}. So, it is time-consuming and tedious as it requires hand pumping continuously. Later, use of motorized power sprayers were found to reduce the spraying time by 50% (3.75-4.00 hours ha^{-1}) and cover double the area. Now, battery-operated sprayers, an improved version over knapsack sprayers, have come into the market. They avoid continuous hand pumping thus reduces human drudgery, but, it requires frequent power charging. Further, better sprayers/traps viz., s*elf-propelled high clearance sprayer with* a ground clearance of 120 cm and swath width of 10.8 m and coverage of 1.6 to 2.0 ha hr^{-1}; *air sleeve boom sprayer with a* swath width of 8.8 m and field capacity of 2.0 ha hr^{-1} and *whitefly suction trap to* suck the whitefly adults, can be used for effectively in a well grown crop.

Stem application:

Stem application with Monocrotophos+water (4:1) or Imidachlorpid+water (20:1) is recommended at 20, 40, 60 and 80 DAS for controlling sucking pests in cotton. Employing a stem applicator can save 3.1 hours ha^{-1} as it takes only 5.65 hours ha^{-1} against 8.75 hours ha^{-1} for manual stem application.

Drone spraying:

In past few years, drones are being used for plant protection operations in Agriculture in many crops including cotton in the USA, China, Australia, etc., They bring down the production costs enormously and avoiding the man-days and helps in pest and disease control at right time. They can also be used for the defoliation of leaves in cotton to facilitate mechanical picking. However, there is a need to choose the right dose of chemicals and validate the same for using drones for plant protection in India on the lines of other Asian

and Western countries. PJTSAU, Hyderabad is making efforts in this direction in its major crops like cotton, rice, pigeon pea, groundnut, maize etc.,

Battery operated sprayer for spraying pesticides

Power operated sprayer for spraying pesticides

Manual stem application in cotton

Stem applicator in cotton

Tractor mounted boom sprayer

Tractor mounted boom sprayer in cotton

Drones in agriculture

Drone for spraying pesticides in cotton

2.6. Harvesting

Cotton is characterized by perennial nature, indeterminate growth and non-synchronous maturity. The entire cotton production in India is hand-picked by manual labour and each labour can pick 5 kg seed cotton per hour. It accounts for 35% of total production cost (Deshmukh and Mohanty, 2016). There are instances where kapas is left on the plants due to non-availability of labour and enormous increase in picking cost (Rs. 4 to 10-12 kg^{-1}) (Anonymous, 2012). Further, it may also be spoiled due to untimely cyclonic rains. In India, battery-operated handheld cotton-picking machines are available. Employing two machines per 0.4 ha area can reduce the man days by 30% and time by 50%. However, it is costly i.e. Rs. 5,000-6,000 per piece and it is not a substitute for human labour and needs frequent charging. Similarly, though several other cotton harvesting machinery like small cotton harvester with pre-cleaner attachment (ICAR-CICR, Nagpur), tractor-mounted cotton stripper (ICAR-CICR-CIRCOT-Mahindra), tractor-operated cotton stalk puller (PAU, TNAU), boll buggy, cotton picker, cotton module, cotton module truck and front loader with bale handling attachment are manufactured they are not popular among farmers in India due to various reasons. Most cotton in the United States, Europe, and Australia is harvested mechanically, either by a cotton picker, a machine that removes the cotton from the boll without damaging the cotton plant or by a cotton stripper. But, it necessitates pre-cleaning to remove high trash content before sending it to ginning mills. Hence, developed countries are cultivating varieties amenable for mechanization and also using defoliating chemicals to defoliate the cotton plants before employing mechanical picking machines. Hence, such varieties must be bred for Indian conditions so as to fully mechanize the cotton-picking.

Manual picking of cotton

Hand held battery operated cotton picking machine

Field operation of Hand held battery operated cotton-picking machine

High capacity mechanical cotton picking machine

2.7. Residue management

According to Ramanjaneyulu *et al*., (2021), most of the cotton farmers are heaping the cotton residues (stems, locules, leaves and unopened bolls) with or without feeding to the small ruminants followed by burning the same. This is causing environmental pollution and leading to loss of valuable nutrients thus soil fertility. Though, rotavator or slasher can be used, running tractor-drawn multi-crop shredder is the best option as it helps in chaffing the standing crop into tiny pieces and leaving it in the field. Thus, it improves soil fertility, microbial activity and also kills pink bollworm. Moreover, it is less costly and environmentally friendly than manual heaping and burning.

Insitu incorporation of cotton stubbles with rotavator

Tractor operated multi-crop shredder for chaffing cotton stubbles

2.8. Post-harvest processing

Processing of cotton involves three steps as detailed below.

2.8.1. Preparatory process

It involves ginning, blending, carding, combing and drawing. Cotton is ginned in India on commercial size double roller (DR) and saw gins (SG), but are not feasible for ginning of small cotton samples required for assessing fibre quality attributes. The portable ginning machines of ICAR-CIRCOT perform quick ginning of a small quantity of cotton samples to assess the fiber quality for the benefit of cotton traders, graders, ginners and researchers. It helps farmers to obtain seeds for sowing too.

2.8.2. Spinning

Most spinning today is done using break or open-end spinning. This is a technique where the staples are blown by air into a rotating drum, where they attach themselves to the tail of formed yarn that is continually being drawn out of the chamber. Other methods of break spinning uses needles and electrostatic forces. It replaced the traditional mode of ring and mule spinning. It is also is easily adapted for artificial fibers. Generally, cotton fibers are supplied to the spinning mill in the bale (170 kg lint) form. Various spinning machines are used for converting bale into yarn form which in turn leads to fabric preparation.

2.8.3. Machines used in textile production

After the thread, yarn or fibers are turned into a more usable material. They are woven, knitted, tufted or made into a cloth or textile. The textiles are sewn, quilted or

Table 1: Machinery in cotton textiles

Sl. No.	Name of the machine	Purpose
1	Knitting Machines	For knitting yarn
2	Crochet Machines	To crochet yarn
3	Lace Making Machines	To weave thread into lace
4	Weaving Machines	To weave thread, such as a loom
5	Tufting Machines	To make textiles where fur is inserted into a base, like carpets or mittens
6	Quilting Machines	To quilt textiles
7	Cloth Measuring Machines	To measure cloth
8	Cloth Cutting Machines	To cut cloth
9	Industrial Sewing Machines	large sewing machines
10	Monogramming Machines	used to create monogrammed fabric, such as towels with initials on them

they can be layered for different types of insulation or other purposes. The product can also be dyed or treated at different points in the process. The textile is then measured and cut, if necessary, so that it can be shipped to sellers. Various machinery used for different purposes in the cotton textile industry (Table 1).

Knitting machine

Tufting machine

Weaving machine in cotton

Quilting machine in cotton textiles

3. Impact of Cotton Mechanization on Fibre Quality

Mechanically picked cotton contains more trash than manual ones (Aguero et al., 2018). As the cotton pass through the machines during pre-cleaning, the fibre quality gets marginally affected. Though the staple length remains more or less the same, an increase in short fibre content (fuzz) and neps was observed. Further, fiber quality and strength are affected due to stretching of fiber following wrapping of cotton fiber around the spindle bars (Gedam and Mahalle, 2015).

4. Conclusion and Future Perspectives

Adoption of mechanization in cotton cultivation may economize 35-40 man days and 85-90 hours time per ha, thus, reduce the cost of production by Rs. 8,500-9,000 ha^{-1} and increase net income by Rs. 12,000-15,000 ha^{-1}. There are several opportunities for mechanized cultivation of cotton in India. However, it necessitates breeding/introduction of varieties suitable for mechanical picking in India. Farmers need to be educated about need for defoliation. Establishment and proper organization of custom service centers and providers will go a long way in upscaling the mechanization process. Public private partnership is required for development of sutable seeds and machinery for complete mechanization in cotton.

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