Evaluation of Techno-Economic Aspects of Mechanized Cotton Harvesting Process

Prof. P. S. Nerkar, V. S. Gautam, M. M. Bedekar

Department of Mechanical Engineering, St.Vincent Pallotti College of Engineering & Technology, Nagpur, Maharashtra, India

ABSTRACT

Cotton is one of the most important crops throughout the history of India and it also plays an important role in social and economic aspects of the Indian society in the present age. Recent technological advances and trade liberalization have made India a major player in international cotton markets. The overall objective of this paper is to assess the competitiveness of Indian cotton producers and potential implications for India as a competitor in the world cotton market if it mechanizes harvesting of cotton. The study reveals that the net income of the Indian cotton farmers will increase considerably with the mechanization of cotton harvesting. In that scenario, the cotton production in India can increase considerably which can impact the international markets.
Keywords: Cotton Harvesting, Mechanization, Techno-Economic Analysis.

I. INTRODUCTION

Cotton is one of the most important crops throughout the history of India and it also plays an important social and economic role in the Indian society in the present age. India has made tremendous gains in the cotton sector in recent times, as it stood second in the world in terms of production,consumption and exporting in 2015-2016. The increasing role of the Indian cotton sector in international markets is a direct challenge to major cotton exporters like the United States especially in fast growing markets like China. In this context, a better understanding of the Indian cotton production system is necessary in order to comprehend its future role in international cotton markets.

Various reasons have been attributed to the existence of low yields of cotton in India: the inadequate inputs, lack of awareness about modern cultivation practices among Indian farmers, lack of irrigation facilities, lack of proper timing of field operations and too much dependence on labor to cultivate cotton. Along with the above reasons, the shortage of labor along with the associated rise in wages in some fast industrializing areas of India is impacting the profitability of the cotton crop. Within this context, a better understanding of the Indian cotton sector and the impact of mechanization on cotton cultivation are needed to assess India's competitive position in international markets.

The success of mechanization of cotton harvesting depends not only on the availability of suitable harvesters, but also depends upon various other factors. So this paper analyses the impact of mechanical harvesting of cotton on the profitability of Indian cotton farmer as well as the practical feasibility of the adoption of the mechanical harvesting by Indian farmers. In the following section, a brief description of the cotton production and its cultivation aspects, the status of mechanization of farm operations and the status of mechanization of cotton harvesting in India are presented.

II. METHODS AND MATERIAL

2. Cotton Production and Mechanization In India

2.1 Cotton Production in India

Cotton is an important cash crop for Indian farmers. It takes the third place in total acreage planted among all crops in India behind rice and wheat. In the last decade, cotton acreage increased by almost thirty two lakh hectares from 2006 to 2016 as shown in Table 1. Cotton is produced in three zones in India, namely the Northern zone comprising the states of Punjab, Haryana and Rajasthan, the Central zone comprising the states of Maharashtra, Madhya Pradesh and Gujarat, and the Southern zone comprising the states of Andhra Pradesh, Karnataka and Tamil Nadu.

Table 1 : Area, production and productivity of cotton in India from 2005-06 onwards

Year	Area In Lakh Hectares	Production In Lakh Bales Of 170kgs	Yield kgs Per Hectare
2005-06	86.77	241	472
2006-07	91.44	280	521
2007-08	94.14	307	554
2008-09	94.06	290	524
2009-10	103.1	305	503
2010-11	114.4	339	517
2011-12	121.78	367	512
2012-13	119.7	370	525
2013-14	119.6	398	566
2014-15	128.1	380	504
2015-16	118.8	352	504

Source: Cotton Advisory Board

The states of Gujarat, Maharashtra and Andhra Pradesh contribute about three quarters of the total production. Top 6 states in india in terms of area, production and yield are shown in Table 2.
Table 2:

Year	2014-15(P)			2015-16(P)		
State	Area in lakh	Production in lakh bales 170kgs	Yield in kgs per hectare	Area in lakh	Production in lakh bales 170 kgs	Yield in kgs per hectare
Gujarat	27.73	108	662	27.61	101	622
Maharashtra	41.9	78	316	38.27	77	342
Telangana	17.13	57	566	16.94	58	582
Andhra Pradesh	8.21	27	559	6.63	25	641
Karnataka	8.75	31.5	612	6.12	20	556

Source: Cotton Advisory Board (CAB)

2.2 Journey of Cotton Mechanization

Starting from the early 1920s, cotton was still picked by hand and caused a lot of manual labor; people would go day by day picking the flowers from the plants placing them in bags continuing the traditional cotton picking which was in place since long as shown in Fig 1.

Figure 1. Manual Picking in 1920

In the late 1930's,as shown in Fig 2, the first one row cotton picker was developed by John Rust but was not commercially sold since the picker proved to be less durable and so the inventor was reluctant to sell many.

Figure 2. Cotton picking in 1930

Then in the early 1940's, as shown in Fig 3 , the cotton picker was commercially made and sold. The barbed spindles would pick the cotton off the plants and would drop it to the ground this did potentially degrade the cotton but it was mechanical and this meant less labor.

Figure 3. Cotton Picking in 1940

In the 1950's,as shown in Fig 4, the original spindle for the cotton picker was re-designed into a more durable and stronger metal, which could pick multiple rows and had a basket to catch the cotton instead of dropping it on the ground.
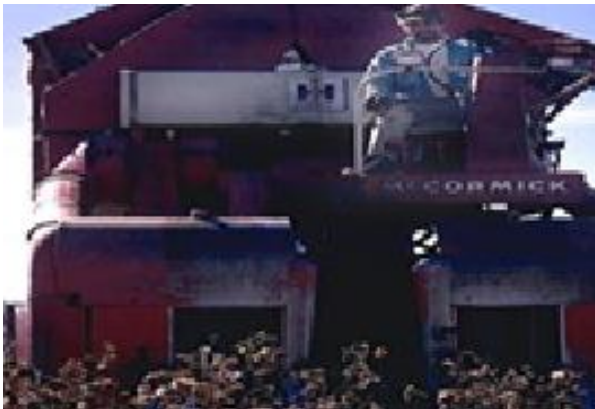

Figure 4. Cotton picking in 1950

From the 1960's to 1980's, various modifications were made in the cotton pickers as shown in Fig 5, keeping the basic concept same. In the 70's the first picker with a driver's cabin was introduced. This ensured the driver's safety and comfort making working on fields a pleasant experience.

Figure 5. Cotton Picker with Cabin

The 4-row cotton picker, as shown in Fig 6, was introduced by John Deere in 1980 which increased operator's productivity by 85-95%. This increased the efficiency of cotton picking to a large extent and was welcomed by the farming community.

Figure 6. Mechanized Cotton Picker

In the late 90's,as shown in Fig 7, the six row cotton picker had been introduced with a large basket on the back this new picker made cotton picking much faster and easier as the cotton was just tipped into a module builder where it was Pressed.

Figure 6. Multi-Row big Basket Cotton Picker

In 2009, as shown in Fig 8, John Deer released the first round baler which picks the cotton, rolls it, places it in a tarp and drops it to the ground. Therefore, less manual labor was needed again and the module builders were no longer needed to press the cotton.

Figure 8. Cotton Baler

2.3 Status of Mechanization of Farms in India

Farm mechanisation in India stands at about 40-45 percent. This is still low when compared to countries such as the US (95 percent), Brazil (75 percent) and China (57percent). While the level mechanisation lags behind other developed countries, the level of mechanisation has seen strong growth through the last decade. The farm power availability on Indian farms has grown from 1.47 kW/ha in 2005-06 to 2.02 kW/ha in 2013-14. In India, the level of mechanisation varies greatly by region. States in the north such as Punjab, Haryana and Uttar Pradesh have high level of mechanisation due to the highly productive land in the region as well as a declining labour force. The state governments in these states have also provided timely support in promoting mechanisation of farms. The western and southern states in the country have a lower level of mechanisation due to the smaller land holdings prevalent in these regions as well as the land holding being more scattered. As a result, in many cases, mechanisation has been uneconomical leading to the lower development. In north-eastern states, the level of mechanisation is extremely low.

III. RESULTS AND DISCUSSION

Operation-wise, the level of mechanisation varies from 42 percent for soil working and seed bed preparation, 29 percent for seeding and planting, 34 percent for plant protection and 37 percent for irrigation. Figure 9 shows farm power availibility in indian farms.
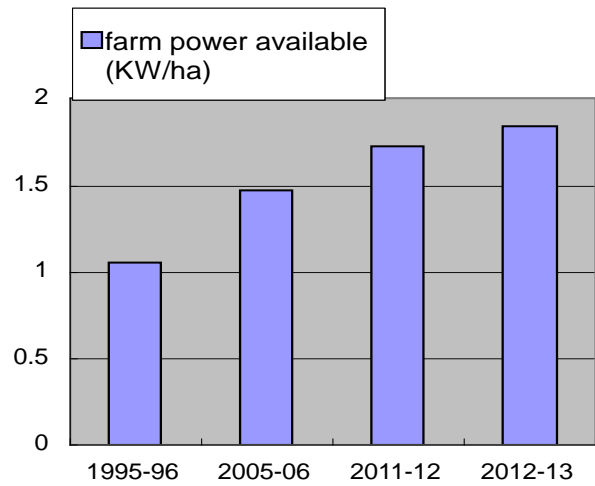

Figure 9. Farm power availibility in Indian farms

In India majority of cotton is hand-picked by human labor spending about 0.9 man-h/kg of cotton and costing almost 10 times than irrigation and two times the weeding costs. Below is the level of mechanization in percentage for cotton.

Crop	Seedbed Preparation	Sowing/ planting /transplanting	Weed and pest control	Harvesting and threshing
Cotton	90-95	50-60	50-60	0

India is lagging behind many other large producers of cotton in mechanization of Harvesting. In the USA, machines harvest the entire cotton crop, whereas in some regions of China, it is estimated that by 2020, about 60% of cotton will be mechanically picked . It is expected that India will soon have to mechanize its cotton harvesting operations as it is facing labor shortages and rising farm wages. It is reported that the labor availability has dropped from 70.3% of the population in 1961 to 48.9% in 2010 and cost of picking cotton from the farm has increased to Rs 10-12 a kg now from Rs 4 in 2007.

Studies have been done on the feasibility of introducing mechanical pickers in India, and most of them have concluded that in order to have a successful introduction of cotton pickers, many other aspects have to come together. The first aspect is about the spacing between the plants in the field. In our visits to the cotton farms in India, we observed that the spacing ranged from 3 feet (inter-row) by 3 feet (inter-plant) to 5 feet (inter-row) by 2 feet (inter-plant), which is much higher than what is

needed for cotton plants to be harvested by mechanical picker. With the above-mentioned range of spacing, the plant population comes to around four to five thousand plants per acre, whereas, from our discussion with industry personnel, it was recommended to have a population of more than 50,000 plants per acre, if mechanical picking is to be done. Secondly, the cotton plant should not be too tall and having many branches, as it will be difficult for the picker to pick all the bolls. Also, the bolls should be well of the ground so that the amount of soil and dirt collected during the picking may be reduced. Studies have shown that the trash content in hand-picked cotton is much less than in the mechanically picked cotton, thereby, creating a need for pre-cleaning of mechanically picked cotton before sending it to ginning mills.

Another important aspect is that all the bolls should come to maturity at the same time, as mechanical picking is expensive to be done multiple times. The plants also need to be treated with defoliants as it is necessary that green leaves should not be present on the plant when cotton bolls are picked up by the machine. The expenditure incurred for mechanical picking also includes the cost of defoliators and their application costs. So in order to have a successful 8introduction of cotton pickers, farmers need to be educated about the new agronomic practices and awareness has to be created about the costs and benefits involved in the mechanical picking of cotton. The mechanical picking of cotton on a large scale is possible if suitable cotton varieties are introduced along with adequate educational and awareness programs for cotton farmers in India.

3.Hand Picking And Mechanical Picking

In Hand Picking,shown in fig 9, the picking is done by hands. Huge amount of labour is required for this process. In this a labour picks the cotton boll manually by hands. This process requires labour hours ranging from 6 to 10 hours a day. Being done by labour the working hours are flexible and also result in low labour productivity. Physical conditions also effect this process as labour being human gets tired and different conditions effect them differently depending on their physical attributes. This process is also time consuming. But this process yields better cotton quality and also in this process the unwanted material is also very low which results in better yield.

Figure 10. Hand Picking

While in machine picking the picking is done by machine. Basically a full-fledged machine or a portable picker is employed for machine picking. In this process the machine takes the complete boll or in case of bigger machine the complete plant is taken out for the process. But in this process the fibre quality is not good compared to the hand picking process since in this there is too much unwanted material. This also is expensive as they are complicated machinery and there is also need for a separator chamber to separate the unwanted material from the cotton which also ads up to the cost. But this process is very productive as it's yield is high. This also is an one time investment. This process is less time consumption and there is no time constraint it can work 24 hours a day also.

Hand picking process is more favourable in India and generally practiced because it yields better quality cotton fibre than machine picking and also there is lack of effective mechanization for cotton harvesting and also less knowledge about the mechanical picking practices and farmers is also unaware of recent advancements in this field in India.

The collaborative cotton mechanization is joint efforts of the John Deere India Pvt. Ltd, Bayer Crop science Limited and Bajaj Steel Industries Limited to develop cotton mechanization in India. The project started in 2009 with the import of 2 row cotton picker from Turkey. But this 2 row cotton picker was found to unsuitable and then John Deere started working on single row picker machine and simultaneously started to collaborate with Bayer and Bajaj steel to build the complete ecosystem for cotton mechanization in India.

Currently cotton mechanization project is being operated in 3 cotton growing states such as Punjab, Maharashtra and Telangana. In Punjab project is being run under public private partnership and is also supported by Department of Agriculture, Punjab. Department of Agriculture Punjab provide the seed subsidies to the farmers who adopt cotton mechanization. It is an integrated approach and the objective of this project is to showcase cotton mechanization technologies.

A farmer who is adopting machine picking needs to overcome the issue of high trash % (compared to hand picking) which is common in all countries that have adopted machine picking. Therefore, after machine picking the seed cotton has to pass through high impact pre-cleaners before ginning. High impact pre-cleaner is already developed in India by Bajaj steel Industries. The need of the hour is that ginning mills needs to install these pre-cleaners so that the machine picked cotton can be ginned and baled with high quality cotton without any trash and contaminants.

4. Selection of Mechanical Cotton Harvester

In India, efforts are being made to design and develop a commercial cotton harvester to harvest selected cotton varieties sown by adopting common agronomic practices locally for cotton cultivation. The crop parameters for two different planting systems (existing planting system prevalent in India and experimental high density planting system) together with machine performance attributes of mechanical cotton harvesters using different types of mechanisms have been reviewed in this paper. Suitable cotton harvester was selected for both type of planting systems on the basis of attribute coding system.

The main crop parameters which affect the performance of a cotton harvester like row spacing, plant height, plant population and crop yield were selected for the study. Machine performance attributes selected were picking efficiency, trash content, gin turnout, field capacity and field losses. Equal wattage was given to all machine attributes like picking efficiency, losses, trash content, gin turnout and field capacity of the cotton harvester. The spindle type cotton picker was best suited to the existing cotton planting system of India.

For mechanization purpose proper planting system is to be adopted. These are

i) Existing Planting System (EPS)
ii) High Density Planting System (HDPS)

4.1 Machine Performance Attributes For Cotton Harvesters

Machine performance attributes include picking efficiency, field capacity, field losses, gin or lint turnout and trash content. The coding/grading of machine attributes can be used to select and design cotton harvester from the available harvesters for different planting systems.

Table 3. Shows the range and coding/grading of machine performance attributes.

Table 3. range and coding/grading of machine performance attributes

S.N	Picking Efficiency		Field Losses		Gin/Lint Turnout		Trash Content	
	Range (%)	Code/Grade	Range (%)	Code/Grade	Range (%)	Code/Grade	Range (%)	Code/Grade
1	<=75	1	<=5	5	<=25	1	<=10	5
2	75-80	2	5-10	4	25-30	2	10-15	4
3	80-85	3	10-15	3	30-35	3	15-20	3
4	85-90	4	15-20	2	35-40	4	20-25	2
5	>=90	5	>=20	1	>=40	5	>=25	1

The additional expenditure incurred due to the above practices in order to mechanically harvest cotton using cotton pickers and the additional revenue obtained due to higher yields are given in table 4.

Table 4. Additional expenditure and additional revenue due to mechanization of cotton harvesting

Expenditure	$/acre
Seed cost and labor	110
Defoliant	50
Mechanized harvesting	45
Total additional expenditure	205
Additional revenue due to higher yields	244

IV. CONCLUSION

This paper analyzed the impact of mechanical harvesting of cotton on the profitability of Indian cotton farmers as well as its implications on cotton supply in the international markets. The more usage of cotton pickers

may lead to increase in yields and thereby increased cotton production in India, which may put a downward pressure on international cotton prices.

Portable cotton picker can improve cotton harvesting efficiency without defoliation. Labor is fast becoming a bottleneck and important cost factor, therefore manual picking will soon become unviable in Indian cotton production. Collaborative efforts by various organizations have successfully demonstrated machine picking is viable in India. Project farmers have experience 30 to 40% yield increase. Mechanization adoption rate will be driven by development of machine suitable hybrids and continuous support from the government.

V. REFERENCES

[1]. G. Majumdar, A. R. Raju, "Evaluation of Portable Cotton Picker", International Journal of Agriculture Innovations and Research, Volume 2, Issue 1, ISSN (Online) 2319-1473, 2013,pp. 104-107.

[2]. S. K. Bal, and S. Sharma,"Ergonomic assessment of cotton harvesting activity with conventional and mechanical methods", (2012),APP-28,16th Punjab Science Congress, Feb7-9th2013, PunjabAcademy of Sciences, Patiala..

[3]. M. R. Chaudhary, "Harvesting and ginning of cotton in the world" Baba Farid University of Health Sciences, Faridkot, 151203, (Punjab) India (2011),Available:www.icac.org/cotton_info/speeches/Chaudhry/ BW97.pdf (online).

[4]. Srinivasa Konduru, "A Study of Mechanisation of Cotton Harvesting In India And Its Implications", Journal of Agricultural Science and Technology, B3 (2013), 789-797, 2013.

[5]. S. S. Kohli1 , Manjeet Singh , Karun Sharma and Gayatri Kansal " Multiple Atttribute Decision Making For Selection Of Mechanical Cotton Harvester", Academic Journals, Vol. 8(48), pp. 2318-2331, 2013,DOI: 0.5897/SRE2013.5641 ISSN 1992-2248.

[6]. R. Kapur, S. Chouhan, S. Gulati, V.Saxena, "Transforming Agriculture Through Mechanisation, A Knowledge Paper on Indian farm equipment sector, 4th International exhibition and conference on agri-machinery and equipments, AGRIMACH INDIA 2015, Dec3-5, 2015, Delhi.

[7]. G. Majumdar, "Mechanisation of cotton production in India", CICR Nagpur,CICR Technical Bulletin.

[8]. A. S. Deshmukh, A. Mohanty, "Cotton Mechanization in India And Across Globe: A Review" International Journal of Advance Research in Engineering, Science & Technology e-ISSN: 2393-9877,p-ISSN: 2394-2444 Volume 3, Issue 1, 2016.