International Journal of Agricultural Sciences ☞DOI:10.15740/HAS/IJAS/19.1/329-335
Volume 19 | Issue 1 | January, 2023 | 329-335 ■ ISSN : 0973-130X Visit us : *www.researchjournal.co.in*

A REVIEW

Cotton harvesting

B. M. Khanpara* **and** V. S. Vala
Department of Farm Machinery and Power Engineering, Junagadh Agricultural University, Junagadh (Gujarat) India (Email : brijeshkhanpara1111@gmail.com; vimalsinhvala2227@gmail.com)

Key Words : Cotton harvesting

View Point Article : Khanpara, B. M. and Vala, V. S. (2023). Cotton harvesting. *Internat. J. agric. Sci.*, **19** (1) : 329-335, **DOI:10.15740/HAS/IJAS/19.1/329-335.**

Article History : Received : 30.09.2022**; Accepted :** 29.10.2022

INTRODUCTION

Cotton (*Gossypium herbaceum*) is one of the most important fibre cash crops of India as well as the world. It is a crop with multiple uses that supplies basic product *viz.,* lint, oil, seed, hulls and linters. Among them lint is the most important product of the cotton plant and provides the much of high quality fibre for the textile industry.

India was one of the earliest civilizations to domesticate, spin and weave cotton. Its economy thrived on cotton by producing one of the finest and most beautiful fabrics from cotton. The first reference pertaining to cotton, so far as is known at present, is to be found in *Hindu Rig-Veda* hymen, which was written about 15 centuries BC (according to most of the scholars). The use of cotton about 800 BC can be noted from the records of Manus "Dharmashastra". The Sanskrit word karpasa-i was used in this literature that is connected to kapas of modern Hindustan. The technological and agricultural term in English, Cotton, which describes cultivated species of *Gossypium,* comes from Arabic word *qutum* or *kutum*.

Cotton belongs to Genus *Gossypium* having 20 species among which 16 are wild type with Short seed Fuzz and 4 are cultivable with spinnable lint. Four cultivable species are *G. arboreum*, *G. herbaceum*, *G. hirsutum* and *G. barbadense*. Among the four species of cotton, *hirsutum* occupied 50 % of total cotton area followed by *G. arboreum* (29 %) and *G. herbaceum* (21 %) *G. barbadense* is with negligible area. Out of total cotton area, 30% is occupied by hybrids.

Cotton fibre accounts for almost 70 % of the raw material mix of the textile industry. The different sectors of Textile industry accounts for 20 % of the industrial production, 7.5 % of the GDP and provide employment to about 27 million persons. Textile industry contributes about 32 % of the foreign exchange earnings of the country (dacnet.nic.in). Maximum cotton produced in India used for domestic purpose and exporting substantial quantities, earning foreign exchange. Recently there is great demand for medium staple cottons.

Cotton is not only a principal cash crop but every part of the cotton plant is also useful to the Indian farmers in one or the other ways. The seeds provide oil and are also used as cattle feed. The stalk is used as fuel and

***Author for correspondence:**

leaves falling on the ground increase the content of the soil organic matter. The most important by-product of seed oil (16-18 %) which is used primarily as a cooking medium and manufacture of margarine, soap, oil, cloth and glycerin. Cotton seed hulls are used as soil mulch. The pressed cake contains about 25 - 30 % protein and can be used as fertilizer. Cotton provides gainful employment to millions of people in the world who are engaged in its cultivation, trading, processing, manufacturing, fabricating and marketing.

According to the International Cotton Advisory Committee (ICAC), the global yield of the fibre crop would be around 25.7 million tonnes (mt), up 6% from the previous year (www.statista.com). India remained the world's second-largest cotton producer, following China, with 6.162 million tonnes (6.423 mt). Cotton is grown in three separate agro-climatic zones in India: the North zone, which includes Punjab, Haryana, and Rajasthan; the Central zone, which includes Maharashtra, Gujarat, and Madhya Pradesh; and the South zone, which includes Tamil Nadu, Karnataka, and Andhra Pradesh. Cotton cultivation is rainfed in nearly 60% of cases, with the remaining 40% being an irrigated crop.

G.herbaceum, *G.hirsutum*, *G.arboreum*, and *Intra-hirsutum* are the most common cotton species grown in India. Apart from *G.hirsutum* and *G.arboreum, G.herbaceum* is grown in Gujarat. So far, 7 *G.hirsutum* varieties, 4 *G.arboreum* variants, and 11 *G.herbaceum*

Table 1 : Cotton properties

Sr. No.	Researcher name	Research topic	Source	Journal name
1.	Mohsenin N. N.	Physical properties of plant and animal materials	Mohsenin (1980)	Gordon and Breach S Publishers
2.	Murugesan R. and Manojkumar T. S.	Picking Force Measurement of Some Cotton Varieties	Murugesan and Manojkumar (1999)	Agricultural Engineering Today
3.	Singh S., Jasdev S. and Ajay S.	Energy and Power Use Pattern in Production Agriculture in Punjab	Singh *et al.* (2002)	Agricultural Engineering Today
4.	Bulent C. M.	Determination of variety effect of simple cotton picking machine on design Parameters.	Bulent C. M. (2003)	Pakistan Journal of E Sciences
5.	Sandhar N. S., Satpathy S. K. and Goyal R.	Prospects of Mechanical Cotton Picking in India	Sandhar *et al.* (2004)	Agricultural Engineering Today
6.	Parvin D. W., Martin S. W., Cooke F. and Freeland B. B.	Effect of Harvest Season Rainfall on Cotton Yield	Parvin *et al.* (2005)	Journal of Cotton Sci
7.	Selvan T. and Raghunathan K.,	Effects of Picking Periods and Average Mass of Seed on Fiber Properties of MCU-5 Cotton	Selvan T. and Raghunathan K. (2006)	Indian Journal of Fib Textile Research
8.	Mygdaos E.	Factors Affecting Picker Capacity, Area Harvested and Harvesting cost of Cotton	Mygdaos,(2009)	Journal of Food , Ag Environment
9.	Goyal R., Singh A., Dixit A., Manes G.	Study on Varietal Characteristics of Promising Cotton Varieties with Reference to their Suitability for using Modern Cotton Picker	Goyal *et al.* (2009)	SKUAST Journal of
10.	Wanjura J. D., Parnell C. B., Shaw B. W., Capareda S. C. and Lacey R. E.	Source Sampling of Particulate Matter Emission From Cotton Harvesting - System Design ad Evalution	Wanjura *et al.* (2009)	Applied Engineering Agriculture
11.	Sui R., Thomasson J. A., Byler R. K., clif Boykin J. and Barnes E. M.	Effect of Machine-Fiber Interaction on Cotton Fiber Quality and Foreign Matter Particle Attachment to Fiber.	Sui *et al.* (2010)	Journal of Cotton Sci
12.	Sabesh M., Prakash A. H., Bhaskaran G.	Shift in Indian Cotton Scenario due to Shift in Cotton Production Technology	Sabesh *et al.* (2014)	Cotton Research Jou
13.	Gora A., Singh R. N. and Chavda J.	Physical properties of cotton bolls (GTHH-49)	Gora *et al.* (2020)	International Journal Microbiology and Ap Sciences

varieties have been released in this state. Two *G.hirsutum* varieties (G.Cot 12 and G.Cot 16), three *G.arboreum* varieties (Sanjay, G.Cot 15 and G.Cot 19), and three *G.herbaceum* varieties (G.Cot 13, G.Cot 17 and G.Cot 19) are now being grown (*www.cicr.org.in*).

Cotton harvesting :

Generally cotton crop cultivation requires sequence of farm operations as seed bed preparation by ploughing and harrowing, sowing by planter or dibbler, interculturing and weeding, plant protection and picking or harvesting. After harvesting of the cotton, the standing stalks are disposed Cotton is harvested either by hand or machine. It is estimated that about 30 % of the world cotton is picked mechanically. All cotton is machine picked only in Australia, Israel and USA. Over 90% of production is machine picked in Greece, Mexico and Spain. China, India and Pakistan are among the five largest cotton producing countries in the world where entire cotton is picked by hand. Two types of machines, strippers and spindle pickers are used to pick cotton mechanically. Strippers are used only in USA (Prasad *et al.*, 2004).

Mechanical pickers are selective in that the seed cotton is removed from the en bolls, whereas green, unopened bolls are left on the plant to mature for later picking. Pickers are more versatile than strippers, tolerating a wider range of plant characteristics and conditions and being less affected by grass and weeds. In high yielding areas and in other areas where serious weather hazards make it important to start harvesting as early as possible, it is common practice to go over the field twice, allowing about 4 - 6 weeks between picking. Under some conditions, the second picking is not economically justifiable.

Strippers, on the other hand, are once over machines. All bolls, whether open or closed, are removed from the plant in a single pass. Harvesting with a stripper is usually delayed until the plants shed their leaves. Strippers predominate over pickers where the plants are small and yields are relatively low. Strippers are most successful with plants having storm resistant bolls and in areas with dry weather during the harvest season. Chemical defoliants and desiccants are sometimes applied to permit earlier stripping.

In India, entire cotton, whether it is rainfed or irrigated, is hand-picked by human labours. It must be

Table 2 : Knapsack type cotton picker

Sr.No.	Researcher name	Research topic	Source	Journal name
14.	Asota C. N.	Field Performance Evaluation of a Manually Operated Cotton Picker	Asota,(1996)	AMA
15.	Murugesan R., Shukla S. K., Arude V. G. and Patil P. G.	Development of Shoulder Mounted Power Driven Cotton Picker	Murugesan *et al.*(2004)	Agricultural Engineering Today
16.	Rangasamy K., Divaker D. and Muthamilselvan M.	Optimization of Machine Parameters of Pneumatic Knapsack Cotton Picker	Rangasamy *et al.* (2006)	AMA
17.	Tajuddin A.	Development and Testing of Engine Operated Pneumatic Cotton Picker	Tajuddin, (2008)	AMA
18.	Muthamilselva M., Rangasamy K., Durairaj C. D. and Manian R.	Knapsack Type Pneumatic Cotton Picker - Physiological Cost Analysis with Indian Worker	Muthamilselva *et al.* (2010)	AMA
19.	Selvan M. M., Rangasamy K. Divaker D. And Manian R.	Knapsack type pneumatic cotton picker: physiological cost analysis with Indian worker.	Selvan *et al.* (2012)	Agricultural Mechanization in Asia, Africa and Latin America
20.	Adebija J. A., Jackson B. A.	Performance Evaluation Of a Manually Operated Cotton Picker	Adebija and Jackson (2013)	African Journal of Agricultural Research
21.	Verma V. K. and Mathur R.	Performance Evolution of Knapsack Portable Engine Operated Cotton Picker	Verma *et al.* (2016)	International Journal of Agriculture engineering
22.	Varun, K., Singi, V. N., Vinay, R., Hiremath R. and Shekar K.	Review on Man Portable Cotton Picking Machine	Varun *et al.* (2020)	International Journal for Research in Applied Science and Engineering Technology

done when more than 35 % bolls are opened. Timely picking of cotton must be followed, and after first picked interval of 15-20 days is to be maintained for second picking.

Manual picking is labour intensive and needs lot of human energy. It is a time consuming and tedious job. All cotton is picked up by hand, which meant collecting each cotton ball individually. There are two positions one could assume in picking cotton. The primary position is bending over, picking the fiber from the bolls, and then depositing it by hand into the cotton sack's opening. A good picker would pick 250-275 lb/day First picking of cotton should be done when 30-35 % bolls open fully (Bolner, 1996).

In case of early picking, small staple length with shrinking quality would be obtained, which will result in sub-standard fabrics and immature fiber obtained from bolls would immediately be darkened. The seed obtained from early picking possesses no any good quality in terms of low seed germination and also low edible oil content.

Table 3 : Mechanical type cotton picker

Sr. No.	Researcher name	Research topic	Source	Journal name
23.	Corley T. E.	Correlation of Mechanical Harvesting with Cotton Plant Characteristics	Corley,(1970)	Trans. Of ASAE
24.	Mahmoud A. H.	Mechanical harvesting of cotton in the sudan	Mahmoud,(1985)	Agricultural Mechanization in Asia, Africa and Latin America
25.	Mahmoud A. H., Bilal B. D., Mohamed S. A. and Simsaa E. A.	Harvesting of acala cotton by machines in rahad scheme in the sudan	Mahmoud *et al.* (1987)	Agricultural Mechanization in Asia, Africa and Latin America
26.	Khalilian A., Sullivan M. J. and Mueller J. D.	Increasing picker efficiency by using a boll saver attachment	Khalilian *et al.* (1999)	The Journal of Cotton Science
27.	Prasad J. and Majumdar G. (1999)	Present practices and future needs for mechanization of cotton picking in India	Prasad J. and Majumdar G., (1999)	Agricultural Engineering Today
28.	Sandhar N. S. (1999)	Mechanized picking of cotton in Punjab	Sandhar,(1999)	Agricultural Engineering Today
29.	Selvan M. M.; Rangasamy K. and Divaker D. (2004)	Development and evaluation of trolley mounted cotton picker	Selvan *et al.* (2004)	Madras Agriculture Journal
30.	Kitsopanidis G., Mygdakos E. and Gemtos T.	Optimum replacement time for cotton picker in Greece	Kitsopanidis *et al.* (2005)	Agricultural Economics Review
31.	Prasad J., Kanpur T., Majmudar G., Sandhar N. S., Patil P. G., Shukla S. K., Jaiswal B. N. and Patil A. B.	Performance Evaluation of Spindle Type Cotton Picker	Prasad *et al.* (2007)	Journal of Agriculture engineering
32.	Selvan M. M. Rangasamy K. and Ananthakrishnan D.	Mechanical picking of cotton – A review	Selvan *et al.* (2007)	Agriculture Review
33.	Wanjura J. D., Holt G. A., Byler R. K., Brashears A. D. and Bakker R. V.	Development of a High Capacity Extractor Cleaner for Cotton Stripper Harvesters - Machine Design and Optimization	Wanjura *et al.* (2009)	Transactions of The American Society for Agricultural & Biological Engineering
34.	Baker K. D., Hughs E. and Foulk J.	Cotton Quality as Affected by Changes in Spindle Speed	Baker *et al.* (2010)	Applied Engineering in Agriculture
	Manes G. S., Mahal J. S., Singh A., Apoorv P. and Kumar D. A.	Performance evaluation of battery operated portable cotton picker	Manes *et al.* (2012)	Indian Journal
35.	Erdal OZ	Performance Evaluation of a Tractor Mounted Mechanical Cotton Picker	Erdal OZ,(2014)	Bulgarian Journal of Agricultural Science
36.	Patel J. S., Patel J., Patel H. D. and Patel V. S.	Design Evaluation and Analysis of Harvesting Cotton Bolls Mechanism in Most and Uneven Condition	Jay *et al.* (2019)	International Journal of Advance Engineering and Research Development

For late picking, there is possibility of losses in lint quality. The lint or seed cotton left on the cotton plant for longer time may come under losses, the continuous dew fall and air blowing carries dust over the cotton that changes the colour of the lint. The speedy winds may shed seed cotton or lint from opened bolls and may be one of source to decrease in per acre yield. The late picked cotton fiber give dirty look, which reduces quality of fineness and shininess of clothes. There is dearth of fiber strength in late picked cotton as poor quality fiber with low stretch of fiber may frequently snap in textile mills and garment factories (Tunio, 2001).

Table 4 : Economics

Sr.No.	Researcher name	Research topic	Source	Journal name
36.	Nelson J., Misra S. K. and Brashears A.	Cost Associated with Alternative Cotton Stripper Harvesting system in Texas	Jeannie *et al.* (2000)	The Journal of Cotton Science
37.	Mygdaos E. and Gemtos T. A.	Reliability of Cotton Picker and Its Effect on Harvesting Cost	Mygdaos *et al.* (2002)	Biosystems Engineering
38.	Umar B.	Comparison of manual and Manual-cum-mechanical Energy Uses in Groundnut Production in a Semi-arid Enviroment	Umar B.(2003)	Agricultural Engineering International: The CIGR Ejou
39.	Muthamilselva M., Rangasamy K. and Sampathrajan A.	Feasibility and Economic Viability of Knapsack Cotton Picker in India	Muthamilselva *et al.* (2007)	Indian Journal of Agricultural Research
40.	Dagistan E., Handan A., Bekir D. and Yalcin Y.	Energy Usage and Benefit-Cost Analysis of Cotton Production in Turkey	Dagistam (2009)	African Journal of Agricultura Research
41.	Venugopalan M. V., Sankaranarayanan K., Bllaise D., Nalayini P., Prahraj C. S. and Gangaiah B.	Bt Cotton in India and Its Agronomic Requirement - A Review	Venugopalan *et al.* (2009)	Indian Journal of Agronomy
42.	Isin f., Isin S. and Uzmay	Economic Analysis of Cotton Production and Adoption of Harvest Mechanization: A Case Study of The Aegean Region of Turkey	Isin *et al.* (2009)	Journal of Food , Agriculture Environment
43.	Nelson J. M., Misra S. K. and Brashears A. D.	Cost Comparison of Alternative Stripper and Picker Cotton Harvesting Systems	Nelson *et al.* (2010)	Applied Engineering in Agriculture
44.	Selvan M. M. and Rangasamy K. (2011)	Economic cost and adoption feasibility of gender friendly walking type pneumatic powered cotton picker for Indian cotton farms	Selvan and Rangasamy (2011)	Madras Agriculture Journal
45.	Patel S. R. and Gajakos A. K.	Effect of Mechanization on Cost of rainfed Cotton Cultivation in Vidarbha	Patel *et al.* (2015)	International Journal of Agriculture engineering

Table 5 : Ergonomics

Sr.No.	Researcher name	Research topic	Source	Journal name
46.	Ghugare B. D.,Adhaoo S. H., Gite L. P., Pandya A. C., and Patel S. l.	Ergonomics Evaluation of a lever-operated Knapsack Sprayer	Ghagure *et al.* (1991)	Applied Ergonomics
47.	Goyal M. R., Byg D. M. and Singh K.	Appropriate Technology for Cotton Production in India	Goyal *et al.* (1979)	AMA
48.	Tewari V. K., Ailavadi R., Dewangan K. N. and Sharangi S.	Rationalized Database of Indian Agricultural Workers for Equipment Design	Tewari *et al.*(2007)	Agricultural Engineering International: The CIGR Ejournal

Due to scarcity of labour and higher cost of manual picking, need for mechanization of cotton harvesting is being realized. Because of the staggered blooming characteristics of Indian cotton plants, mechanical harvesters were not considered suitable for Indian conditions. As the biological scientists are gearing up to develop suitable plant type amenable to mechanical picking, it is high time to develop suitable technology and equipment for mechanized cotton harvesting system in India.

The average value of picking force ranged from 2.03-2.55 N for the cotton varieties G.Cot.12, G.Cot.18 and RCH-2 (Bt), respectively (Sandhar *et al.*, 2004). The power requirement to suck the cotton from the fully opened boll was 11.52 W.

REFERENCES

Adebija, J. A. and Jackson, B. A. (2013). Performance evaluation of a manually operated cotton picker, *African J. Agric. Res.*, **8** (29) : 3883-3887.

Asota, C. N. (1996). Field performance evaluation of a manually operated cotton picker. *AMA*, **27** (4) : 24-26.

Baker, K. D., Hughs, E. and Foulk, J. (2010). Cotton quality as affected by changes in spindle speed. *Applied Engg. in Agriculture*, **26** (3) : 363-369.

Bolner, J. (1996). Picking cotton is beyond any doubt, the most inhumane labor a person can perform picking cotton. *www.spillwayreview.com.*

Bulent, C. M. (2003). Determination of variety effect of simple cotton picking machine on design Parameters. *Pakistan J. Biological Sciences*, **6**(7): 640-643.

Corley, T. E. (1970). Correlation of mechanical harvesting with cotton plant characteristics. *Trans. of ASAE*, **13**(6): 768-778.

Dagistan, E., Handan, A., Bekir, D. and Yalcin, Y. (2009). Energy usage and benefit-cost analysis of cotton production in Turkey. *African J. Agril. Res*., **4** (7): 599-604.

Erdal, O.Z. (2014). Performance evaluation of a tractor mounted mechanical cotton picker. *Bulgarian J. Agric. Sci.*, **20**(2): 487-496.

Ghugare, B. D., Adhaoo, S. H., Gite, L. P., Pandya, A.C. and Patel, S. L. (1991). Ergonomics evaluation of a lever-operated knapsack sprayer. *Applied Ergonomics*, **22**(4): 241-250.

Gora, A., Singh, R. N. and Chavda, J. (2020). Physical properties of cotton bolls (GTHH-49). *International J. Curr. Microbiol.& Appl. Sci.*, **9**(6): 4064-4069.

Goyal, M. R., Byg, D. M. and Singh, K. (1979). Appropriate technology for cotton production in India. *AMA*, **10**(2):73-78.

Goyal, R., Singh, A., Dixit, A. and Manes, G. (2009). Study on the varietal characteristics of promising cotton varieties with reference to their suitability for using modern cotton picker. *SKUAST J. Res.*, **8**(1): 15-18.

Isin, F., Isin, S. and Uzmay, A. (2009). Economic analysis of cotton production and adoption of harvest mechanization: a case study of the Aegean Region of Turkey. *J. Food, Agric. & Environ.*, **7** (2) : 387-393.

Khalilian, A., Sullivan, M. J. and Mueller, J. D. (1999). Increasing picker efficiency by using a boll saver attachment. *The J. Cotton Science,* **3** : 122-125.

Kitsopanidis, G., Mygdakos, E. and Gemtos, T. (2005). Optimum replacement time for cotton picker in Greece. *Agric. Econ. Rev.,* **6**(1): 54-63.

Mahmoud, A. H. (1985). Mechanical harvesting of cotton in the sudan. Agricultural Mechanization in Asia, *Africa & Latin America,* **16** (4).

Mahmoud, A. H., Bilal, B. D., Mohamed, S. A. and Simsaa, E. A. (1987). Harvesting of acala cotton by machines in rahad scheme in the sudan. Agricultural Mechanization in Asia, *Africa & Latin America,* **18** (2).

Manes, G. S., Mahal, J. S., Singh, A., Apoorv, P. and Kumar, D. A. (2012). Performance evaluation of battery operated portable cotton picker. *Indian J.,* **49**(4): 269-272.

Mohsenin, N. N. (1980). *Physical properties of plant and animal materials.* Gordon and Breach Science Publishers, N W, New York, U.S.A.

Murugesam, R. and Manojkumar, T. S. (1999). Picking force measurement of some cotton varieties. *Agricultural Engineering Today,* **23** (5-6): 56-62.

Murugesan, R., Shukla, S. K., Arude, V. G. and Patil, P. G. (2004). Development of shoulder mounted power driven cotton picker. *Agril. Engg. Today*, **28**(1&2): 54-58.

Muthamilselvan, M., Rangasamy, K. and Sampathrajan, A. (2007). Feasibility and economic viability of knapsack cotton picker in India. *Indian J. Agril. Res.*, **41**(2): 86-91.

Muthamilselvan, M., Rangasamy, K., Durairaj, C. D. and Manian, R. (2010). 8 Knapsack type pneumatic cotton picker-Physiological cost analysis with Indian workers. *AMA*, **41**(3): 41-45.

Mygdakos, E. and Gemtos, T. A. (2002). Reliability of cotton pickers and its effect on harvesting cost. *Biosystems Engg.*, **82** (4): 381-391.

Mygdakos, E. (2009). Factor affecting picker capacity, area harvested and harvesting cost of cotton. *J. Food, Agriculture & Environment,* **7** (3): 214-223.

Nelson, J., Misra, S. K. and Brashears, A. (2000). Cost associated with alternative cotton stripper harvesting system in texas. *The J. Cotton Science*, **4** : 70-78.

Nelson, J. M., Misra, S. K. and Brashears, A. D. (2001). Cost

comparison of alternative stripper and picker cotton harvesting system. *Applied Engineering in Agriculture,* **17**(2): 137-142.

Parvin, D. W., Martin, S. W., Cooke, F. J. and Freeland, B. B. J. (2005). Effect of harvest season rainfall on cotton yield. *J. Cotton Science*, **9** (3) : 115-120.

Patel, J. S., Patel, J., Patel, H. D. and Patel, V. S. (2019). Design evaluation and analysis of harvesting cotton bolls mechanism in most and uneven condition. *Internat. J. Adv. Engg. & Res. Develop.*, **6** (5): 21-28.

Patel, S. R. and Gajakos, A. K. (2015). Effect of mechanization on cost of rainfed cotton cultivation in Vidarbha, *Internat. J. Agric. Engg.*, **8**(1): 92-96.

Prasad, J. and Majumdar, G. (1999). Present practices and future needs for mechanization of cotton picking in India. *Agricultural Engineering Today*, **23** (5-6).

Prasad, J., Kapur, T., Majmudar, G., Sandhar, N. S., Patil, P. G., Shukla, S. K., Jaiswal, B. N. and Patil, A. (2004). Technology and equipment for harvesting, cleaning and ginning of cotton. *Technical Bulletin* No. CIAE/2004/113, CIAE, Bhopal.

Prasad, J., Kapur, T., Sandhar, N. S., Majumdar, G., Patil, P. G., Shukla, S. K., Jaiswal, B. N. and Patil, A. B. (2007). Performance evaluation of spindle type cotton picker. *J. Agril. Engg.*, **44**(1): 38-42.

Rangasamy, K., Divaker, D. and Muthamilselvan, M. (2006). Optimization of machine parameters of pneumatic knapsack cotton picker. *AMA*, **37**(3): 9-14.

Sabesh, M., Prakash, A. H., Bhaskaran, G. (2014). Shift in Indian cotton scenario due to shift in cotton production technology, *Cotton Research J.*, **6**(1): 75-82.

Sandhar, N. S. (1999). Mechanized picking of cotton in Punjab. *Agricultural Engineering Today,* **23** (5-6) : 21-27.

Sandhar, N. S., Satpathy, S. K. and Goyal, R. (2004). Prospects of mechanical cotton picking in India. *Agril. Engg. Today*, **28** (3-4) : 34 - 41.

Selvan, M.M., Rangasamy, K. and Divaker, D. (2004). Development and evaluation of trolley mounted cotton picker. *Madras Agric. J.*, **91** (7-12) : 433-440.

Selvan, M. M., Rangasamy, K. and Ananthakrishnan, D. (2007). Mechanical picking of cotton – A review. *Agriculture Review*, **28** (2): 118-126.

Selvan, M. M. and Rangasamy, K. (2011). Economic cost and adoption feasibility of gender friendly walking type pneumatic powered cotton picker for Indian cotton farms. *Madras Agric. J.*, **98** (4) : 193-196.

Selvan, M. M., Rangasamy, K., Divaker, D. and Manian, R. (2012). Knapsack type pneumatic cotton picker: physiological cost analysis with Indian workers. *Agricultural Mechanization in Asia, Africa &Latin America,* **41**(3).

Selvan, T. and Raghunathan, K. (2006). Effects of picking periods and average mass of seed on fibre properties of MCU-5 cotton. *Indian J. Fibre &Textile Res.*, **31**(2): 346-352.

Singh, S., Jasdev, S. and Ajay, S. (2002). Energy and power use pattern in production agriculture in Punjab. *Agril. Engg. Today*, **26** (5&6): 74-83.

Sui, R., Thomasson, J.A., Byler, R. K., Clif Boykin, J. and Bames, E. M. (2010). Effect of machine-fibre interaction on cotton fiber quality and foreign matter particle attachment to fiber. *J. Cotton Science*, **14**(3): 145-153.

Tajuddin, A. (2008). Development and testing of engine operated pneumatic cotton picker, *AMA*, **39**(4): 37-38.

Tewari, V. K., Ailavadi, R., Dewangan, K. N. and Sharangi, S. (2007). Rationalized database of Indian agricultural workers for equipment design. *Agril. Engg International: The CIGR Ejournal*, **9** : 1-12.

Tunio, S. (2001). Cotton picking-measure for clean and high standard cotton. *A Report* published by the Department of Agronomy, Sindh Agricultural University, Tandojam, Pakistan.

Umar, B. (2003). Comparison of manual and manual-cum-mechanical energy uses in groundnut production in a semi-arid environment. *Agricultural Engineering International: The CIGR Ejoumal*, Manuscript EE03 **003** (V).

Varun, K., Singi, V. N., Vinay, R., Hiremath R. and Shekar, K. (2020). Review on man portable cotton picking machine, *Internat. J. Res. Appl. Sci. & Engg. Technol.*, **8**(4).

Venugopalan, M. V., Sankaranarayanan, K., Blaise, D., Nalayini, P., Prahraj. C.S., and Gangaiah, B. (2009). Bt cotton (*Gossypium* sp.) in India and its agronomic requirements - a review. *Indian J. Agronomy*, **54**(4): 343-350.

Verma, V. K. and Mathur, R. (2016). Performance evolution of knapsack portable engine operated cotton picker. *Internat. J. Agric. Engg.*, **9** (2): 156-162.

Wanjura, J. D., Holt, G. A., Byler, R. K., Brashears, A.D. and Baker, R.V. (2009). Development of a high capacity extractor cleaner for cotton stripper harvesters machine design and optimization. *Trans. American Society for Agril. & Biological Engg.,* **52** (6) : 1821-1829.

Wanjura, J. D., Parnell, C. B. J., Shaw, B. W., Capareda, S. C. and Lacey, R. E. (2009). Source sampling of particulate matter Emissions from cotton harvesting system design and evaluation, *Applied Engg, in Agriculture*, **25**(1): 85-96.