TECHNICAL REPORT

on

Design and Development of a Cotton Picking Head

Funded by

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Participating Agencies

Punjab Agricultural University, Ludhiana

ICAR-Central Institute for Cotton Research, Nagpur

CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana

CSIR-CMERI CENTRE OF EXCELLENCE FOR FARM MACHINERY

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TECHNICAL REPORT

1. **Title of the project:** Design and Development of a Cotton Picking Head
2. **Principal Investigator(s) and Co-Investigator(s):**
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3. **Implementing Institution(s) and other collaborating Institution(s):**
   Punjab Agricultural University, Ludhiana
   ICAR-Central Institute for Cotton Research, Nagpur
   CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana
4. **Date of commencement:** 01.04.2010
5. **Planned date of completion:** 31.03.2013
6. **Actual date of completion:** 31.12.2017
7. **Objectives as stated in the project proposal:**
   - ✓ Conduct basic studies on the design of cotton picking head.
   - ✓ Design & development of a working model of a cotton picking head which can be operated by an engine for a self propelled machine and can also be tractor mounted driven by tractor PTO.
   - ✓ To evaluate the performance of the working model of the cotton picking head in actual field conditions and modifications thereof.
8. **Deviation made from original objectives if any, while implementing the project and reasons thereof:** No
9. **Experimental work giving full details of experimental set up, methods adopted, data collected supported by necessary table, charts, diagrams & photographs:**

   Collection and review of literature

   Scope and project need identified for cotton harvesting. Literature has been collected and initiated the process of research.

   Varietal Characteristic Required for Mechanical Harvesting:

   Smith and Jones (1948) described the ideal variety for stripping as one producing a semi dwarf plant having relatively short-fruiting, short-noded branches. Storm resistant bolls borne singly but having fairly fluffy locks for good extracting and a medium size boll stem that can be pulled from the limb with a force of 13 to 22 N. Stripping a variety that produce a wide, spreading plant with numerous vegetative and fruiting branches results in low recovery of cotton and excessive field losses. The plants should be determinate in their growth and fruiting characteristics, with a short fruiting period and early, uniform maturity for mechanical picking of cotton. The size of the plant, the type of growth and the nature of the boll all have more influence on the efficiency of the mechanical

picker than does the yield. Where the plant characteristics are suitable, a machine will pick high yielding cotton just as efficiently as it will low yielding cotton. Corely (1970) has pointed out that it takes approximately 100000 cotton bolls to produce one 225 kg bale of lint. Since there are 4 or 5 locks in each boll, there are over 400000 opportunities for picker losses with the harvest of each bale. Therefore the physical characteristics of the boll influence the effectiveness of spindle pickers.

There is the urgent need of cotton picking machines, but challenges for cotton picking in India are cultural, practices and staggered bloom characters of present Indian varieties. Sharma and Goyal (1999) reported that there were three manual pickings in a crop season at an approximate interval of 15 days. The first, second and the third picking constituted 35, 50 and 15 % of the cotton yield respectively. Goyal et al (2009) studied the varietal characteristics of promising cotton varieties with reference to their suitability for using modern cotton picker. The row to row spacing was 67.5 cm and plant to plant spacing was 90 cm. The plant height of cotton varieties were ranged from 50-120, 62-120 and 52-100 cm approximately. The average plant canopy having width along the row and across the row for varieties was 65.0 & 60.0 cm approximately. Number of monopods for these varieties ranged from 1-4. Number of sympods for varieties was in the range of10-40. Height of lowermost sympoidal branch for varieties was 18.0. Height of lowermost and uppermost boll for varieties was 20.0 and 80.0 cm approximately. Sizes of open boll for these varities were 4.5- 5.5 cm. Total number of bolls per plant for these varieties was 20-25 respectively.

Hirsutum cottons can hold locks for a longer period of time without letting the seed cotton fall on the ground. But, if cotton is not picked for weeks and months, it slowly gets loose and ultimately falls on the ground. In G. arboreum varieties, burs do not possess enough holding force to keep seed cotton sticking in the burs (Chaudhry, 1995). It is easy to pick such a cotton but requires more frequent pickings. In China (Mainland), India, Myanmar and Pakistan, where such cottons are grown on significant area, as many as 8-10 picks are very common. Thus arboreum varieties are not suitable for machine picking as locks fall to the ground quickly. Upland cotton locks which fall to the ground are usually loose, but arboreum locks remain more or less intact. G. barbadense types are almost like hirsutum cottons. Most varieties belonging to G. herbaceum are very difficult to pick because of the position of burs after opening. Bolls are smaller and locks after opening are positioned such that each lock has to be picked separately. Varietal differences do exist within all species

Pneumatic picking type cotton harvester

Sandhar and Goyal (2003) tested suction principle for cotton picking. The cotton picker consisted of a blower, tank and suction hose. The components were mounted on a frame hitched to the three point linkage of a tractor. The drive to the blower was provided from tractor PTO through gear box. The picker had the picking efficiency in the range of 63.4 to 77.5 % at suction pressure of 240 mm of water head at the blower speed of 2875 rpm. The machine picked the fully open bolls but left the cotton bolls which were either infected or rigidly adhered to the carpel. The infection dependent upon the season but adherence depended upon variety. The manually picked cotton after machine operation ranged from 22.5 to 36.6%.

Rangaswamy et al (2006) conducted a study for optimization of machine parameter of pneumatic knapsack cotton picker. The dimensions of the machine components viz., pickup diameter, filter type, filter height, capacity of collection drum and speed of aspirator were optimized through statistical analysis. The combination of a 25 mm diameter pickup pipe, a nylon mesh filter 225mm high, a 25 litre collection drum and a 5500 rpm aspirator speed developed maximum pressure. It was found that the field capacity for the first picking (4.93 kg/h) was less than that for the third picking (5.07 kg/h). The picking efficiency was lower (96.35%) in the first picking and higher (97.48%) in third picking. The trash content in the machine picked cotton was a maximum of 13.97% in third picking. The saving labour cost, time and energy in machine picking compared to conventional picking was 9.00, 75.00 and 68.23% respectively.

Ankit (2008) developed a tractor operated pneumatic cotton picker for cotton picking machine comprises a vacuum pump provided to create a predetermined vacuum and a cotton picking unit having single nozzle. Preliminary testing of the developed picking aid was done in the field using various combinations of the picker end diameters (20, 25, 32 and 40 mm) and suction pressures (25, 30, 35, 40, 45 and 50 mm of Hg) to study their effect on picking efficiency, trash content and output capacity. Maximum picking efficiency of 96.3 % was achieved at 25 mm of picker end diameter with suction pressure of 45 mm of Hg. Minimum trash content of 0.65 % was observed at 20 mm of picker end diameter with suction pressure of 30 mm of Hg. Maximum output capacity of 6.25 kg/h was achieved at 25 mm of picker end diameter with suction pressure of 45 mm of Hg. Picking aid was then evaluated for long term field trials with optimized picker end diameter (25mm) at varying suction pressures (35, 40, 45 and 50 mm of Hg) for two stages of picking. Though the picking efficiency and output capacity was

maximum at 50 mm suction pressure for first picking but trash content increased at this suction pressure. However minimum trash content of 5.7 % was obtained at 35 mm of Hg with picking efficiency of 93.9 % and output capacity of 4.2 kg/h. Similarly, for second stage of picking, minimum trash content of 4.39 % was observed at 35 mm suction pressure with picking efficiency of 92.8 % and output capacity of 4.01 kg/h.

Patil et al (2015) developed a knapsack type cotton plucker to suit for farmers cultivating cotton on small scale consisting of prime mover, blower, filter, pick-up pipe and collection drum. A polypropylene container of 50 liter capacity was fixed on the frame to collect cotton. Filter was used inside collection drum to restrict the entry of cotton inside the aspirator. Two lightweight aluminum pipe of 50 mm diameter were used as the pick-up pipe. Total length of suction pipe and pick-up pipe was kept as 1580 mm. The performance of developed knapsack type cotton plucker was tested in a laboratory in terms of fuel consumption, picking efficiency, trash content and output capacity for three different type of drum (A, B and C model) and four different speed of blower (4200, 4700, 5200 and 5700 rpm). Results indicate that the fuel consumption ranged from 0.270 to 0.702 l/h, picking efficiency from 91 to 96 per cent; trash content from 2.07 to 8.03 per cent and output capacity from 4.75 to 9.78 kg/h. On the basis of laboratory results B type drum was selected for field evaluation at 5200 rpm speed of blower. The average fuel consumption (l/h), picking efficiency (per cent), trash content (per cent) and output capacity (kg/h) was observed as 0.603, 94.79, 5.77 and 8.84 respectively.

Mechanical cotton harvester

Prasad et al (2007) evaluated a two-row self-propelled cotton picker at different locations in India. The performance of John Deere 9935 cotton picker was evaluated at PAU Ludhiana and CICR, Nagpur. The mean values of forward speed, effective field capacity, total harvesting loss, mechanical picking efficiency and picker efficiency were 2.62 km/h, 0.28 ha/h, 23.62%, 75.7% and 76.4%, respectively for the experiments conducted at CICR, Nagpur. The mean values of forward speed, effective field capacity, fuel consumption, total harvesting loss, mechanical picking efficiency and picker efficiency were 2.20–3.38 km/h, 0.278–0.563 ha/h, 22.0–24.0 l/h, and 14.29–31.74%, 55.6–83.1% and 68.3–85.7%, respectively for the experiments conducted at PAU, Ludhiana. The cultural practices and staggered blooming characteristics of present Indian cotton varieties poses challenge to engineers in mechanization of cotton picking.

With the advent of new genotypes, it may be possible to introduce mechanical cotton pickers successfully.

Brush type mechanism consisted of a pair of rolls that are approximately 1020 mm or 1170 mm long and 152 to 165 mm in diameter and are mounted at an angle of about 30 degree above horizontal. Their surfaces are fitted with longitudinal brushes altered with rubber paddles at 45 degree interval around steel tube (behind) (Kepner et al 1979).

Materials & Methods

Commercially available hand held cotton picker i.e. chain and roller type was procured and evaluated in cotton crop. The details of pickers as follows:

Chain type portable handheld cotton picking machine:

The chain type portable handheld cotton picker consisted of a D.C. motor; belt-pulley arrangement and an endless chain D.C. motor of 12 volt having power 11 W is used to provide power to belt pulley arrangement. DC motor was operated with battery capacity 12V7AH/20HR, having charge time about 8 h with 5 h discharge time. The belt pulley arrangement was further attached with the chain sprocket mechanism of cotton picker to rotate it. The driver belt pulley was having 12 mm dia. and chains were rotated with the help of driven pulley of 50 mm dia. The chain of picker was attached with prickles which were actually removing the cotton from open boll. The metal wire, fixed over the chain was used as a doffer to separate the picked cotton from chain prickles. A separate bag was provided to be tied behind the operator for collection of the harvested cotton.

Roller type portable handheld cotton picker:

The roller type portable handheld cotton picker consisted of a D.C. motor, belt pulley arrangement and a cylindrical roller, D.C. motor of 12 volt having power 11 W is used to provide power to belt pulley arrangement. DC motor was operated with battery capacity 12V7AH/ 20HR. The driver belt pulley was directly attached with the cylindrical roller pulley, acting as a driven pulley to rotate the roller of cotton picker. The roller was mounted with prickles instead of prickles attach at the chain in chain type mechanism to remove the cotton from plant. The metal wire was used as a doffer to separate the picked cotton from prickles. A separate bag was provided to tie behind the operator for collection of cotton harvested by cotton picker. This machine can continuously work for a long time without any problem.

Operation of portable handheld cotton picker in field:

Cotton collecting bag was attached with the portable cotton picker which was tied to the belly of the operator. The cotton picking machine was operated manually with on/off switch button. The bag attached behind the operator with the picking machine was used to collect the harvested cotton. The operator has to put the harvesting side near the open bolls, the prickles mounted on the chain or roller will bring the cotton in the bag attached behind the operator.

Design and Development of Self Propelled Walk behind Finger Type Cotton Stripper

A conceptual design of finger type cotton stripper was generated by keeping in view the local cotton varieties grown in small/marginal farm. Machine should be of simple design, lower capital cost, lower repairing and maintenance cost and lesser moving components. The physical prototype of finger type cotton stripper was designed to pick/harvest the local high density and dwarf cotton varieties mechanically. The idea of physical development of self propelled cotton stripper was derived from the study conducted by Tupper G R (1966). An experimental cotton stripper was designed and built by the Arkansas Agricultural Experiment Station for harvesting either broadcast or narrow row cotton. Burr cotton was stripped from the plant with a series of stationery teeth approximately 26 in (66 cm) in length and spaced approximately 0.62 in (1.6 cm) between teeth. In operating position, the stripper teeth were inclined approximately 15 degrees in respect to the ground, with the angle of inclination being changeable with hydraulic controls.

A self propelled walk behind finger type cotton stripper was developed by mounting the designed cotton stripper header on the self propelled power tiller having an engine of 4.8 hp (3.6 kW). Cotton stripper header was developed by selecting the suitable specifications of stripping fingers, kicker/paddle, belt-pulley arrangement and material collecting tank. In this self propelled finger type cotton stripper, the stripping fingers of 70 cm length were welded to the front part of engine frame at an angle of 210. The width of the developed header was 64 cm. A rotating paddle/kicker, having a speed in the range of 120-250 rpm, was designed to push the stripped materials (cotton bolls i.e. opened and closed along with sticks and burs) in to the collecting tank. A collecting drum/tank, having capacity 15-20 kg, was attached behind the cotton stripper header for collecting stripped cotton materials. Figure 1 shows the line diagrams of top and side views of cotton stripper and Table 1 shows the brief specifications of developed prototype of self propelled cotton stripper.

The designed cotton stripper works on the principle that when the cotton stripper will move through the cotton field due to its forward motion, inclined fingers will strip the cotton bolls with burs including green bolls, sticks and leaves from the plants and rest of the plant will remain in its position in the field. Cotton bolls with shells/burs will be stripped from the plants with the help of a series of stationery inclined fingers having a narrow gap among the fingers. The stripped materials will be moved upward to the inclined fingers with the force of next group of plants being stripped. A kicker/paddle mounted at the rear-side of the fingers will help to convey the stripped materials to the collecting tank. Figure 2 shows the operational view of self propelled cotton stripper in the field before and after the harvesting.

Table 1: Technical Specifications of Stripper

S. no.	Attribute	Range
1	Engine power, hp (kW)	4.8 (3.6)
2	Forward speed range (km/hr)	2.0 - 4.5
3	Engine speed (rpm)	1500
4	Width of stripper head (cm)	65
5	Number of stripping fingers	19
6	Length of stripping fingers (cm)	70
7	Thickness of stripping fingers (cm)	1.8
8	Gap between two fingers (cm)	1.5
9	Slope angle (with horizontal) of stripper head	21^0
10	Paddle/kicker speed (rpm)	120-250
11	Capacity of collecting tank (kg)	15-20

Boll Crusher cum Seed-Cotton Extractor

The harvested material having leaves, sticks, and cotton with outer shells (bur) need to be removed and separated to obtain seed-cotton. To remove the outer shells from cotton bolls, a boll crusher/seed-cotton extractor (Millennium Model), developed by a local manufacturer and operational at Bathinda, Punjab, was used. Figure 3 shows the self explanatory line diagram of boll crusher currently available in Punjab. The stripped material was fed manually to the boll crusher with the help of air suction unit. The air suction blower created suction to convey the feeding material to serrated drum/cylinder. The working principle of boll crusher cum seed-cotton extractor is when cotton bolls come into the contact with cylinder (drum) and concave assembly than the cotton burs are

removed with the rubbing action between the cylinder and concave and cotton fibre sticks to the drum of having the serrated surface. The seed-cotton wrapped on the drum was removed with the help of brush roller rotating in the opposite direction to the serrated drum with the speed of 1440 rpm. The seed-cotton separated from the shells and other foreign material was collected from the rear side of the machine known as seed-cotton outlet. The foreign material includes burs/shells, leaves, sticks, dust particles etc. was removed with the help of screw conveyor called trash outlet. Figure 3 and Table 2 show the line diagram and operational view of boll crusher/seed-cotton extractor and its technical specifications.

The power requirement for the operation of boll crusher is 15 hp (11.2 kW). Two electrical motors of 5 hp (3.7 kW) each and an air-suction blower operated with 5 hp (3.7 kW) motor are used for the boll crusher operations. The saw drums (large drums) operated with installed motors rotates with 360 rpm (upper drums) and 160 rpm (lower drum) respectively. The parameters like lint turnout and trash content can be calculated during the cotton extracting operation.

Table: 2 Technical Specifications of Boll Crusher/Seed-cotton Extractor

S. No.	Attributes		Observations
1	Total power requirement for boll crusher		15 hp (11.2 kW)
2	Blower power		5 hp (3.7 kW)
3	Blower rpm		1440
4	Drum type		Serrated (saw) drum
5	Speed of rotating drums (rpm)	Drum 1	360
		Drum 2	360
		Drum 3	160
6	Speed of small/brush roller (rpm)		1440
7	Speed of rotating spikes (rpm)		600

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Study of existing cotton picking mechanisms used in India and abroad

Investigation A: Study of existing cotton picking mechanisms used in India and abroad

The cultural practices and staggered blooming characteristics of present Indian cotton varieties poses challenge to engineers in mechanization of cotton picking. With the advent of new genotypes, especially Bt cottons which are more compact and synchronous in maturing it may be possible to introduce mechanical cotton pickers successfully. The tests conducted with John Deere cotton picker at various locations have revealed encouraging results. More tests are to be performed involving the scientists of other disciplines. Future actions are required to develop simpler machines, which can be easily adopted by the farming community.

The heavy trash content of mechanically picked cotton (20-30%) with the best of the machines in the world pose a problem for Indian condition as our Ginneries are not equipped with pre and post cleaners to handle trashy machine picked cotton, thus reducing the price a farmer is expected to get for his produce. In a trial with John Deere picker at Guntur the ginners offered to pay Rs 250/= less per quintal of machine picked cotton. Research efforts are on in the Technology Mission on Cotton projects to develop such pre and post cleaners.

At present John Deere, and New Holland Tractors are trying to conduct trials with a smaller version of their picker more suitable to Indian conditions. However, these smaller pickers are based on the traditional, time tested spindle type mechanism. ICAR and SAUs have been experimenting with alternative mechanisms to pick clean cotton, these mechanisms viz., suction type pickers of various sizes, give a clean pick but the labour requirement has been at par with manual picking. There is need to develop suitable smaller pickers for Indian conditions which will pick relatively trash free cotton.

Of the hundreds of designs of cotton pickers patented viz., mechanical consisting of brush type, saw type, spindle type, needle type and strippers for complete removal of bolls from the plant; suction/pneumatic type, electrostatic charging type, intermittent/pulsed vacuum type, only spindle type pickers have been commercially successful inspite of several drawbacks in them like awkwardness of operation, uncertainty in performance, costlier manufacturing, higher market price, excessive weight, difficult handling and combination of rotary elements with suction for conveying.

Suitable pickers, involving commercially successful spindle type or using other novel picking means, need to be developed for Indian conditions of smaller farm holdings, multiplicity of varieties, picking a relatively trash free cotton considering the fact that Indian Ginneries at present are not equipped to handle the trashy machine picked cotton.

Investigation B: Study and performance testing of hand picking machine

Introduction: A hand picking machine for picking cotton is now commercially available in India. It was studied for mechanical picking and tested at CICR farm in order to assess its performance against the manual picking.

Description: This machine is like a hand tool operated by a single person man/woman and runs on a 12 volt DC battery. The machine can be carried in a single hand while battery can be put in the right or left shoulder of the persons carrying the machine. A sack has been provided at the outlet of the machine where doffing of picked cotton is done. Chain type picking mechanism is

provided for picking of cotton. Two parallel endless chains are provided with inclined pointed hooks for each link and runs on a plastic holder fixed to the mouth of the machine. Doffing mechanism is provided with two metal strings for each chain of which one end is fixed at the upper portion of the chain while another end is leave at the outlet of machine where cotton holding sack is connected. Doffing is done by passing each chain carrying cotton through the metal pins which creates an obstacle for passing the seed cotton which results in removal of seed cotton from chain and doffing is carried out. As soon as doffing is done seed cotton drops in the holding sack attached to outlet of the machine. A power supply to DC motor is provided from 12 Volt DC no maintenance dry battery. Chains are running through belt drive from DC motor. A forward and reverse speed of rotation of chain is being maintained through electronic circuit and can be operated by a switch. Reverse speed can be used for cleaning and clearing the clogging of the machine. The cost of the machine is Rs. 8000/.

Methodology: The hand machine was operated CICR farm as well as in farmers field of villages Belapipla, Mohazilpi. The machine operated by man and woman in a continuous operation with different replication. At CICR, Nagpur it was operated in defoliated cotton. Various parameters like capacity of the machine, picking efficiency, trash percentage in picked were recorded. The drudgery parameters were also taken by oral and visual observation.

Results: It has been found that the machine can cover an area of 1 hectare with 144 man-hrs. against the manual picking of 144.5 man-hrs with per day output of 22.82 kg and 32.67 kg respectively.

Table 3: Performance results of the hand picking machine

Sr. No.	location	Output Kg/hr		Output Kg/day		Efficiency of machine
		Manual	Machine	Manual	Machine	
1	CICR Field	4.02	2.88	32.16	23.4	73
2	Belapipla	4.3	3.1	34.4	24.8	72
3	Mohazilpi (1st field)	4	2.6	32	20.8	65
4	Mohazilpi (2nd field)	4.3	3.14	34.4	25.12	73
5	CICR field	3.8	2.5	30.4	20	66
	Average	**4.08**	**2.84**	**32.67**	**22.82**	**70**

Table 4: Trash percentage of manual vs machine picked cotton (defoliated)

Sr. No.	Location	Trash %	
		Manual	Machine
1	Plot no.E -20 ,CICR field	4.5	**9**
2	Plot no. -20 ,CICR field	3.4	10.70
3	Plot no.E -20 ,CICR field	2.3	10.29
	Average Trash %	**3.4**	**9.99**

Table 5: Trash percentage of manual vs machine picked cotton (undefoliated)

Sr. No.	Location	Trash %	
		Manual	Machine
4	Belapipla (patil's field)	0.67	1
5	Moha zilpi1'st field	1.01	1.69
6	Moha zilpi2'ndfield	1.68	3.44
	Average Trash %	**1.12**	**2.04**

Conclusion: The hand picking machine has been found to be adequate giving about 70 % of the manual picking output with training & practice. The work output of hand picker can be -----par with experienced human cotton pickers.

Fig. 1. Photograph showing machine picking vs manual picking

II & III Operational requirements to be studied verified and selected & Selection of design parameters of design brief

Description: The working principle of the existing two row mechanical cotton picker was studied by operating the machine stationary as well as in filed. The parameters studied were RPM of the cotton picking drum, spindle RPM, running speed of the machine, cotton picking and doffing action. Kinematic model of picking mechanism is developed in AutoDesk Inventor and studied the working mechanism.

The following parameters were identified for spindle type cotton picker.

1.	Harvesting speed and tractors PTO RPM affects	RPM of spindles, RPM of drum, Gear ratios
2.	Inter row spacing affects	Size of drum, number of spindles, Size of casing, Gear ratios
3.	Height of plant affects	Drum height, Spindle bars, Spindles
4.	Power required and available affects	Number of spindle, Size of drum
5.	Position of spindles in picking zone, doffer and moistener affects	Cam profile, Drum size

IV. Suitability testing of some Indian compact cotton genotypes by commercially available two row spindle type mechanical cotton picker.

Investigation A: Study of suitability testing of some Indian compact cotton genotypes.

Description: In order to study the suitability of plant characteristics amenable for mechanical picking experiment was laid out with 10 no. of bt. Cotton hybrids namely Gold Mine, Dhanno, MRC 6025, MRC 6304, Ankur 651, Ankur 3028, Shakti 9 Bt, Bunny Bt., VICH-5 and VICH-15 at CICR, farm. The sowing was done on dated 2nd July 2010. The plant geometry was kept 90x45 cm. 6 lines of each genotype were planted amounting to an area of 0.42 ha by keeping head land of 6 meters from each side for turning the machine. The layout of field experiment is attached herewith as Annexure II.

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Methodology: Observations on various plant parameters like Plant height, width of plant, plant population, no. of monopodia and sympodia, Ht. of 1st monopodia and sympodia, height of lowermost boll, length of monopodia, total no. of bolls including open close and knotty bolls were taken. The plant parameters were taken two times. The average readings of these parameters of 10 varieties are as follows. Following table shows the average plant parameters of enlisted 10 varieties with DAS.

Table 6: Average readings of plant parameters with along with DAS

S. No.	Crop parameters	Gold Mine	Dhanno BG	MRC 6025	MRC 6304	Ankur 651	Ankur 3028	Shakti 9 BT.	Bunny Bt.	VICH-5	VICH-15
	observations on DAS										
1	Plant height, cm	61.6	58.7	69.1	66.3	63.3	65.9	66.3	66.7	74.4	67.9
2	Plant width along, cm	43.5	38.1	41.5	39.3	44.5	41.0	45.2	51.3	49.8	46.3
3	Plant width, across, cm	45.4	35.1	41.9	39.2	48.0	39.5	38.3	51.7	51.2	53.1
4	Plant population/m	2.8	2.9	2.9	3.0	3.0	2.9	3.0	3.0	2.6	3.0
5	No. of monopodia	1.3	0.1	0.0	0.2	0.7	0.1	1.1	1.0	1.5	1.1
6	No. of sympodia	22.2	12.2	12.1	18.4	16.9	17.1	11.3	17.9	11.1	11.6
7	Ht. of 1st monopodia	10.6	2.9	0.0	2.1	7.7	2.3	10.1	10.0	10.9	12.1
8	Ht. of 1st Sympodia	17.3	18.5	20.0	20.5	17.1	21.5	19.1	17.5	16.7	16.3
9	Ht. of lowermost boll	12.3	16.1	16.5	19.6	16.0	21.7	15.1	9.5	14.2	11.7
10	Length of monopodia	23.7	2.5	0.0	4.6	17.9	6.3	23.7	20.2	27.3	26.9
11	Open bolls	7.9	1.4	1.6	4.4	5.4	4.4	4.0	4.2	4.0	4.7
12	Close bolls	5.1	7.1	6.1	2.5	4.7	2.1	2.3	11.7	3.9	2.5
13	Knotty bolls.	1.5	1.2	0.1	0.3	0.5	0.2	0.5	2.5	0.6	0.4

Table 7. Average plant parameters with along with DAS.

S. No.	Crop parameters	Gold Mine	MRC 6025	MRC 6304	Ankur 651	Ankur 3028	Shakti 9 BT.	Bunny Bt.	VICH-5	VICH-15
	DAS observations									
1	Plant height, cm	69.3	85.2	80.2	77.5	93.3	87.5	86.1	86.3	74.1
2	Plant width along, cm	46.3	46.3	40.4	51.0	51.4	58.5	57.2	56.1	51.3
3	Plant width, across, cm	50.0	47.7	44.6	55.2	48.9	60.4	64.1	63.6	58.0
4	Plant population/m	2.9	2.9	2.9	3.0	3.0	3.0	2.9	2.5	3.0
5	No. of sympodia	12.1	11.9	10.7	17.5	16.5	16.1	20.7	14.9	9.7
6	Ht. of lowermost boll	12.8	18.4	18.6	12.9	19.9	15.9	9.5	12.5	12.7
7	Open bolls	9.9	3.7	3.4	9.8	5.7	6.2	5.3	5.0	6.3
8	Close bolls	1.7	3.0	1.6	5.7	4.1	3.0	6.1	5.3	2.5
9	Knotty bolls.	0.5	1.7	0.8	2.3	1.1	1.8	2.9	2.5	0.9

Activity:

- **Fabrication of a Trolley mounted cotton picking head**.

Progress:

A conceptual trolley mounted Chain type and Peg type picker was fabricated (Fig. 1) with variable row to row spacing of 60, 80 and 90 cm. This Conceptual design of a medium size cotton picking machine can be operated by a pair of bullocks or a person pushing from behind the machine The machine is divided into mainly three components i.e.

1. Picker trolley
2. Crop guider & compressing mechanism and
3. Picking mechanism.

The trolley moves in between two rows of cotton. Each row is compressed between a compression plate and a column of chain type or peg type picking units. The plants within the row are progressively compressed and at the maximum compression, picking units pick the bolls coming in contact with them, doffed and collected at the bottom of the trolley. The compression plates can be adjusted and the plants can be compressed from 15 cm down to 8 cm width. Each row is flanked by two crop lifters that lift the lower monopodias and sympodial branches up, straighten them and align them to the picking units for maximum exposure and response time for the picking units. The rows of plants enter the

picker in front as the picker moves in continuous motion and leave the picker from behind undamaged, ready to be picked on the other side of the row on return travel of the picker.

10. Detailed analysis of results indicating contributions made towards increasing the state of knowledge in the subject:

Field evaluation of handheld cotton picking machine:

Commercially available portable hand held cotton pickers having two different mechanism i.e. chain type and roller type were evaluated in the Cotton field to check their performance and efficiency. Different varieties of cotton were selected for harvesting. The evaluations of these machines were carried out at Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana and Research Station, Punjab Agricultural University, Abohar on October- November 2011. Handheld cotton pickers were also evaluated for a LH2076 cotton variety which is bushy type grown in the region along with short dwarf varieties/hybrids like MRC6301, F2383 and MRC6304 which are considered suitable for mechanical harvesting.

Portable handheld cotton pickers were evaluated to measure the picking rate (kg/h) of harvested cotton for different cotton varieties. The weight of cotton harvested/unit time by cotton picking machines was compared to the weight of cotton picked manually. There was significant difference of picking rate for variety MRC6301 and LH2076.

For all types of picking methods, picking rate was maximum for MRC6301 variety and it was minimum for LH2076 variety. It may be due to the reason that MRC6301 variety was fully matured but LH2076 variety which is bushy type, was having green bolls at the time of harvesting. There was no significant difference in the picking rate among chain type, roller type and manual picking at 5 per cent level of significance.

The trash analysis done for 100 g sample of cotton harvested with both handheld cotton pickers and manually. The weight of clean cotton and cotton seed were measured 29.61 and 58.87 g, respectively for chain type cotton picker. For the roller type cotton picker, the weight measured for clean cotton and cotton seed were 28.56 and 61.00 g, respectively. Similarly, for manual picking, the measured weight for clean cotton and cotton seed were 34.42 and 58.15 g, respectively. The percentage of trash content for both chain and roller type cotton pickers was high i.e. 11.52 and 10.44 per cent as compared to trash content of 7.43 percent measured for cotton picked manually. Our results are in conformity with the findings of Asota (19966).

Fig.2. Spindle type picking head fabricated at CoEFM, Ludhiana

11. Conclusions summarizing the achievements and indication of scope for future work:

Indigenous knowhow on design and manufacturing of a spindle type picking head is now available through this project. Further evaluation and refinement can be done by integrating the head with a self propelled prime mover, and after large scale multi location trials it can be marketed for Indian cotton growers.

12. S&T benefits accrued:

I. List of Research publications

S No	Authors	Title of paper	Name of the Journal	Volume	Pages	Year
1.	Kohli, S S, Singh M and Sharma K	Multiple attribute decision making for selection of mechanical cotton harvester.	Scientific Research and Essays(Academic Journal	8(47)	2318-2331	2013
2.	Singh M, Sharma K, Suryavanshi V R, Majumdar G, Yadav A, Gill J S, Sharma A, Mishra P K and Prakash A	Field evaluation of portable hand held cotton picking machines for different crop varieties	J Cotton Res Dev	28(1)	55-58	2014
3.	S S Kohli, Manjeet Singh, Karun Sharma, Ankit Sharma, Pramod Mishra	Attribute Based Coding, Review and Gap Analysis of Cotton Harvesting Processes and Machines	Agric Eng Int: CIGR	Vol.17 (3)	120-127	2015
4.	Karun Sharma, Manjeet Singh, S S Kohli, Pramod Mishra, Ankit Sharma	Design and development of self propelled walk behind finger type cotton stripper	Agricultural Engineering	XL(4)	1 - 8	2015
5.	Mishra P K, Singh M, Manes G S, Patel B and Dixit A.	Study on the varietal characteristics of cotton crop for mechanical harvesting	J. Cotton Res. Dev.	31 (2)	268-272	2017

TECHNICAL REPORT

II. Manpower trained on the project

a) Research Scientists or Research Associates: 04 nos.

b) No. of Ph. D produced: Nil

No. of M. Tech produced: 02 nos.

No. of B. Tech produced: 02 nos.

c) Other Technical Personnel trained:

III. Patents taken, if any: No