

## Influence of spindle material and surface texture on time taken for picking cotton under variable conditions

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■ **ABSTRACT** : Cotton harvesting is done by hand picking in India. Manual picking is not only tedious and labour consuming but also costlier than other agricultural operations. The use of machines for picking is, therefore, considered to be viable in minimizing the drudgery involved in hand picking and reducing the cost of cotton picking. By keeping these factors in mind, the present investigation was undertaken to study the mechanism involved in picking of cotton by the rotating spindles. The spindles were fabricated with the materials selected for the study and they were evaluated for their performance in picking cotton from bolls under laboratory conditions. The spindles were evaluated with the help of the test rig developed for the purpose and the different parameters were recorded. The time taken for picking cotton from the boll varied from 0.48 to 4.53 seconds under variable conditions for selected varieties. The time taken was minimum at the speed of 3000 rpm and maximum at 1000 rpm. The time taken for picking decreased with increase in speed for all the varieties. The time taken for picking also decreased with decrease in the level of moisture content of cotton. The minimum time was taken by the tapered spindle with grooves and knurl whereas the time taken was maximum for tapered plain spindles. The laboratory trials of the spindles revealed that, the hulum spindle of tapered shape with grooves and knurl gave better performance as the time taken for picking was minimum.

■ **KEY WORDS** : Cotton picking, Picking spindles, Picking time, Spindle speed

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India ranks third in the world in production of cotton crop. Cotton is being cultivated in three distinct agro-climatic zones namely; North Zone comprising of Punjab, Haryana and Rajasthan, Central Zone comprising of Maharashtra, Gujarat and Madhya Pradesh and South Zone comprising of Tamil Nadu, Karnataka and Andhra Pradesh.

In India harvesting of cotton is done manually by hand picking. Manual picking is not only tedious and labour consuming but also costlier than other agricultural operations. In recent years it has been observed that labour availability is scarce during peak periods of cotton harvesting. The use of mechanical picking by machine is, therefore, considered to be a viable option in minimizing the drudgery involved in hand picking.

As per the available reports, the research on mechanical picking or cotton pickers are very meagre or no information is available in India. Consequently this area of research and development needs immediate attention of researchers for

development of suitable mechanical pickers. As the biological scientists are gearing up to develop suitable cotton varieties which are amenable to mechanical picking, it is necessary to develop/ identify a mechanical picker suitable for cotton crop cultivated in Indian conditions.

The cotton harvesters available at present are of two types, *i.e.*, pickers and strippers. Mechanical pickers are selective in picking and in this system the seed cotton is removed/picked from the open bolls, where as green and unopen bolls are left on the plant itself to mature for later pickings, while strippers on the other hand are once-over machines. All bolls whether open or closed are removed from the plant in a single pass. Chemical defoliant and desiccants are usually applied to facilitate harvesting.

By Keeping these factors in view, an attempt has been made to identify crop machine and operational variables which influence on the picking mechanism of the cotton pickers and to develop the picking spindles and to conduct exhaustive

trials using different spindles for picking cotton under variable conditions and their suitability for different varieties grown in the region.

## ■ METHODOLOGY

The present investigation was undertaken to study the mechanism involved in picking of cotton by the rotating spindles. The biometric parameters of the selected varieties of cotton crop were noted down which are useful for development of test rig. The criteria adopted for development of spindles of different materials, development, fabrication and working of the test rig are explained. The details of the tests conducted for the measurement of performance parameters are also given.

### Mechanics of picking:

The basic principle of the revolving spindle is penetrating through the cotton plant, winding the seed cotton from the open boll and retracting to a doffing zone, which is employed by all the commercial pickers now available. The rearward movement of the spindles, while in the picking zone is substantially the same as the forward movement of the machine, generally 3.2 to 5.6 km/hr, so that the spindle while in the picking zone, do not move forward or backward with respect to the cotton plant. Each rotating spindle merely probes straight into the cotton plant from the side of the row and works on an open boll if it encounters one and then withdraws straight with a minimum of disturbance and damage to the remainder of the plant. The spacing of the spindles, approximately 38x38mm, is such that they can slip past unopened bolls and leave them on the plant to mature for a latter picking.

The spindles are carried either on bars arranged in vertical drums or on vertical slats attached to the endless chain belts. Tapered spindles are commonly employed on drum type pickers and have three to four longitudinal rows of sharp barbs or grooves for engaging the cotton. The tapered shape facilitates easy removal of the cotton (doffing) after they leave the picking zone. Spindle speeds range from 1850rpm at a forward speed of 2.9km/h to 3250rpm at 5.0km/h.

### Biometric parameters of test crop:

The measurement of biometric parameters of cotton crop helps in fixing the optimum dimensions of the test rig to facilitate the movement of the spindle in horizontal, vertical and transverse directions to pick the cotton from the bolls. The details of cotton crop with respect to selection of varieties, procedure for measurement of various physical parameters are discussed in this section.

### Selection of varieties

The cotton crop presently grown by the farmers of the

region are mainly BT cotton varieties and a few hybrids. The selection of cotton crop varieties for the study was done by keeping in view the different varieties grown in the region. Three predominantly grown varieties of cotton crop were selected from within the BT cotton and hybrid varieties grown in the region.

### Size of spindles:

The dimensions of spindles were decided by considering the size of spindles available on the existing cotton pickers.

### Development of test rig for evaluation of picker spindles:

A laboratory test rig was developed to facilitate for testing the performance of spindles at different peripheral speeds. The test rig developed had the provision to move the spindle in all three directions *i.e.*, horizontal, vertical and transverse directions. The test rig was fabricated by using standard fabrication techniques. Two variable speed dc motors were selected, one for rotating the spindle at different speeds and the other to move the spindle in all three directions. The test rig was mounted on a table attached to a pedestal. The test rig can be moved up and down along with the table by rotating the handle.

### Selection of variables of study:

The evaluation of the picking spindles were carried out by taking into consideration the different independent variables. The working of the spindles under variable conditions influenced the different parameters, these parameters were considered as dependent variables.

### Independent variables:

<b>Material type</b>	<b>4 levels</b>
Mild steel	M <sub>1</sub>
Aluminum	M <sub>2</sub>
Nylon	M <sub>3</sub>
Hylum	M <sub>4</sub>
<b>Surface texture</b>	<b>3 levels</b>
Tapered plain	S <sub>1</sub>
Tapered with grooves	S <sub>2</sub>
Tapered with grooves and knurl	S <sub>3</sub>
<b>Spindle speed</b>	<b>5 levels</b>
1000 rpm	N <sub>1</sub>
1500 rpm	N <sub>2</sub>
2000 rpm	N <sub>3</sub>
2500 rpm	N <sub>4</sub>
3000 rpm	N <sub>5</sub>
<b>Moisture content</b>	<b>3 levels</b>
2.5 – 3.5 %	mc <sub>1</sub>
3.5 – 4.5 %	mc <sub>2</sub>
4.5 – 5.5 %	mc <sub>3</sub>
<b>Varieties</b>	<b>3 levels</b>

NHH-44

NCH-145

RCH-2

**Replications****3****Dependent variables:**

Time taken for pickings

**Measurement techniques for various parameters of study:**

The spindles developed for the study were evaluated under variable conditions at College of Agricultural Engineering, Raichur, for their performance with the help of the developed test rig.

Laboratory tests were conducted to evaluate the performance of selected spindles at three levels of moisture content and five different spindle speeds. The time taken for picking and trash content were observed and recorded during the trials. The methodology followed is as under.

**Time taken for picking:**

The time required for picking cotton from each boll was measured using a digital stop watch with an accuracy of 0.10 s. This was measured by rotating the spindles at the selected speed by switching on the d.c.motor. The spindle was moved towards cotton boll, the stop watch was started as soon as the spindle tip touched the lint and stopped immediately as the cotton detaches from the boll. The time required for this operation was measured as time taken for picking cotton and recorded.

**Spindle speed:**

The different types of spindles developed for the study were rotated by holding them in the chuck of the variable speed motor in the test rig. The spindle speed was recorded as indicated in the digital speed indicator attached to the test rig. The different speeds required for the study were obtained by regulating the speed with the help of a dimmer connected to the motor.

**Moisture content of cotton:**

The moisture content of cotton from each boll was measured by using a digital moisture meter. The digital moisture meter was pre calibrated by adopting the standard procedure. The cotton picked from the boll was filled in the cup and the ram was pressed against the cotton in the cup by rotating the handle for required number of revolutions. The moisture content was noted on the indicator panel.

**■ RESULTS AND DISCUSSION**

The observations on the different parameters were recorded as per the methodology discussed earlier. The spindles were fabricated with the materials selected for the

study and they were evaluated for their performance under laboratory conditions for picking the cotton from the bolls. The spindles were evaluated at variable conditions with the help of the test rig developed for the purpose and the time taken for picking cotton from the boll by the spindles was recorded.

**Varieties taken for study:**

Selection of cotton varieties for the study was done by keeping in view the different varieties grown in the region. Three most promising varieties of cotton crop grown in this region namely NHH-44 a hybrid variety and NCH-145 and RCH-2 from BT cotton varieties were selected for the study.

**Development of picking spindles:**

The development of spindles was carried out by considering various boll parameters and the spindles were fabricated by adopting standard fabrication techniques and also by taking into consideration the shape, surface texture and size of the spindles available in the existing cotton pickers.

**Selection of the materials:**

The selection of the material for spindles was done by taking into consideration the machinability aspects, availability and the cost of the materials. Four types of material namely mild steel, aluminum, nylon and hylum were selected for the study.

**Selection of surface texture:**

The shape and surface texture of the spindle were selected by considering the ease of picking, ease of doffing, machinability aspects etc. The tapered shape was commonly adopted for all the materials. Three types of surface textures namely tapered plain, tapered with grooves and tapered with grooves and knurl, were selected for study. The surface texture was formed by adopting standard fabrication techniques.

**Size of spindles:**

The size of spindle was determined by considering the spindles available on the existing cotton pickers. The total length of the spindle is 125 mm out of which the length of the tapered portion is 75mm. A length of 25mm on the other side of the spindle is used for holding the spindle with the chuck for rotating the spindle. The diameter of the spindle is 10mm at the larger end of the taper and is 2 mm at the smaller end of the taper.

**Development of test rig for evaluation of picking of cotton by spindles:**

The biometric observations of the crop were considered for the development of test rig. The test rig was fabricated by using standard fabrication techniques. Two variable speed dc

motors of 0.25 hp were used, one for rotating the spindle at different speeds and the other to move the spindle. A regulator is provided to vary the speed of the motor from 0 to 3000 rpm. An electronic speed indicator is provided to display the speed of rotation of the spindle. The test rig is mounted on a table attached to a pedestal. The test rig can be moved up and down along with the table by rotating the handle. The height of the pedestal was fixed as 125 cm so that it can guide the spindle to the level of the uppermost boll. The arm of the table is pivoted to the pedestal so that it can swing at any angle required. The arm of the table can move forward up to 75 cm to facilitate the spindle to reach the boll nearest to the stem. The table can also move in the transverse directions to reach the bolls at the extreme ends of the plant.

**Evaluation of picking spindles under variable conditions:**

The spindles were evaluated at College of Agricultural Engineering, Raichur, for their performance with the help of the test rig, under variable conditions.

The laboratory evaluation of the above spindles were carried out for three varieties of cotton namely NHH-44, NCH-145 and RCH-2, at three range of moisture contents namely 2.50 to 3.50 per cent, 3.50 to 4.50 per cent and 4.50 to 5.50 per cent and five speeds in the range of 1000 to 3000 rpm with steps of 500 rpm. The time taken for picking was observed during the trials.

**Time taken for picking:**

The time taken for picking of cotton for different varieties under variable conditions is shown in Fig.1 to12. The time

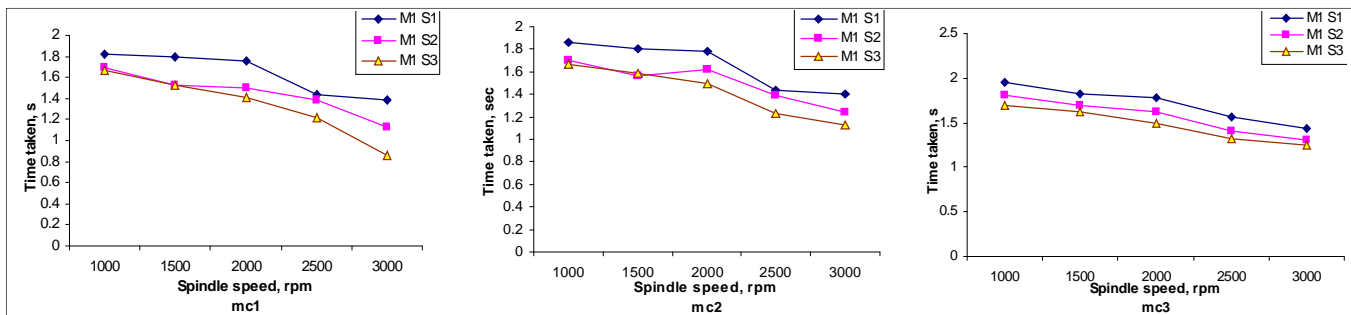


Fig. 1 : Time taken for picking by mild steel spindle under variable conditions for NHH-44 variety

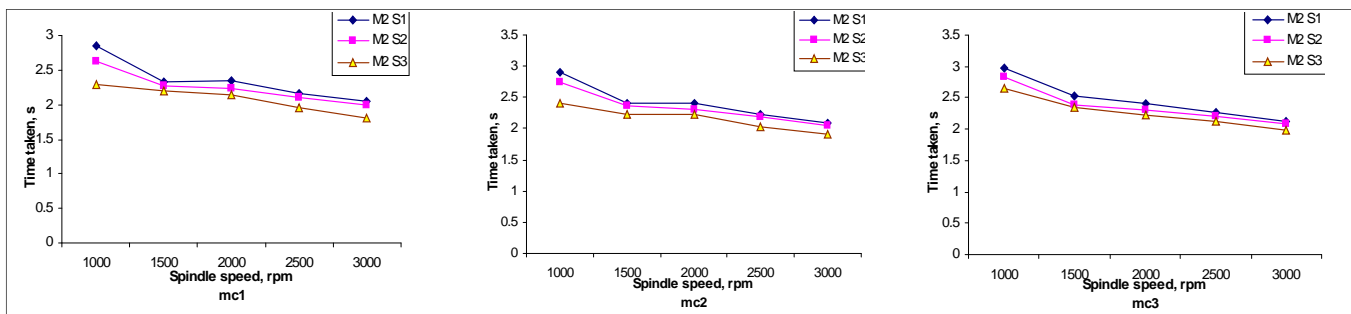


Fig. 2 : Time taken for picking by aluminum spindle under variable conditions for NHH-44 variety

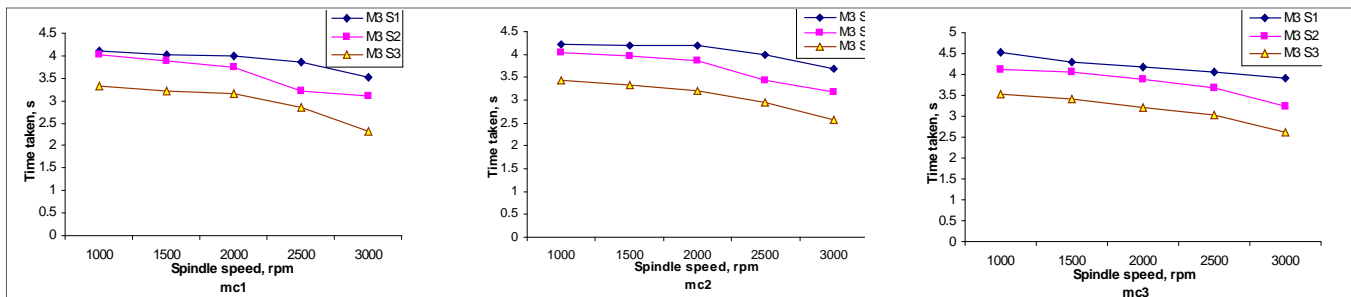


Fig. 3 : Time taken for picking by nylon spindle under variable conditions for NHH-44 variety

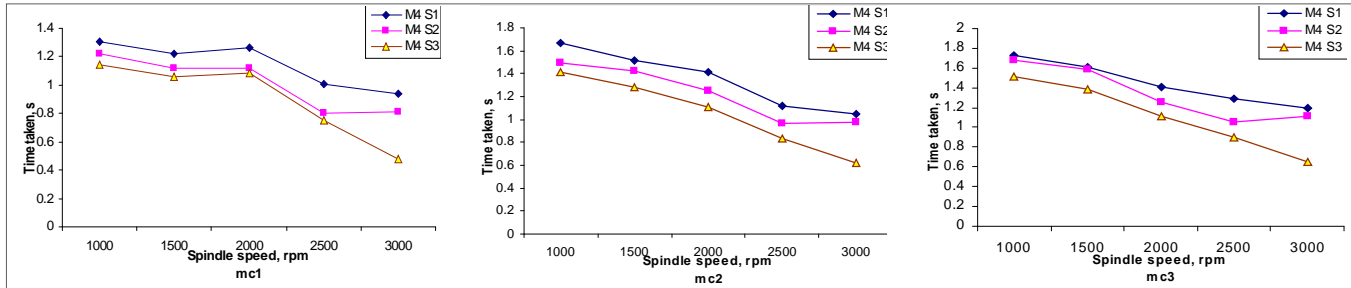


Fig. 4 : Time taken for picking by hylum spindle under variable conditions for NHH-44 variety

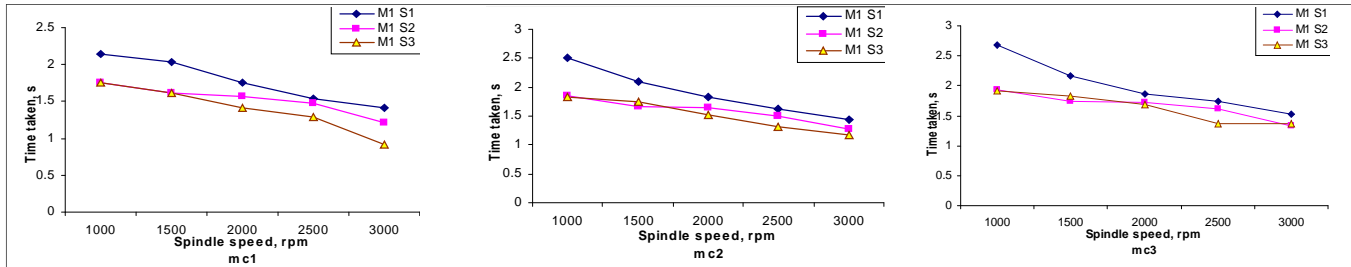


Fig. 5 : Time taken for picking by mild steel spindle under variable conditions for NCH-145 variety

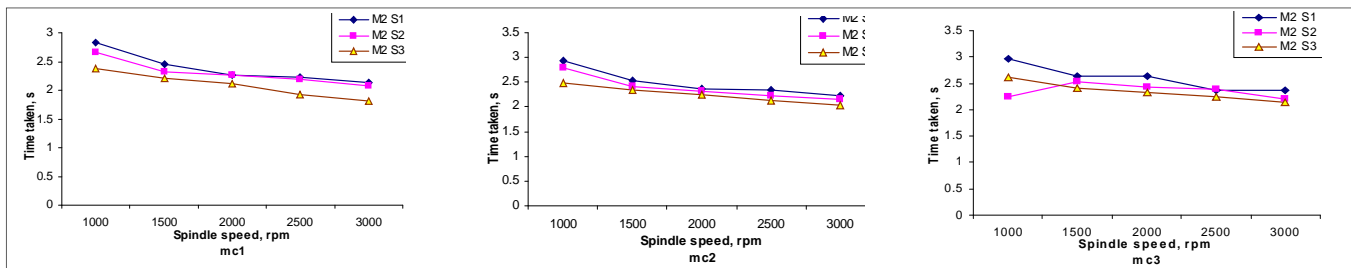


Fig. 6 : Time taken for picking by aluminum spindle under variable conditions for NCH-145 variety

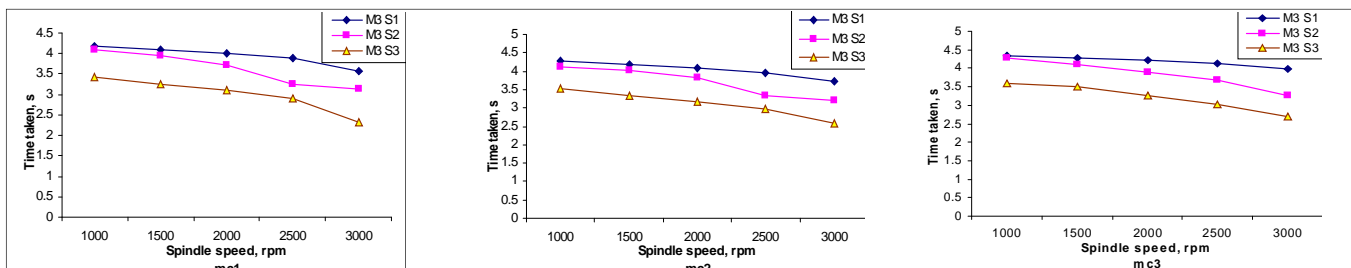


Fig. 7 : Time taken for picking by nylon spindle under variable conditions for NCH-145 variety

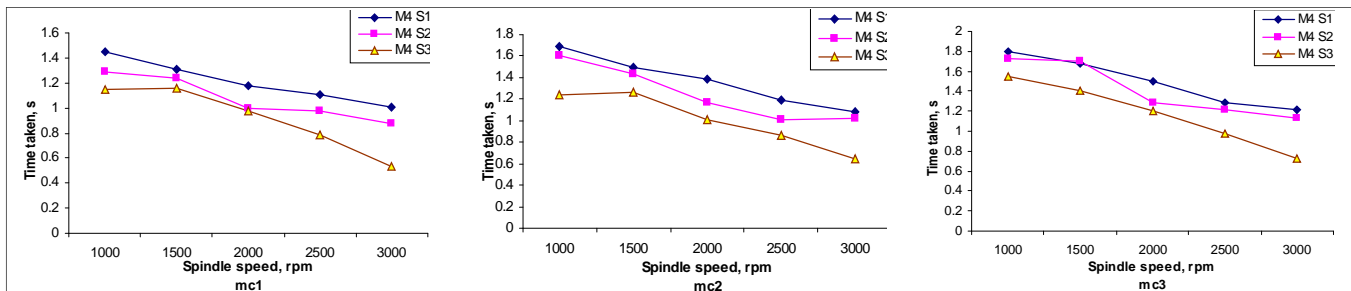


Fig. 8 : Time taken for picking by hylum spindle under variable conditions for NCH-145 variety

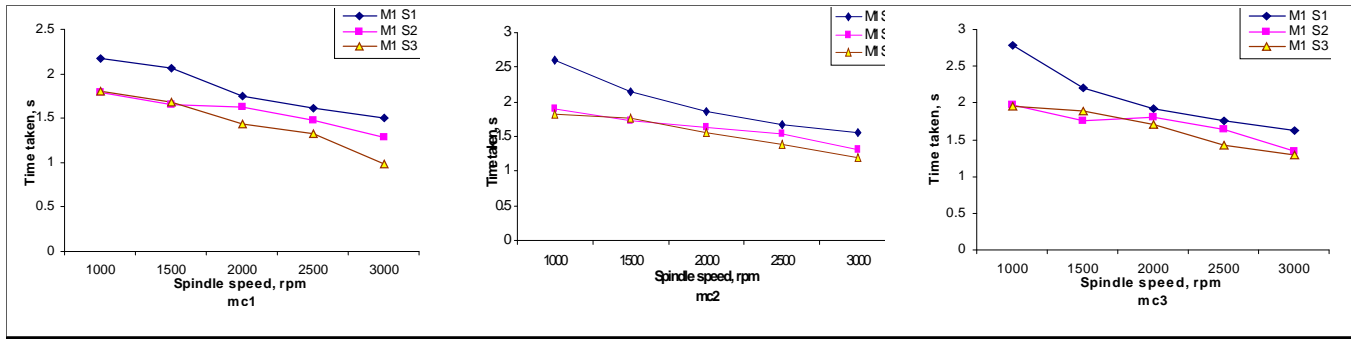


Fig. 9 : Time taken for picking by mild steel spindle under variable conditions for RCH-2 variety

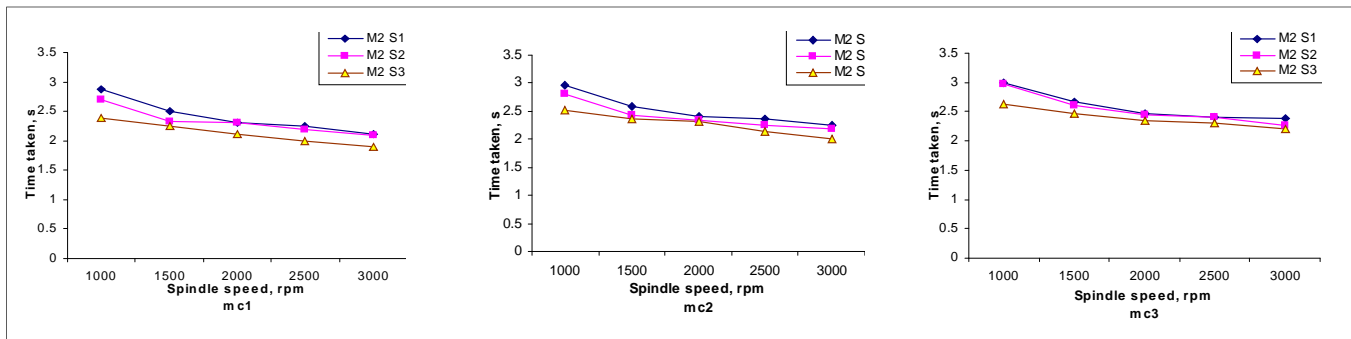


Fig. 10 : Time taken for picking by aluminum spindle under variable conditions for RCH-2 variety

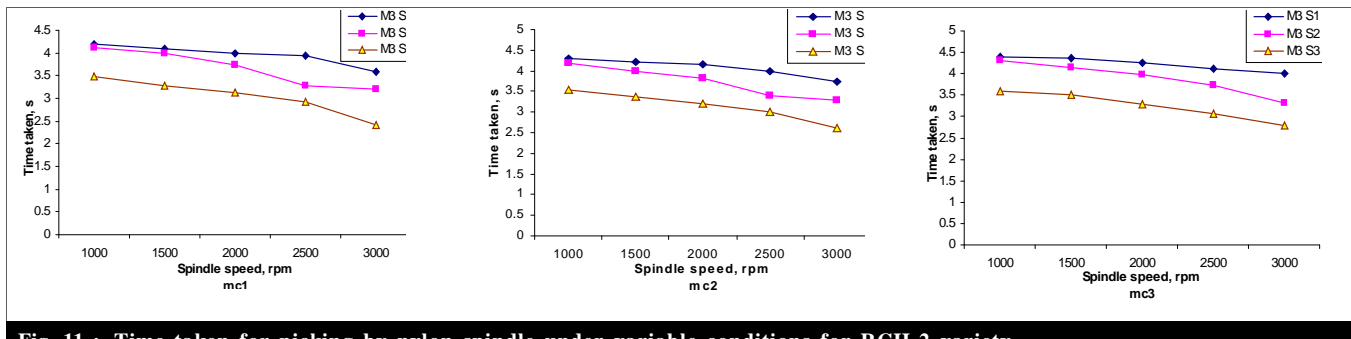


Fig. 11 : Time taken for picking by nylon spindle under variable conditions for RCH-2 variety

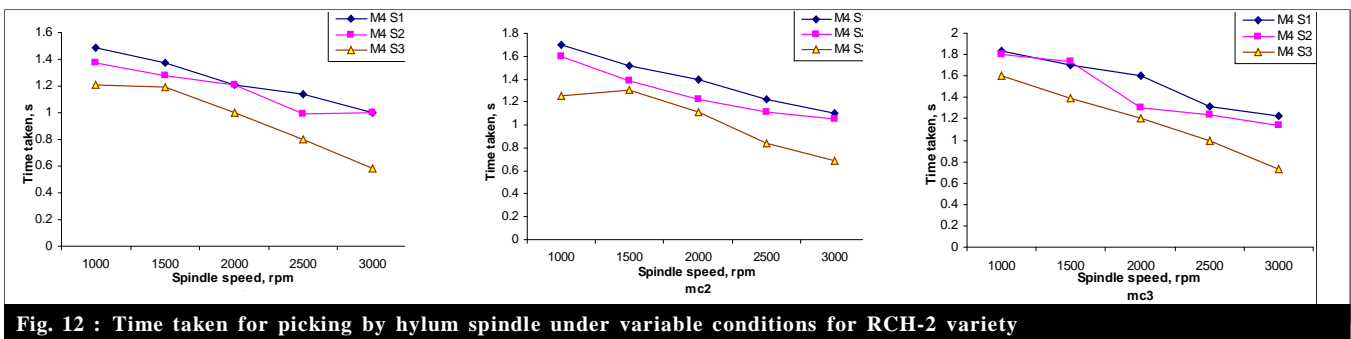


Fig. 12 : Time taken for picking by hylum spindle under variable conditions for RCH-2 variety

taken for picking cotton from the boll varied from 0.48 to 4.53 seconds under variable conditions for selected varieties. The material of construction of spindle influenced the picking time. The time taken was minimum for hylum spindle and maximum for nylon spindle, this may be due to the frictional properties of the material. The speed of rotation of spindle is also an important variable. The time taken was minimum at the speed of 3000 rpm and maximum at 1000 rpm. The time taken for picking decreased with increase in speed for all the varieties, this is because the surface area of the spindle coming in contact with cotton within the same time increases with increase in speed of rotation. The time taken for picking also decreased with decrease in the level of moisture content of cotton, this is because the force required to detach cotton from the boll is greater at higher levels of moisture content. The surface texture also influenced the picking time. The minimum time was taken by the tapered spindle with grooves and knurl whereas the time taken was maximum for tapered plain spindles, this is due to the higher coefficient of friction of spindles with grooves and knurl and lower coefficient of friction in case of plain spindles. Similar to present experiment an investigation on performance evaluation of spindle type cotton picker was also carried out by Prasad *et al.* (2007).

#### Conclusion:

The conclusion drawn from the study are, the laboratory trials of the spindles revealed that, the hylum spindle tapered with grooves and knurl gave better performance as the time taken for picking was minimum. The study helps in getting the basic information regarding the mechanism of picking with

the spindles under variable conditions of picking. This helps in building a base for further development of cotton picker indigenously and also to develop suitable varieties of cotton crop for efficient picking of cotton by machine pickers.

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