REDESIGN OF DRUMSTICK PLUCKER
PRODUCT DESIGN PROJECT II

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Industrial Design Project II

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Approval sheet

The project titled "Redesign of drumstick plucker" by Hargude Akshay Narayan [136130007] is approved for the partial fulfillment of the requirement for the degree of Master of Design in Industrial Design.

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Declaration

I hereby declare that this written submission represents my idea in my own words and where others' ideas have been included; it has been adequately cited and referenced the original source. I declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any data/ idea/ facts/ sources in my submission. I understand that any violation of the above entitles the institute to take disciplinary action against me to which I shall be answerable to.

Signature: 

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Date: 20 Nov, 2014

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Abstract

India is the largest producer of Moringa tree's pod referred to as Drumsticks in the world. Unfortunately, there is not any dedicated drumstick plucking tool available in the market. Farmers are using self made tools made-up of locally available material. These tools are not efficient enough to pluck only mature drumsticks out of bunch. Sometimes, the entire branch of drumsticks gets damaged and breaks along with immature pods causing loss.

Also there are some other problems related such as the collection of plucked pods, its market value, transportation and storage of plucker, apart from issues like affordability, physical affliction, etc.

With this project, all these problems in drumstick plucking activity are solved and it is made a more efficient, quick and easy task.

Index

1. Introduction

Fig.1: Drumstick farm

India is the largest producer of Moringa pods called Drumsticks, with an annual production of 1.1 - 1.3 million tons from an area of 380 km^2. Among the states, Andhra Pradesh leads in both area and production (156.65 km^2) followed by Karnataka (102.8 km^2) and Tamil Nadu (74.08 km^2) [1].
Though the origin of usage drumsticks is India, due to its medicinal and nutritional value it has also cultivated in other countries. In the Philippines, it is commonly grown for its leaves which are used as food. Moringa is also actively cultivated by the World Vegetable Center in Taiwan, a center for vegetable research. In Haiti, it is grown as windbreaks and to help reduce soil erosion [2].

A tree can yield around 300 to 400 pods per year. In India, a hectare can produce 31 tons of pods per year. Under North Indian conditions, the fruits ripen during the summer. Sometimes, particularly in South India, flowers and fruit appear twice a year, so they are harvested twice, in July to September and March to April [3]. Fig.1 depicts the image of a full grown tree in a farm.

Botanical Name: Moringa Oleifera
Common names: Horseradish tree, Ben oil tree
Other vernaculars: Hindi-muranka
Kannada-moringa
Marathi- shevga chi seeng
Tamil-murungai
Gujarati- seeng ni phali
Malayalam-sigru
Telugu-sajana
Bengali-sajna [4]

2. Medicinal uses of Drumstick tree

Fig.2: Health benefits of drumstick tree
http://blog.koreadaily.com/_data/user/Z/i/j/Zija/image/2012/4/19082654_2.jpg as on 5th Nov, 2014

The drumstick is valued mainly for its tender pods, which are relished as vegetable but all its parts - bark, root, fruits, flowers, leaves, seeds and even gum are of medicinal value. Fig.2 depicts the health benefits of drumstick tree.

Leaves:	Relieves headache Stops bleeding from a shallow cut Treats gastric ulcers and diarrhea Anti-bacterial and anti-inflammatory effect High iron content, used against Anemia
Flowers:	Beneficial during pregnancy Useful against urinary problems
Pods:	Cures joint pain Malnutrition treatment - High content of protein and fiber
Seeds:	Antibiotic and anti-inflammatory properties Treats arthritis Relaxant for epilepsy Oil is used to treat hysteria, scurvy, prostate problems [5]

3. Field Study

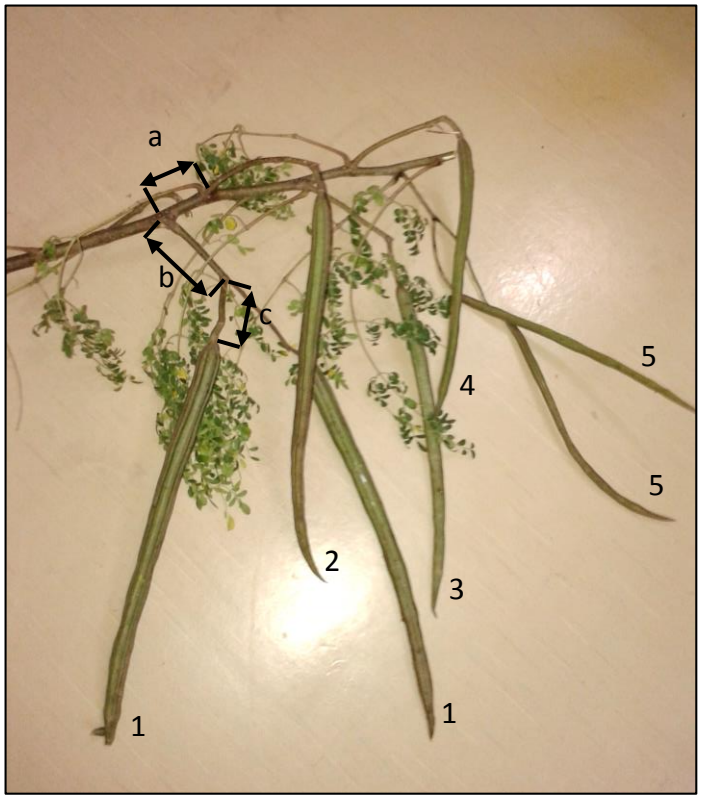


Fig.3: Drumsticks bunch

In India two types of drumstick farming is practiced, that are - main field farming and fence farming. While main field farming is practiced for commercial purpose, fence farming is practiced for domestic purposes.

Average height of drumstick tree is about 20 feet. Pods come at the height of around 5 feet to 18 feet from ground level. Generally pods grow at the end of the branch.

Order of getting mature

The Fig.3 shows typical bunch of drumsticks. The drumsticks get matured in an orderly fashion. The pods closer to the main trunk are older ones and hence will get mature first; after that the next pods will get mature and so on. Newer flowers bloom at the end of the branch, which metamorphose into immature pods first and then finally into mature ones.

Average stem thickness is about 5 mm to 8 mm.
General arrangement of pods in a bunch and the stem length is as below. Refer Fig.3

a = 50 mm to 90 mm
b = 80 mm to 120 mm
c = 40 mm to 90 mm

3.1. Harvesting statistics

Harvesting of drumsticks is a cyclical process. All drumsticks on the tree do not mature at the same time. So the plucking activity is repeated after every 10 days. Each time, a tree can give around 10-20 pods. In current scenario with available plucking tool, it takes around 5 to 6 minutes per tree.

In case of main field farming, approximately 65 to 80 trees are there in a field. Generally the farmer's male family member or some other helper helps him in harvesting. It takes around 2.5 to 3 hours to pluck pods from all the trees.

The plucked pods are cleaned, bunched and sold in the market as shown in Fig.4.

Fig.4: Drumsticks bunch

http://grocerybelowmrp.com/image/cache/data/Drumsticks%20(Sahajan,%20Shevgyachya,%20shenga)-1000x1000.jpg as on 5th Nov, 2014

3.2. Tools being used

Tool: 1

Fig.5: Tool made-up of a bamboo and small wooden stick

In current scenario, there is no specially designed tool available in the market for plucking drumsticks. Farmers use tools which are made by themselves. These tools are made up of locally available low cost material such as, bamboo, PVC pipe, wood, *Khurpe,* etc.
The length of bamboo or PVC pipe is more than 15 feet, due to which, the transportation and storage of the tool is a major problem for them. Sometimes, they hook the tool to the tree itself, which tempt other people to use the same tool and steal the pods in the absence of farmer.

Fig.5, Fig.6, Fig.7 and Fig.8 shows four different types of tools currently being used by farmers.

Tool: 2

Fig.6: Tool made-up of a bamboo and small *Khurpe*

Tool: 3

Fig.7: Tool made-up of a bamboo and long steel rod

Tool: 4

Fig.8: Tool made-up of a PVC pipe and steel rod

3.2.1. Tool 1

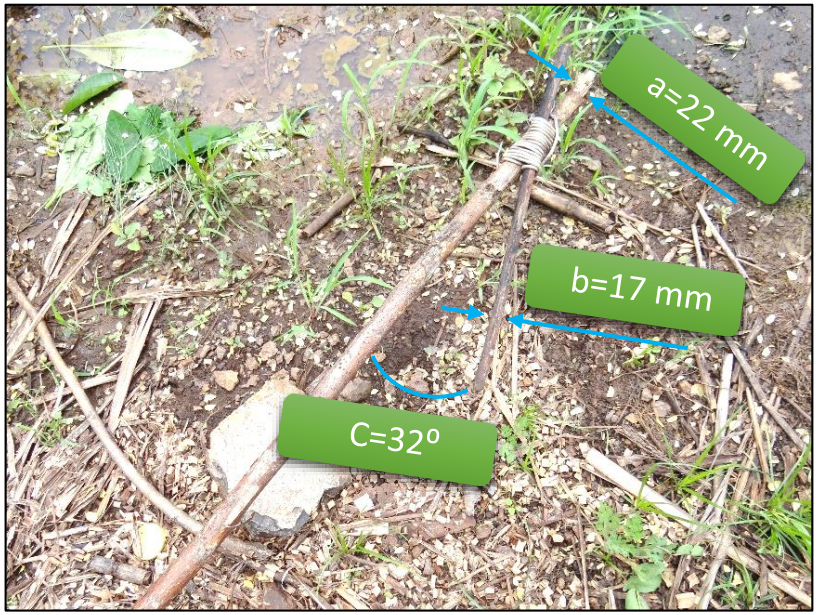


Fig.9: Tool made-up of a bamboo and small wooden stick

Fig.9 shows one of the tools used by farmers for plucking drumsticks. The main problem about this tool is that it does not allow selective plucking. The farmer uses this tool to break entire branch of the tree along with immature pods and flowers; and then he plucks only mature pods by hand and discards the rest. Thus loosing the immature pods and causing loss.

This tool weighs about 4.8 Kgs. Due to it's heavy weight, it causes neck pain, back pain and shoulder pain. Balancing such a heavy tool is very difficult, and as a result the upper holding arm suffers from pain. The tool is difficult to carry and store.

Each time after plucking, the farmer has to collect plucked pods. This is time consuming process.

Fig.10 shows Steps of plucking drumsticks by using Tool 1.

Farmer hooks the tool to the branch with pods. Then breaks the entire branch with mature and immature drumsticks. He then puts the tool down and goes near the broken branch and plucks only mature pods and throws away immature pods and flowers.

Fig.10: Picture frames showing the plucking activity

3.2.2. Tool 2

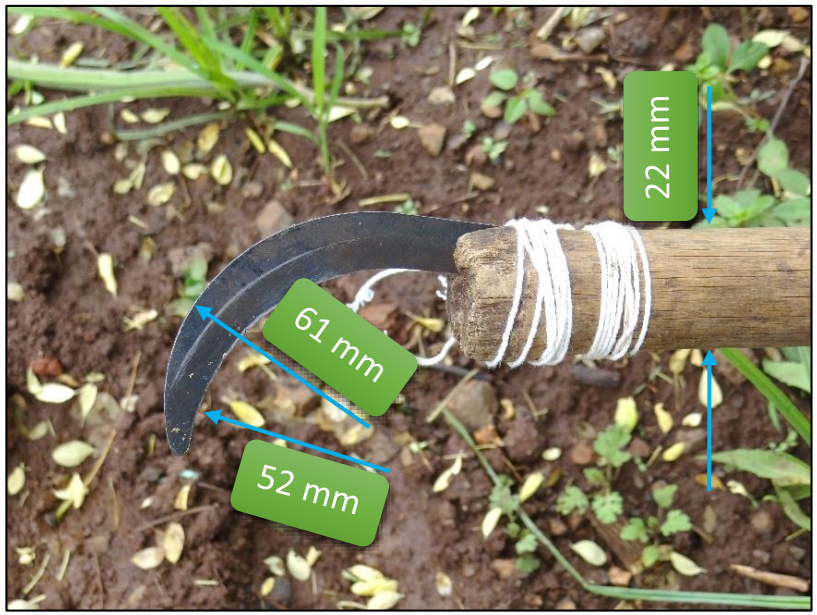


Fig.11: Tool made-up of a bamboo and small *Khurpe*

The farmer made this tool purposely to pluck mature drumsticks only. He attached "*Khurpe*" at the end of bamboo [Fig. 11]; But, it does not help him with the task completely. He hammers the branch with this tool, which breaks the entire branch causing loss of immature pods and flowers.

This tool weighs about 3.4 Kgs. It is heavy and causes neck pain, back pain and shoulder pain. The upper arm is affected due to such a heavy weight handling and causes pain.

Each time after plucking, the farmer has to collect plucked pods. This is time consuming process. The tool is difficult to carry and store

Fig.12 shows Steps of plucking drumsticks by using Tool 2.

Farmer 1st puts the cutting edge (*Khurpe*) on the branch having bunch of drumsticks. Then he lifts the tool approximately 1 feet up and hammers it on the branch. The entire branch breaks and comes down. After placing the bamboo on the ground he approaches the branch and plucks the mature pods discarding the rest.

Fig.12: Picture frames showing the plucking activity

3.2.3. Tool 3

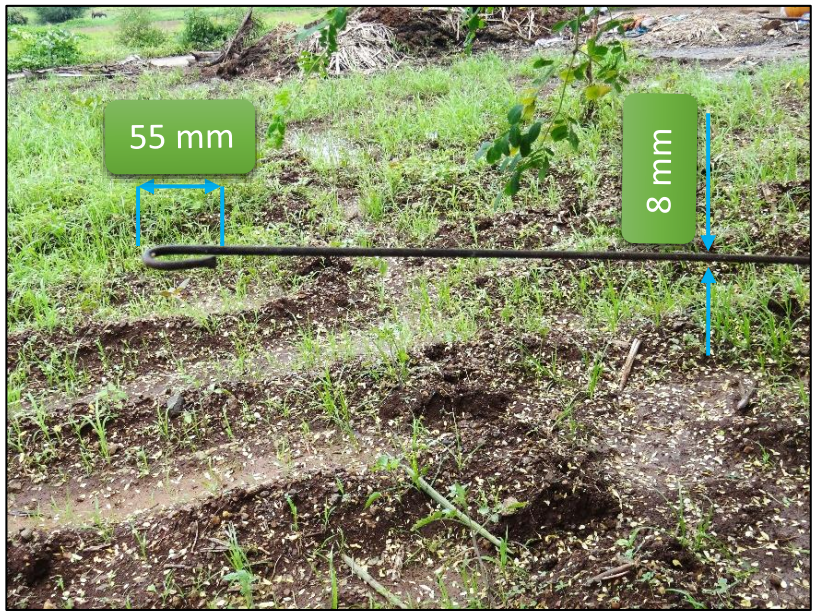


Fig.13: Tool made-up of a bamboo and long steel rod

The farmer uses this simple hook tool. But, it's a difficult task to hook particular pod from a distance of around 15 ft. Also the angle of hook makes it difficult to hook. [Refer Fig. 13]
This tool weighs about 2.9 Kgs. Due to it's heavy weight, it causes neck pain, back pain and shoulder pain. Balancing such a heavy tool is very difficult, and as a result the upper holding arm suffers from pain.

Similar to previous tools, here also farmer plucks the mature pods discarding the rest. This is time consuming process. The tool is difficult to carry and store.

Fig.14 shows Steps of plucking drumsticks by using Tool 3. Farmer hooks either mature drumstick or branch having bunch of drumsticks in the tool and pulls down. Sometimes, the entire branch breaks. Then only the mature drumsticks are plucked discarding the immature pods and flowers.

Fig.14: Picture frames showing the plucking activity

3.2.4. Tool 4

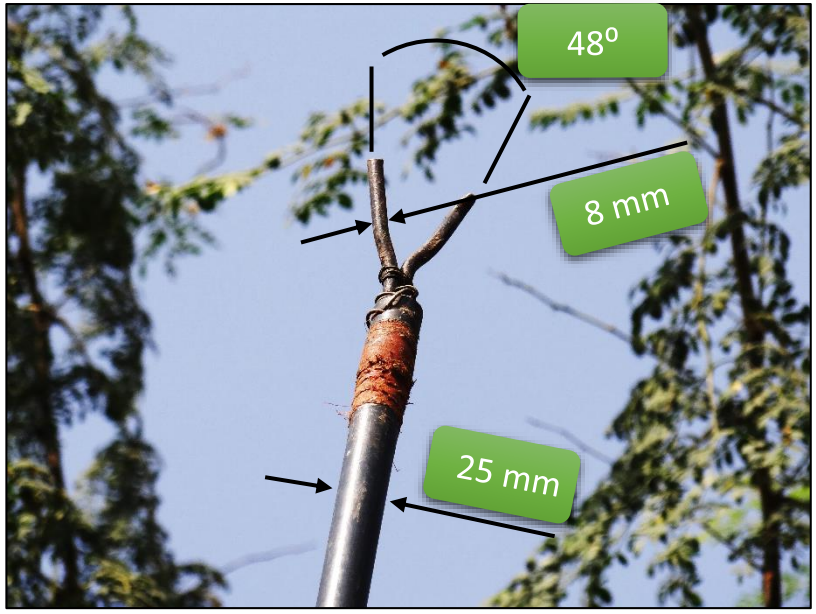


Fig.15: Tool made-up of a PVC pipe and steel rod

Fig.15 shows slightly better design of drumstick plucker. The farmer made this tool specially for plucking mature drumsticks. Here, instead of pulling the pod or branch down, he pushes the tool up, or sometimes twists it.
But cause of wide angle, the drumstick-stem slips out of the hook. The efficiency of plucking pod in first attempt is very less.
As the tool is made up of two concentric PVC pipes of 1 inch and ¾ inch, it is light weight; around 1.2 kg. But the PVC pipe bends, which makes it difficult to aim and hook at particular pod.
Similar to previous tools, here also farmer has to collect the mature pods in a time consuming process. The tool is difficult to carry and store.

3.3. Activity analysis

Fig.16: Activity analysis on time basis

3.4. Insights from activity analysis

I divided the entire plucking activity in three main groups, viz. Approaching the tool, Plucking, Collection. Fig.16 shows activity analysis of plucking drumsticks on time basis. After analyzing all these activities in detail, I got following insights:

Approaching the tool:
The tool should be light weight. [Approximately 2 Kgs]
It should be easy to hold and easy to handle
Cutter angle should be appropriate

Plucking:
The tool should be easy to aim at selected pod
Cutter should be such that, it does not hide other pods behind
Cutter should be easy to hook/ cut/ pluck
It should be balanced in upright as well as in tilted position

Collecting the plucked pods:
The tool should be integrated with pod collecting mechanism
Precaution should be taken such that, plucked pods do not get trapped in lower branches.

Others:
The tool should allow selective plucking (mature drumsticks only)
It should not damage other pods while plucking
It should be easy to carry and convenient to store
It should be maintenance free
It should be steady and strong

4. Design statement

Redesigning of drumstick plucker for safe and secure gathering of mature drumsticks

5. Design brief

- It should allow selective plucking
- It should gather drumsticks safely
- It should eliminate drumstick-skin damage
- It should be easy to cut / hook / plucked
- It should be affordable
- It should be light weight
- It should be maintenance free / repairable at home
- It should be easy to operate
- It should be easy to carry and store
- It should be steady and strong

6. Parallel product study

Fig.17: orange plucker
http://ecx.images-amazon.com/images/I/61hUuMo1%2BbL.jpg as on 5th sept, 2014

Fig.18: orange / apple plucker
http://ecx.images-amazon.com/images/I/51rnqkp8UML._SL1500_.jpg as on 5th sept, 2014

Fig.19: Mango plucker
http://thebchmag.com/wp-content/uploads/2014/06/008-the-tool-of-the-pluckers-trade.jpg as on 5th sept, 2014

Fig.20: Mango plucker
http://de.rolandschmid.ch/images/articles/4394_23cb21b86abb8fee14fb14a6cce71c1a_5.jpg as on 5th sept, 2014

Parallel products study was done by considering all types of plucking and cutting tools available for harvesting fruits, vegetables and flowers.

Fig.17 shows orange plucker. It is slightly an advanced design in terms of its functionality and usability. Use of only two rings to hold such a delicate fruit is a considerate idea.

Fig.18 shows another advanced orange/ apple plucker. It consists of three jaws at the tip and jaw operating lever at the handling end.

Fig.19 shows traditional mango plucker. It is made up of a mild steel circular frame, two hooks, nylon net and bamboo or pipe. It is a low cost design.

Fig.20 shows advanced mango plucker. It consists of a circular frame with teeth on upper edge and a bag below it.

Fig.21: Fruit plucker
http://clevedoncounty.com/wp/wp-content/uploads/Ppicker.jpg as on 5th sept, 2014

Fig.22: Fruit collector
http://www.cutedecision.com/wp-content/uploads/2011/10/harvester-03.jpg?e9936a as on 5th sept, 2014

Fig.23: Flower stem cutter
http://images.knifecenter.com/knifecenter/clauss/images/AU33503.jpg as on 5th sept, 2014

Fig.24: Flower stem cutter (slant cut)
http://bilder.myfavoritethings.se/flower_cutter_-_skarare_for_snittblommor.jpg as on 5th sept, 2014

Fig.21 shows a general fruit plucker which can be used to pluck most of the fruits at a considerable height. But it doesn't have collection bag.

Fig.22 shows a fruit collection unit.. It consists of a four wheeled vehicle with a frame like structure and a cloth for collection plucked fruits. It can be used in with fruit plucker shown in Fig.21.

Fig.23 shows simple flower stem cutter. It has a retracting spring to keep its blades always in open position.

Fig.24 shows advanced flower stem cutter. It helps user to cut flower stem in slant direction.

7. Ideation

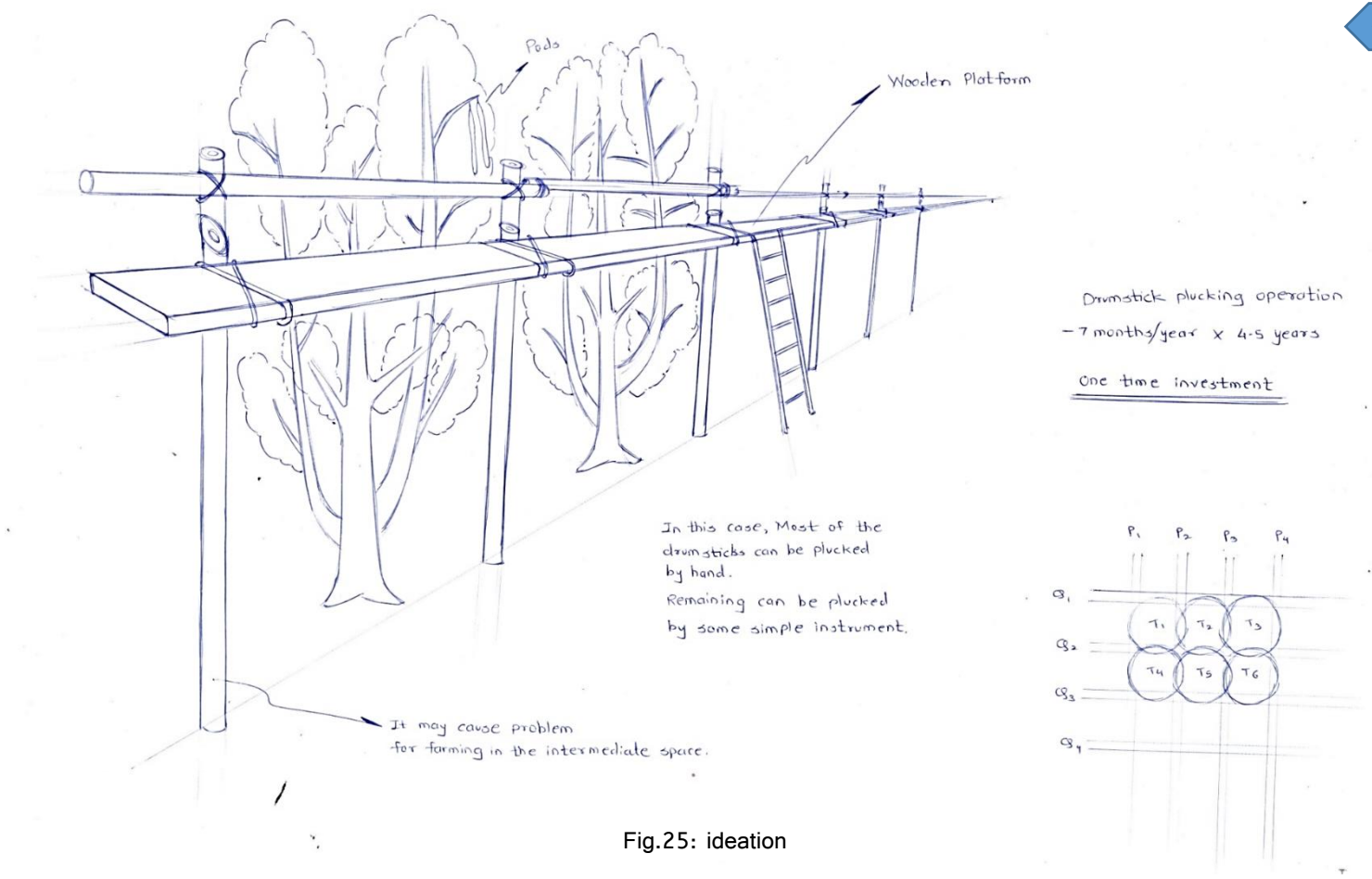


Fig.25: ideation

Under this ideation a system design approach was developed including the field land.

As shown in Fig.25, there will be a platform at height of 10 feet from ground level. This platform will be constructed near all trees in the matrix pattern.
This platform can be used to climb up and pluck drumsticks by hand, or by using simple light weight plucker.

Firstly, such a structure is not economically feasible.
Secondly, for this kind of structure to be built the terrain was supposed to be plane; which in reality is very uneven.

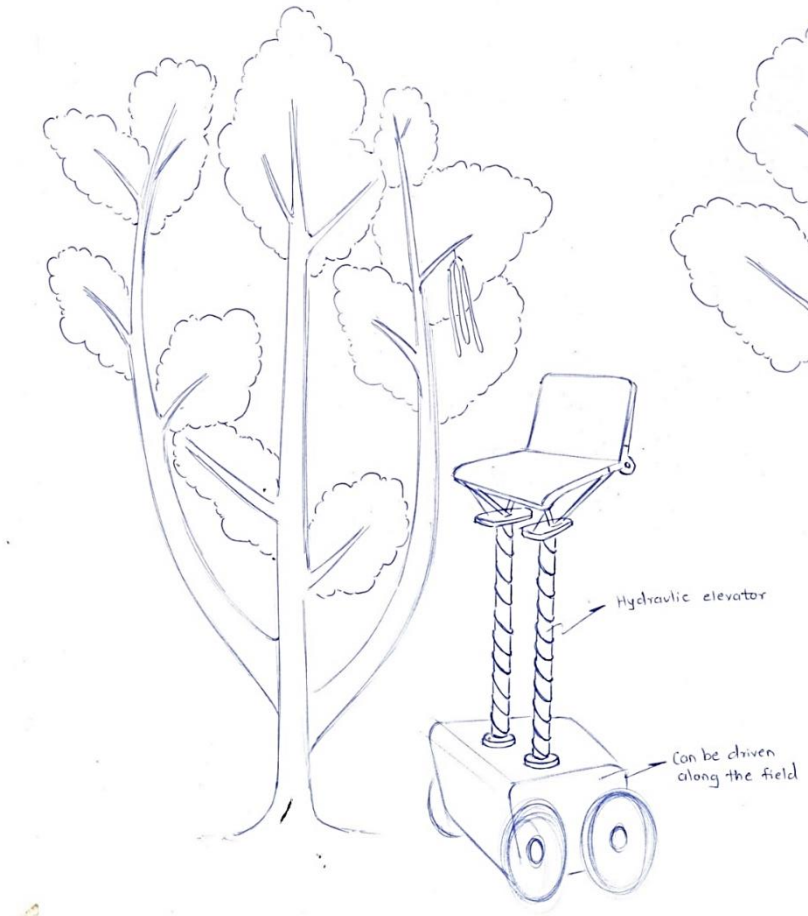


Fig.26: ideation

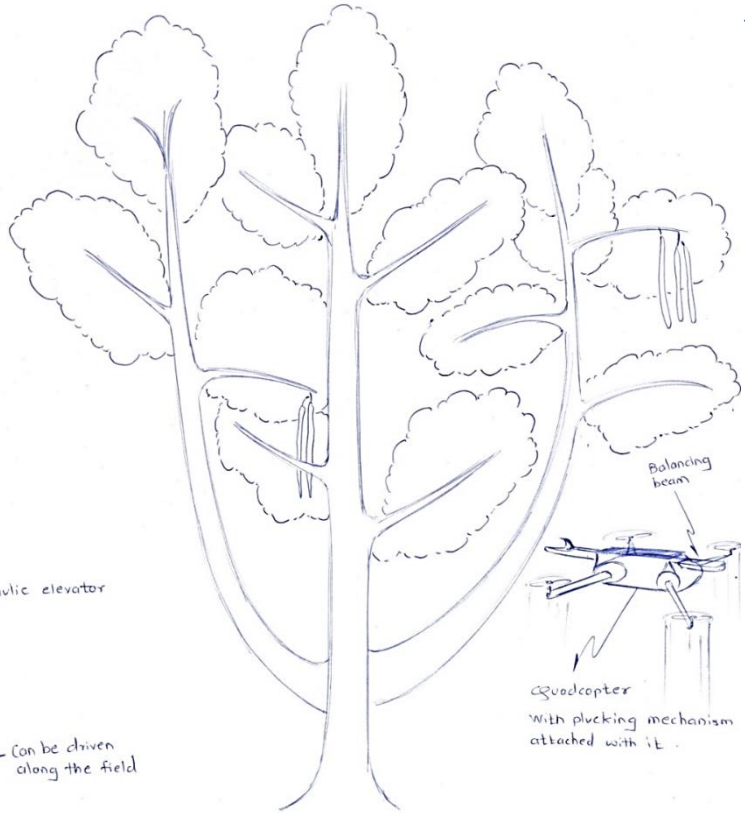


Fig.27: ideation

In this ideation more radical and high-tech thought was given to make drumstick plucking activity a simple and easy task.

In this 2nd idea as shown in Fig. 27, A quad-copter with cutting mechanism is proposed. But it will be difficult to use considering the nature of the branches of the tree and overall affordability.

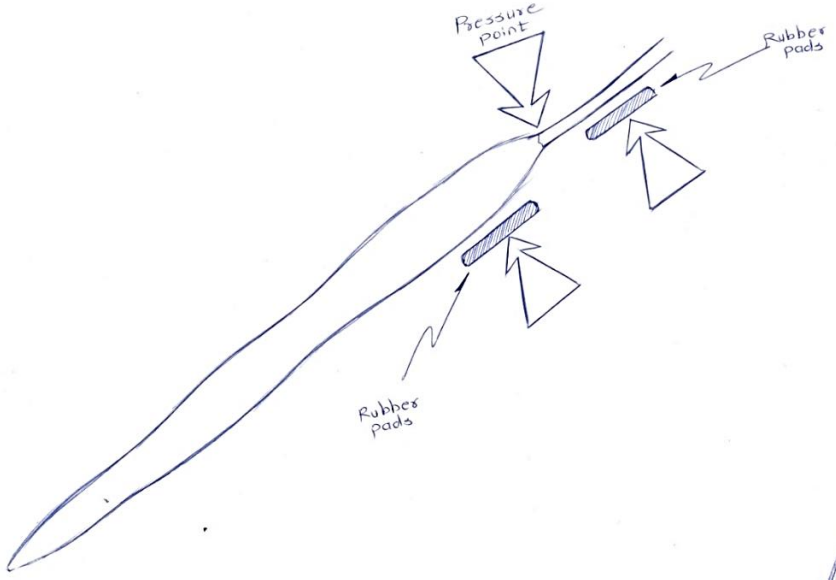


Fig.28: ideation

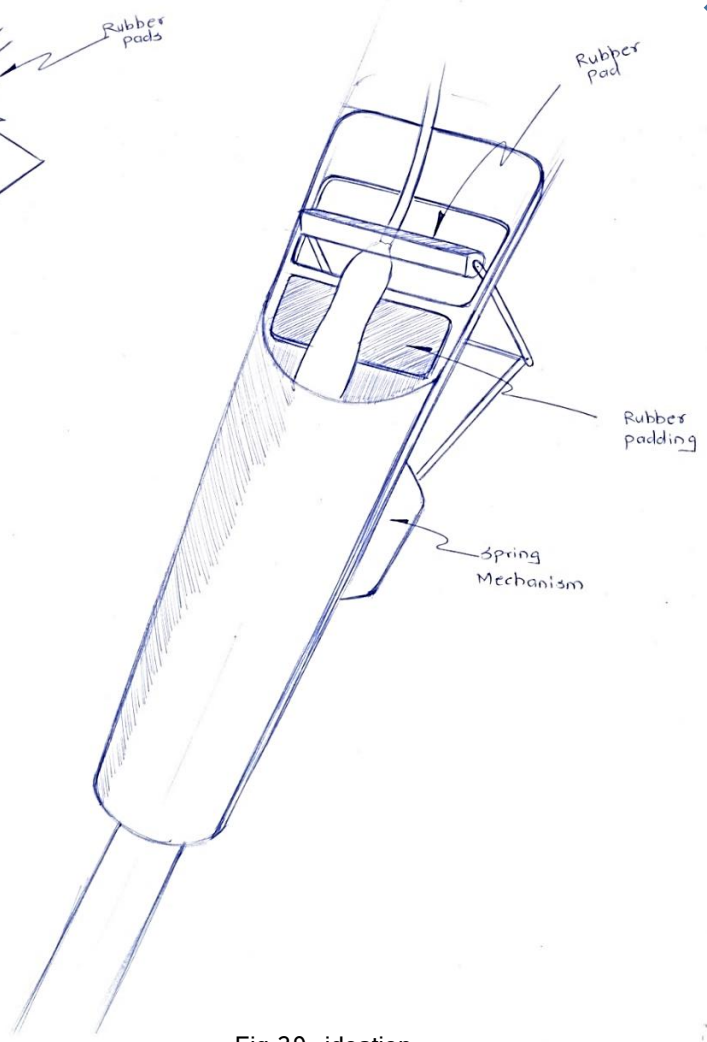


Fig.29: ideation

Here, the drumstick's structural study was done, which gave an interesting insight.
The connection point of pod with its stem is very weak; and it will easily break at this point after applying a small amount of pressure. Fig. 28 shows pressure points.

This principle was used to design new concept as shown in Fig.29 It is a tool which will allow the user to pluck the pod at connection point only.

Here, the problem is finding the exact point from a distance of approximately 15 feet at ground

7.1. Concept 1

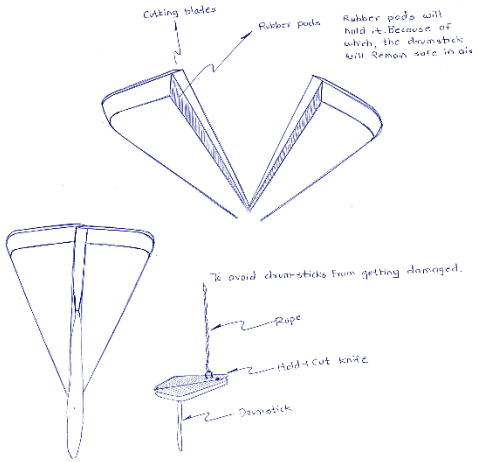


Fig.30: ideation

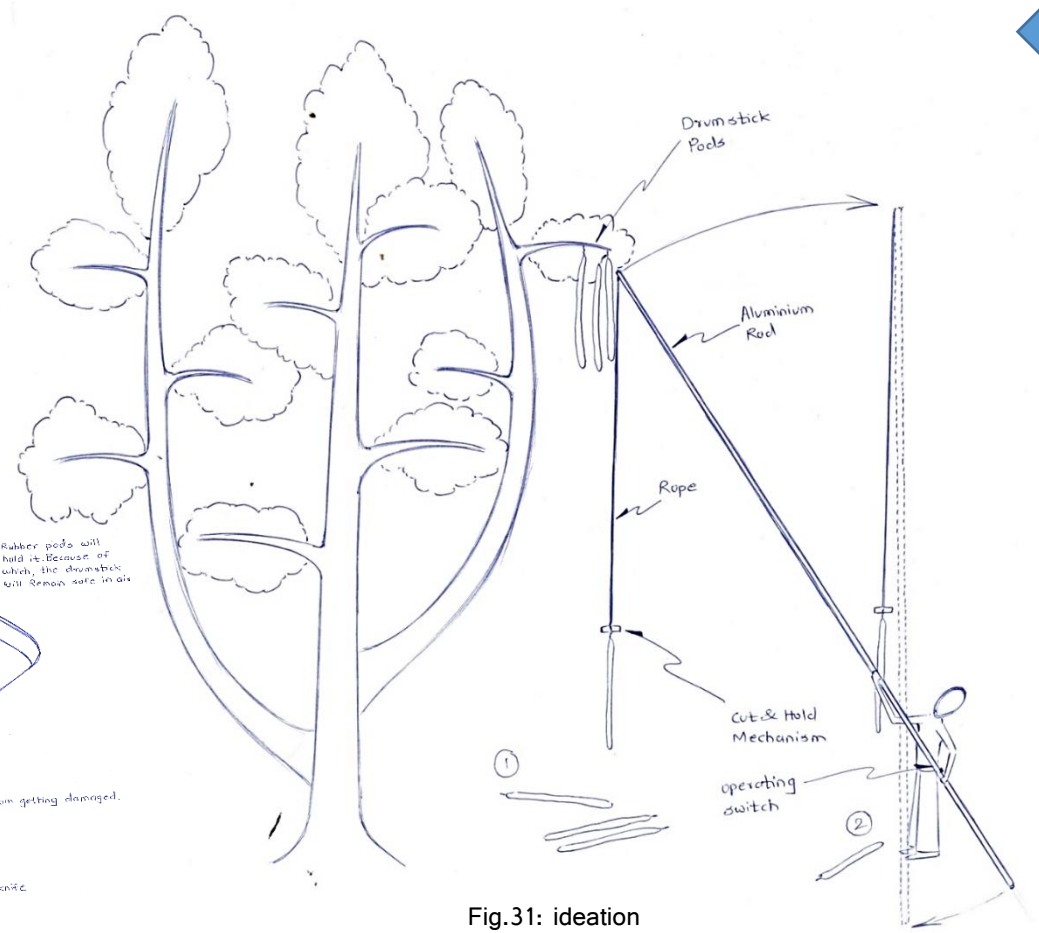


Fig.31: ideation

Concept 1:
In this concept, a new type of cutter was designed which will hold the pod 1st, and then cut it; such that it will not fall down. Fig.30 shows the working principle of cutter.

As shown in Fig.31, the plucker will work similar to fishing rod. The tool will be at the end of the pipe. 1st it will cut the pod, then entire cutter along with pod will come down near ground then the pod will be released, and then again cutter will go back to its original position on pipe.

7.2. Concept 2

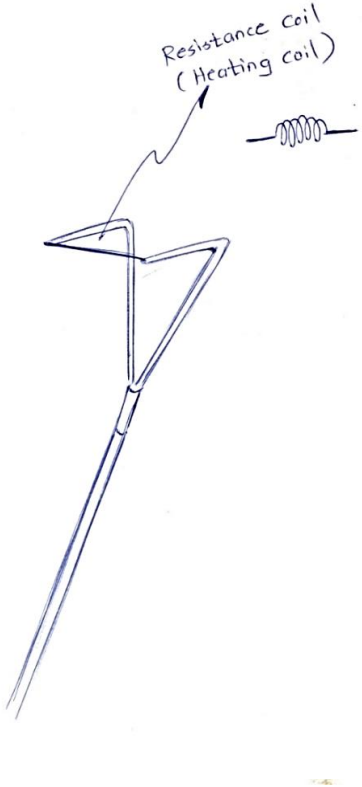


Fig.32: ideation

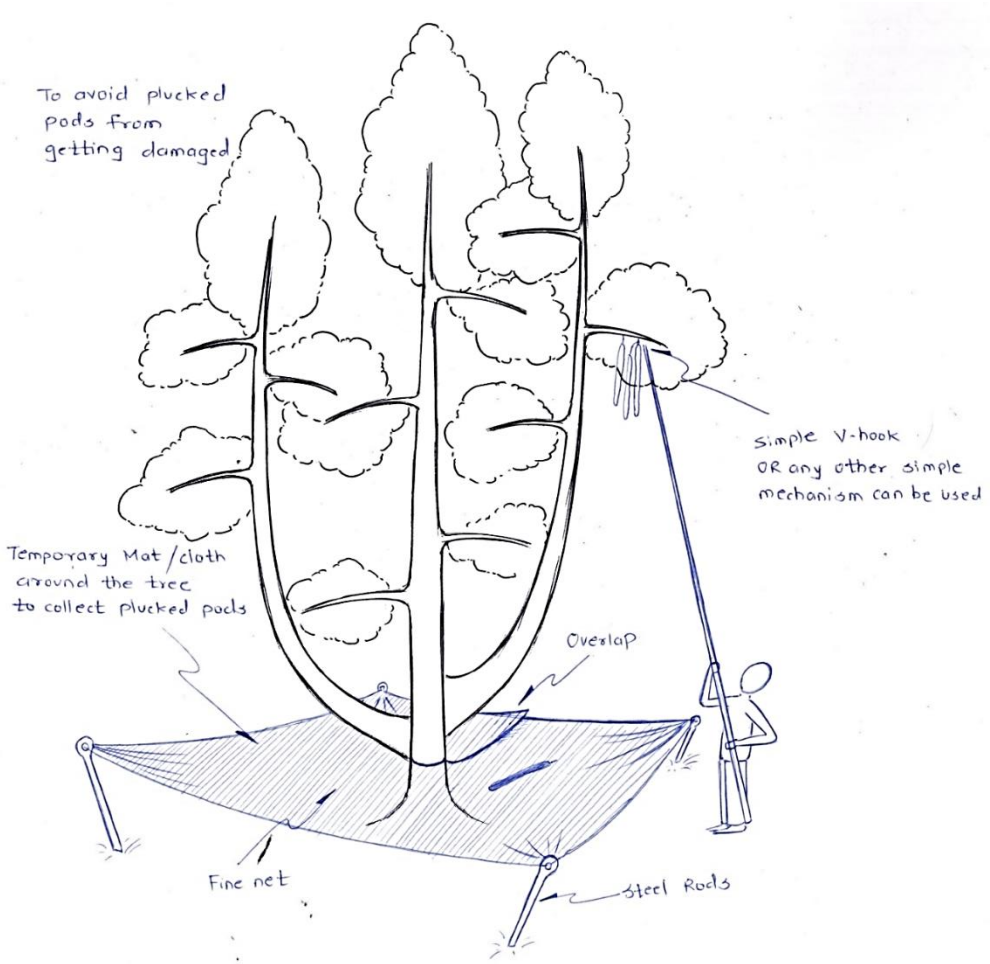


Fig.33: ideation

Concept 2:
In this Idea followed by concept development, an electrical cuttings blade system with a resistance coil was used.

As shown in Fig.32, resistance coil will work on 9 volt electrical supply, which will create enough heat to cut stem of drumstick pod.

As shown in Fig.33, this cutter will work in coordination with collection-mat. There will be a mat/ cloth which can be laid around the tree. So the plucked drumsticks will fall on the cloth and will be protected from getting damage. Also it will help farmer in collection activity.

7.3. Concept 3

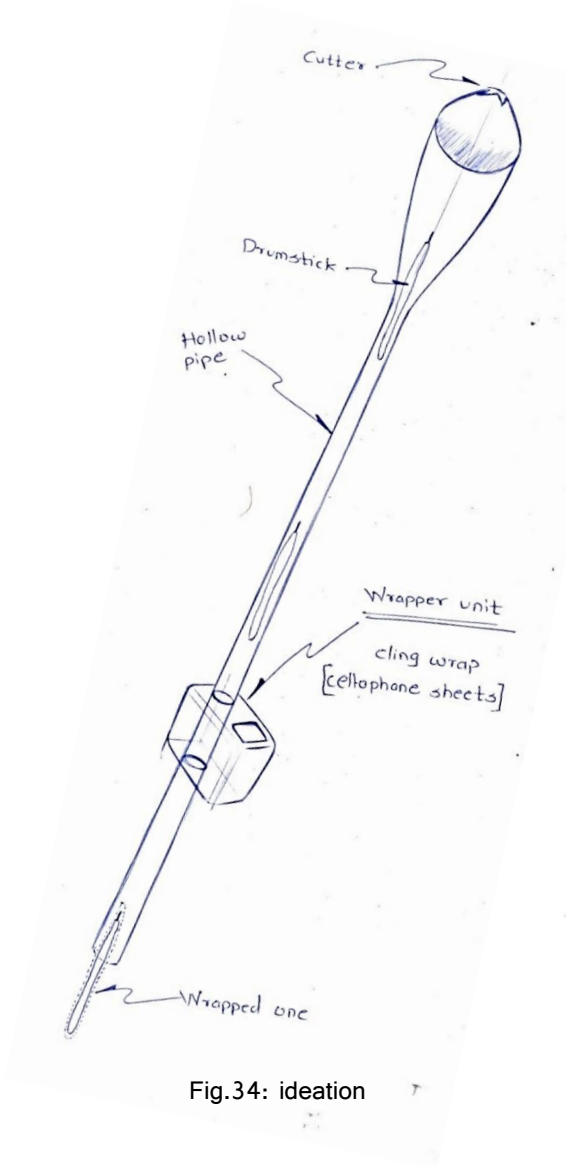


Fig.34: ideation

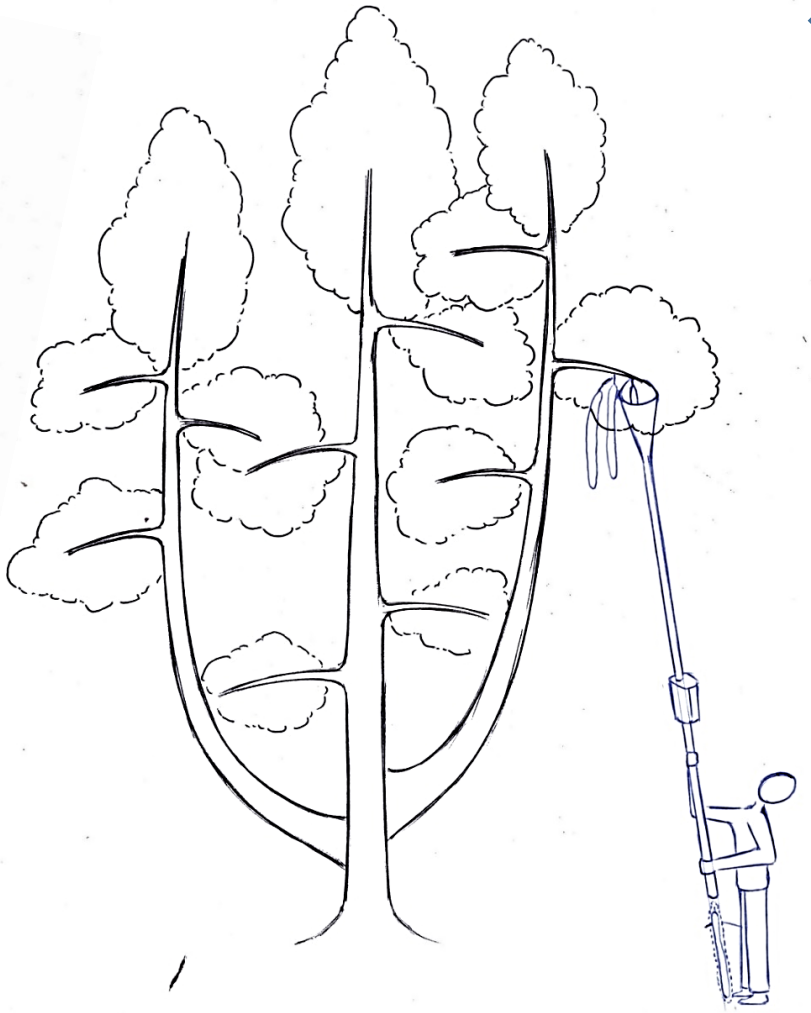


Fig.35: ideation

Concept 3:
Here the main importance was given to 'pod collection' activity.

Fig.34 and Fig.35 explain working principle of the tool. The pod will be plucked by using a cutter. The plucked pod will slide down through the pipe, and it will come to the farmer.
For cutting mechanism, hydraulic or pneumatic or a simple cycle break lever mechanism operated cutter can be used.

While coming down, the pod will go through wrapping unit, which will wrap the pod in cling paper.

7.4. Concept Evaluation

Criteria	Concept 1	Concept 2	Concept 3
Selective plucking	✓	✓	✓
Quick operation	≈	≈	✓
Easy to use	≈	✓	✓
Light weight	≈	✓	✓
Maintenance free	✓	≈	≈
Affordability*	✓	✓	✓
Easy to carry & store	✓	≈	✓
Steady & strong	≈	≈	✓

* Considering all concepts are affordable

Fig.36:Prototype comparison table

For comparing the three concepts, roleplaying method was used by which results of selective plucking, quick operation, easy to use and easy to carry & store were found out.

Results of other comparison criteria were arrived at by discussion with the guide.

After comparing all three concept from user point of view as shown in Fig.36, the concept 3 was found to be best among the three.

So, concept 3 was taken forward for further refinement.

7.5. Refined concept

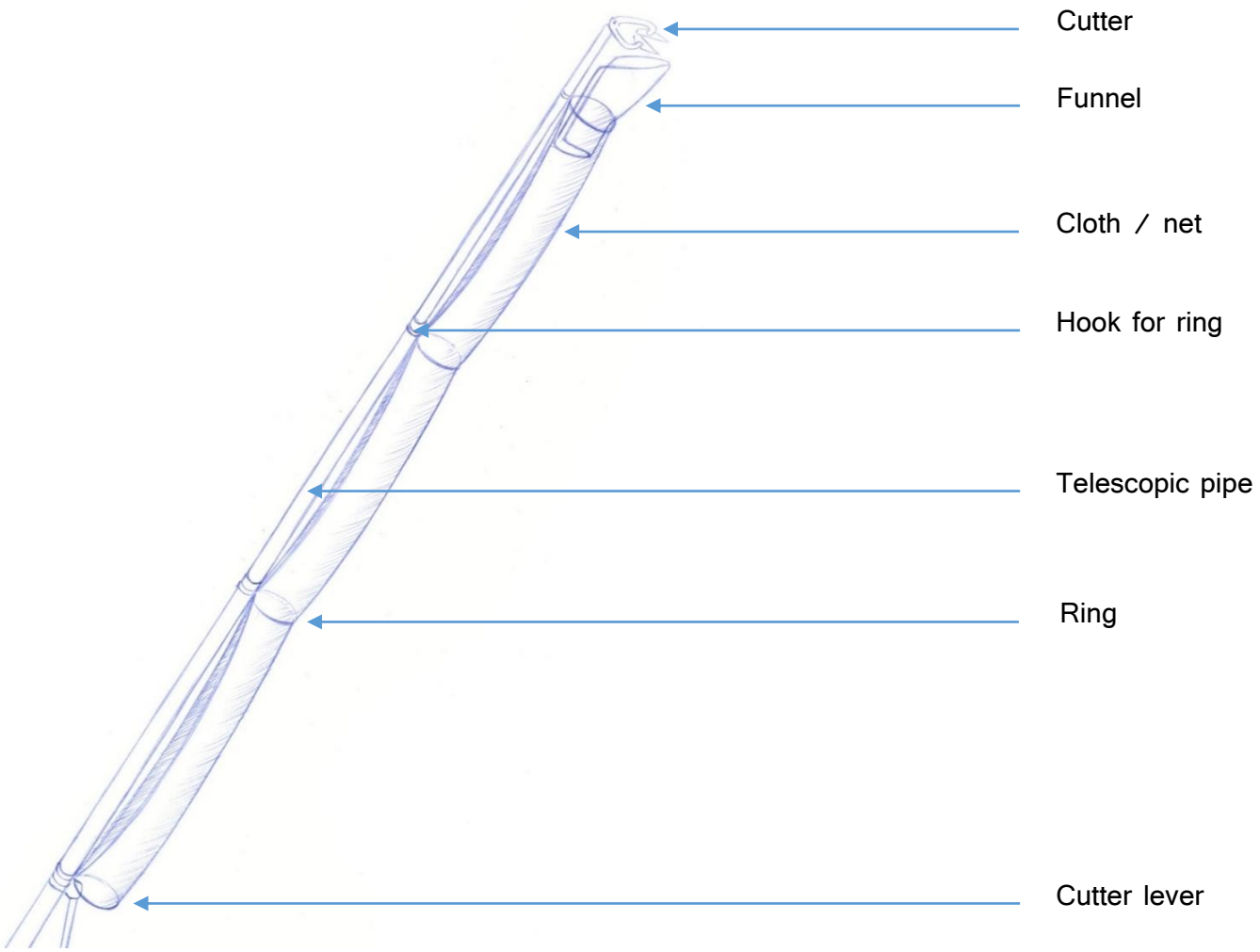


Fig.37: Refined concept

Refined concept:
After discussing the concept 3 with farmers, some important changes were incorporated in the design.

Farmers wash the plucked pods with water before sending them to market. It removes dust particles from pod and makes it look more fresh.
So, the wrapping unit was removed from the design.

All drumstick pods are not straight. Some have bent structure. So, such pods can not pass through smaller diameter pipe. Increasing pipe diameter beyond certain limit will make it difficult to hold and also it will increase the weight and price of pipe.
So, a separate collection bag was attached which will run along length of the pipe. [Fig.37]

8. Prototyping

Fig.38: Cutter blade-1

Fig.39: Cutter blade-2

Cutter Blade

To develop the cutter two different types of cutting blades were designed, viz. Moving, Non moving. Moving cutter would work like a scissor while the non moving cutter would work like a hook. The blades were made up of 3 mm stainless steel.

The two blades of moving cutter were of unequal length. Longer blade has curvature at the end. This long blade would help the user to aim the cutter to selected pod easily. There were V-notches along the length of the blade, which would hold the stem firmly at its position and eliminates chances of slipping out. [Fig. 38]

Stationary cutter blade was made up of two parts, viz. Guiding blade and a sharp edged blade. [Fig. 39]

Fig.40: Aiming of cutter towards drumstick stem

Working Principle

Fig.40 and Fig.41 explains the sequence of operation of cutter blade. The long blade of the cutter worked like a guide way for stem. The farmer had to look at longer blade, and then had to push the blade below the stem. After that he had to slide the blade in horizontal direction. The stem of pod would automatically slide into the cutting gap between two blades.
The efforts and time required for aiming the cutter to pod were reduced.

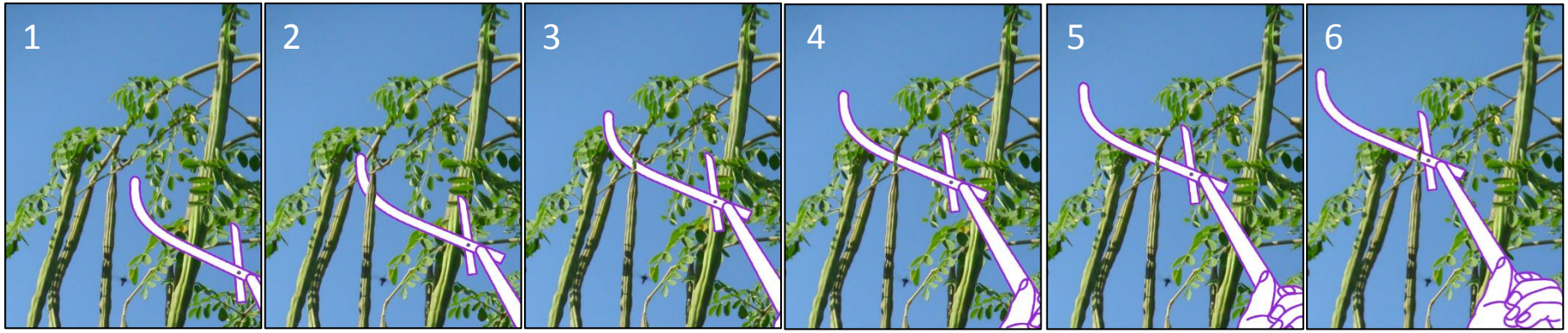


Fig.41: Cutter blade-2- Sequence of operation

8.1. Prototype 1

Fig.42: Prototype 1

The prototype was made up of three main parts, viz. Telescopic pipe, Cutter, Cutter operating mechanism. [Fig. 42]
The material of telescopic pipe was Aluminium. The cutter blades were made up of 3 mm stainless steel. The cutter operating mechanism was similar to bicycle braking mechanism. The inner cable of operating mechanism was 1.5 mm wire rope; and the outer cable was taken from auto rickshaw industry. [Fig.43 & Fig.44]
Retracting spring was also used to keep blades in open position.

Fig.43: Cutter blade-1 and its parts

Fig.44: Operating lever

8.2. Prototype 2

Fig.45: Prototype 2

The prototype was made up of mainly two parts, viz. Telescopic pipe and Cutter..[Fig. 45]
The material of telescopic pipe was Aluminium. The cutter blades were made up of 3 mm stainless steel.

The cutter had two blades. Longer one was the guiding blade. It didn't have any cutting edge. Second one was cutting blade. It had sharpened edge. [Fig. 46]

Fig.46: Cutter

8.3. Prototype testing

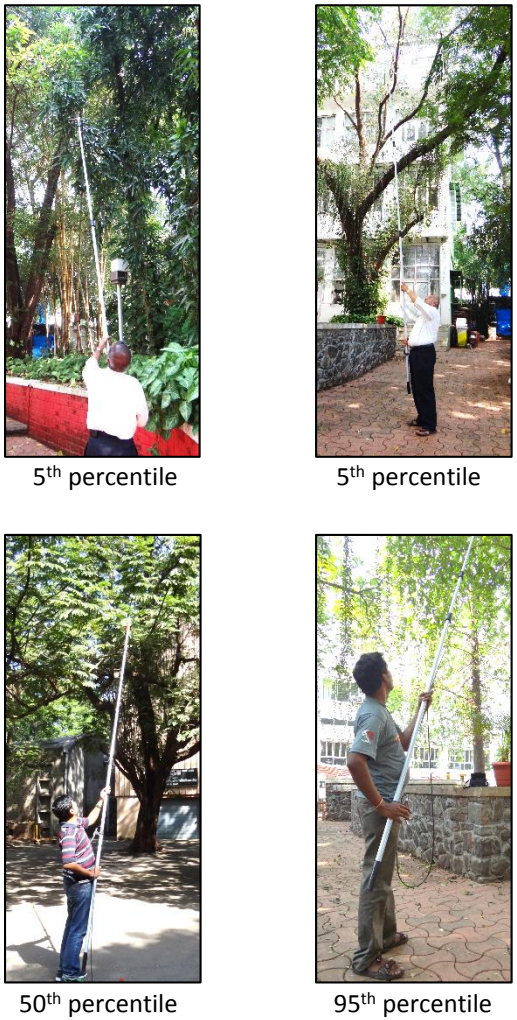


Fig.47: Prototype testing

To check feasibility and best suited prototype out of the two, prototype testing was done.

While testing the prototypes, the time required to aim the tool to specific stem was measured. Also, other factors like - ease of operation, balancing of the tool and physical strain were taken into consideration.

Fig.47 shows testing of the prototypes by considering users of different percentile.

Prototype 1 was found quite difficult to use. As it had operating lever, the user had to put his one hand continuously on that. Thus, the degree of freedom was reduced, and the lever was forced him to be conscious about the entire plucking activity. Also the cutter and its operating lever was quite heavy, which was pushing center of gravity of entire tool away from the user making it difficult to balance.

Comparatively, prototype 2 was found very easy too use. As there was no operating lever, the farmer was getting higher degree of freedom. Also It was light weight, easy to aim, and easy to balance.

8.4. Prototype comparison

Fig.48:Prototype 1

Fig.49:Prototype 2

Criteria	Prototype 1	Prototype 2
Selective plucking	✓	✓
Quick operation	✓	✓
Easy to use	≈	✓
Light weight	≈	✓
Maintenance free	≈	✓
Affordability	≈	✓
Easy to carry & store	✓	✓
Steady & strong	≈	✓

Fig.50:Prototype comparison table

Fig.48 and Fig.49 shows Prototype 1 and Prototype 2 respectively.
Fig.50 shows the tabular comparison of the two prototypes.
Prototype 2 was taken forward for further refinement as it was better than Prototype 1 in several ways (ref Fig. 50).

8.5. Refined cutter

Fig.51: Refined cutter

While testing of prototype in the field, it was realized that two cutting blades are not enough to aim at pod. Because of only two blades, the user had to consciously move the pipe such that, the stem will go exactly in the gap. But if there were two blades on both sides of longer blade, it would make this activity easy.
Also, the slant edge of previous cutting blade was not helpful as, the stem use to slip out of it while pushing or twisting.
So, the cutter blades were redesigned such that the sharpen edges will be on both sides of central longer blade. Also the blade profile was changed such that, blades will be parallel for some length, after which they will converge at a single point on both sides of central blade.
Fig.51 shows refined profile of cutter.

8.6. Ideations of clamp

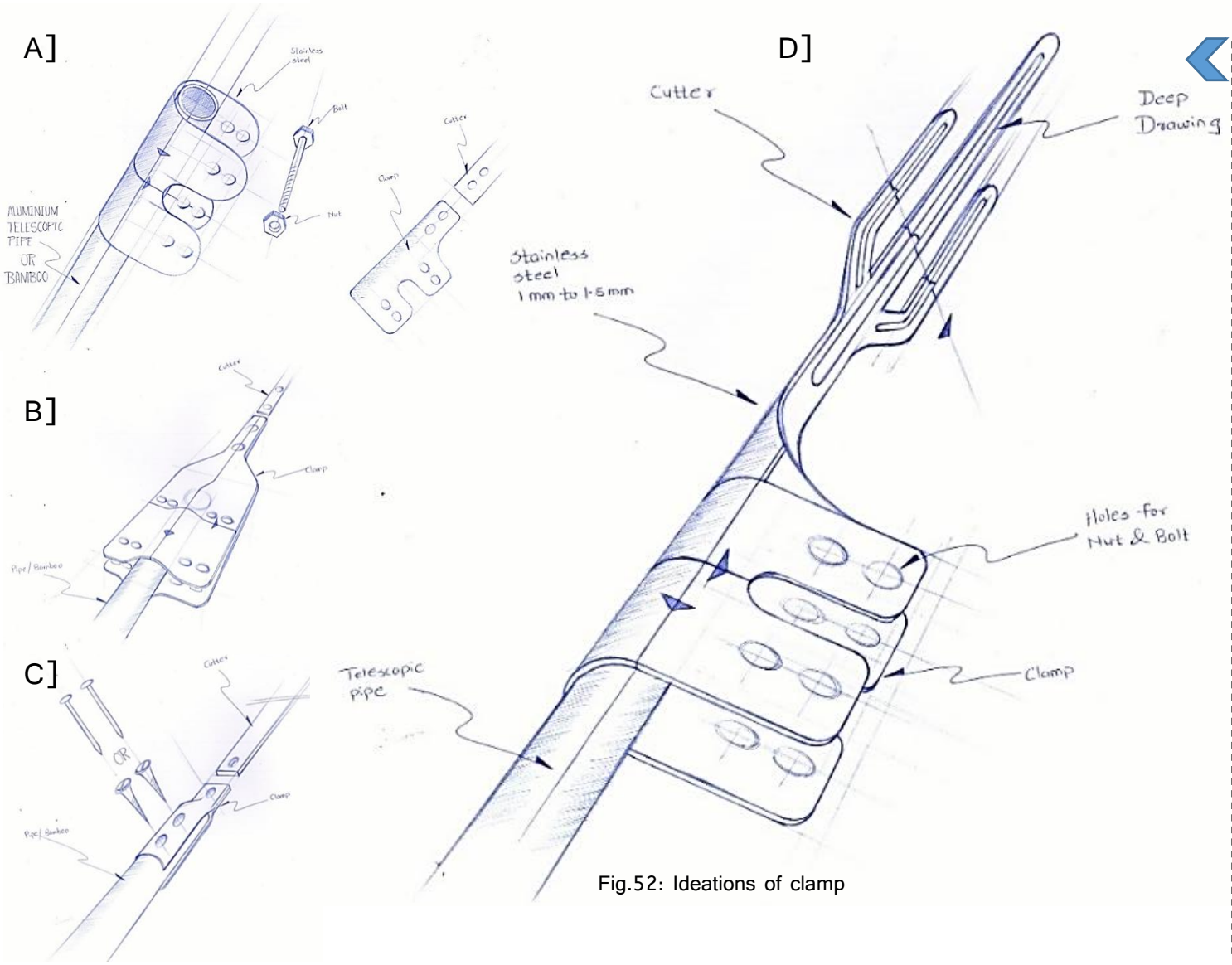


Fig.52: Ideations of clamp

From product point of view, mass manufacturing plays an important role for which product detailing is paramount.

So, different ideations were made to design a clamp which will fit on pipe as well as bamboo; and also which will be light weight but yet strong enough to withstand torsional forces acting on it while twisting. [Fig.52]

Design ‘D’ was finalized in which both the clamp and the cutter would be integrated into a single unit. It would be made up of 1 mm thick Stainless steel sheet. Cutter part would go through forming process to get required strength.

8.7. Collection bag

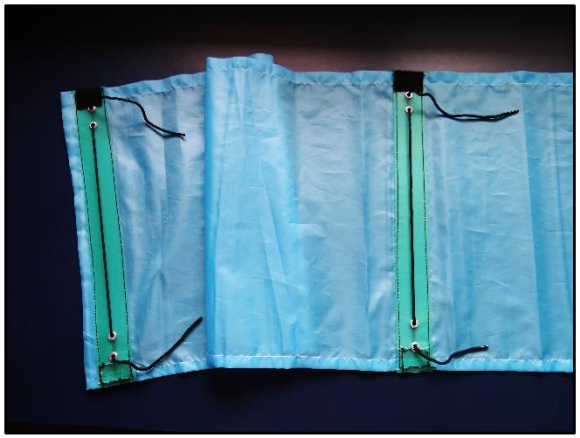


Fig.53: Collection bag and its parts

Fig.54: Collection bag

Collecting plucked pods was a time consuming and tiresome activity. Sometimes, pods get lost into grass on the ground. So, to avoid this, a long bag which will run along the length of the pipe was designed; through which the plucked pod would come to the user.

The bag was designed by considering following important points:
-The pods should not stick / hook into it
-It should be strong enough to provide wear resistance while rubbing against branches
-It should be light weight
-It should not soak water
-It should be easy to assemble & disassemble
-It should be easy to store [occupy less space]
-It should be designed with consideration of bent pods.

Special type of polyester material was used which is used in bag manufacturing industry. Polypropylene strips were stitched at a distance of 2 feet through-out the length of cloth to give it cylindrical shape. Holes were provided on these PP strips to insert lace through it. These holes were riveted to give more strength and avoid damage. [Fig. 53]

Velcro was provided at the ends of PP strips to connect ends of the strip and to make it cylindrical. [Fig. 54]

8.8. Final prototype

Fig.55a: Prototype 3

Fig.55b: Prototype 3- Cutter blade

Fig.55c: Prototype 3- Collection bag

Fig.55a shows final prototype of the drumstick plucker. It had a telescopic pipe, Cutter blade, and a collection bag.

Fig.55b shows the refined profile of cutter blade.

Fig.55c shows the collection bag and how it gets tied with the telescopic pipe. PP strips help it to stay in cylindrical shape.

8.9. Prototype testing

Fig.56: Prototype 3

The prototype testing was done in a village (*Kesnand*) near Pune. [Fig.56]

Insights:
The collecting bag was found inefficient; as wind makes it unstable. Also it was difficult to take plucked drumstick pod into the bag. Because of bag, it was difficult to see exact position of cutter blade and stem of pod. Also, assembly of this bag was time consuming activity.
The cutter was found to be effective. It allowed the user to pluck mature pods only. Aiming of the cutter to particular pod was also easy as compared to previous cutter. Different combinations of cutter blades were tried out; and realized that the combination as shown in Fig.57 was more efficient.

Fig.57: Prototype 3

9. New concept

Fig.58: New concept

After the prototype testing, It was realized that, the cutter blade was working very well. The problem was with collection bag.

So, the current design was kept aside, and new ideations were generated. Conscious effort was made to integrate cutter and collection bag into single unit which resulted into new concept as shown in Fig.58.

It was made up of 3 inches diameter pipe. It had 6 vertical slots of 10 mm width along the circumference of the upper edge.

Firstly, the user would take the pod inside the pipe, and then he would push it upwards [Refer Fig.59a, 59b, 59c, 59d, 59e]. The stem of pod would go into one of the vertical slots [Refer Fig.59f, Fig.59g]. Then he would twist the tool [Refer Fig.59h, Fig.59i] , such that the stem would get twisted at the weak point and would get easily plucked. As the entire pod is in the pipe, after getting plucked, it would remain in the pipe only [Refer Fig.59j].
Fig.59k, Fig.59l, Fig.59m, Fig.59n show the schematic diagram of relative movement of cutter pipe and drumstick.

A collar was provided on the base of the cutter pipe on which a long collecting bag can be tied to transfer pod to the user.

9.1. New concept: Working Principle

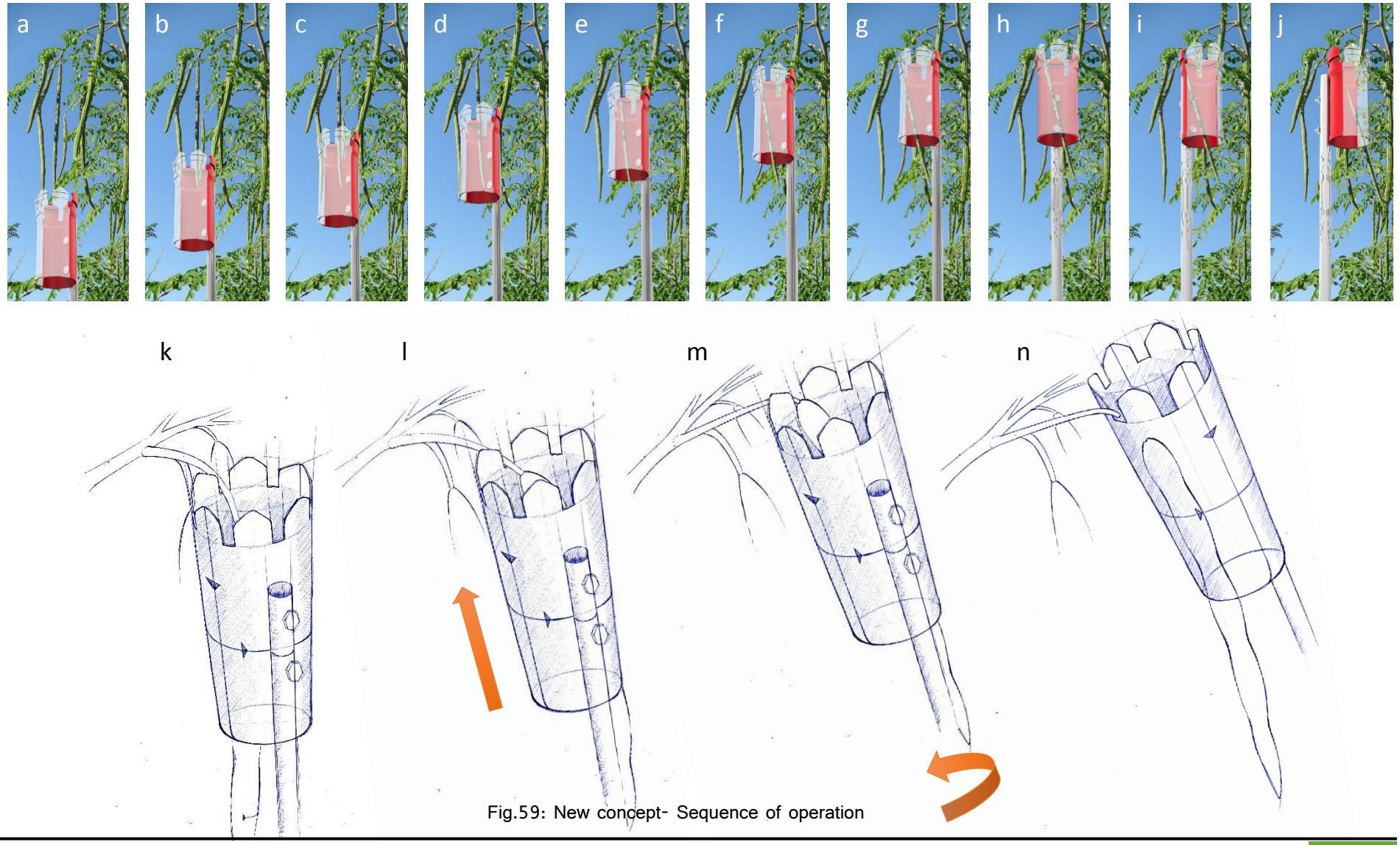


Fig.59: New concept- Sequence of operation

9.2. Prototype 4

Fig.60a: Prototype 3

Fig.60b: Prototype 3- Cutter Blade

Fig.60c: Prototype 3- Collection Bag

Fig.60a shows the prototype of new concept. It has a telescopic pipe, 3 inch diameter cutter pipe and a collection bag.

Fig.60b shows the close up of the Cutter Blade

Fig.60c shows the Collection Bag and how it gets tied with the Telescopic pipe. Collar like design helps the bag to stay in its position

9.3. Prototype testing

Fig.61: Sequence of operation

Fig.61 shows sequential operation of drumstick plucking activity by using new cutter pipe. Firstly, the pod was taken into the Cutter Pipe. The stem of pod went into one of the six slots on pipe. Then the pipe was pushed upwards and twisted slightly. The pod got plucked at its weak point (where the pod joins the stem). The plucked pod slides through the collection bag which was retrieved from the opening provided at the bottom. Refer Fig.62

Fig.62: Picture frames showing the plucking activity

9.4. Prototype testing : Results

- The tool allowed the user to selectively pluck mature drumsticks only.
- The collection bag worked better. Pods slide down the pipe easily.
- The pod- skin damage was reduced, almost eliminated.
- Plucking time was reduced to 12 seconds per pod.
- The tool was steady and balanced in upright as well as in tilted position.
- The weight of entire tool was found to be 1.8 kg only; lesser than traditional tools used for the purpose.
- The tool was easy to operate.
- The tool was easy to carry and store.
- The collection bag allowed the user to collect around 12 pods at a time, hence the tool was over all time efficient.

Thus, as compared to traditional tools and last three prototypes, this tool was found much better in all aspects.

9.5. Product detailing

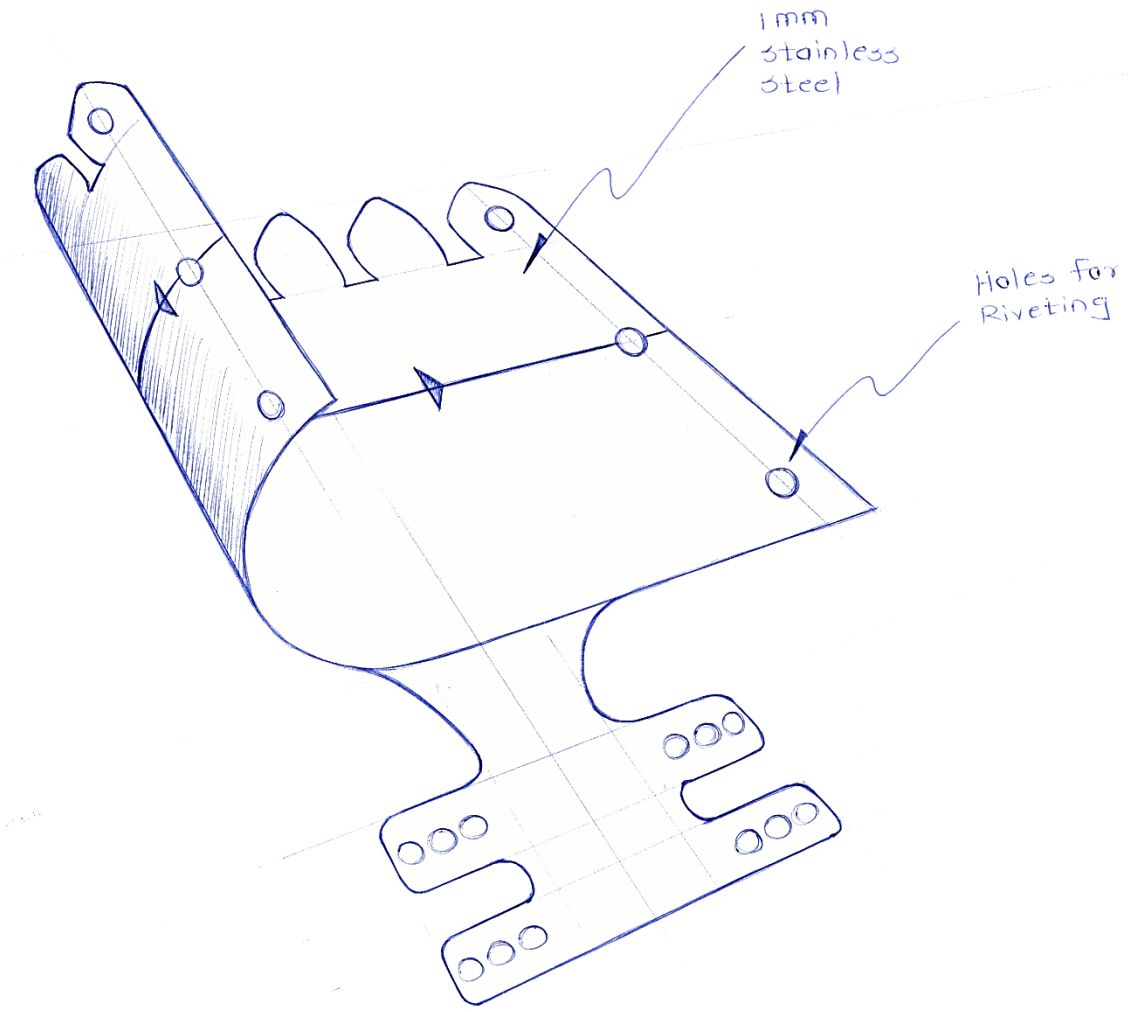


Fig.63: Cutter by using sheet metal

Modified cutter pipe:

Fig.63 shows schematic diagram of the process of bending sheet metal for Cutter Pipe
As HDPE/PVC prone to breakage and crack, sheet metal was concluded to a suitable material for cutter pipe. The cutter as well as clamp were integrated into the one unit. 1mm thick stainless steel was used, and it was laser cut into the required profile; and the ends were joined together by rivets.
In future for mass manufacturing, this profile can be cut by punching operation.
Multiple holes were provided on clamping part to make it easy to mount on telescopic pipe as well as bamboo of varying diameter.

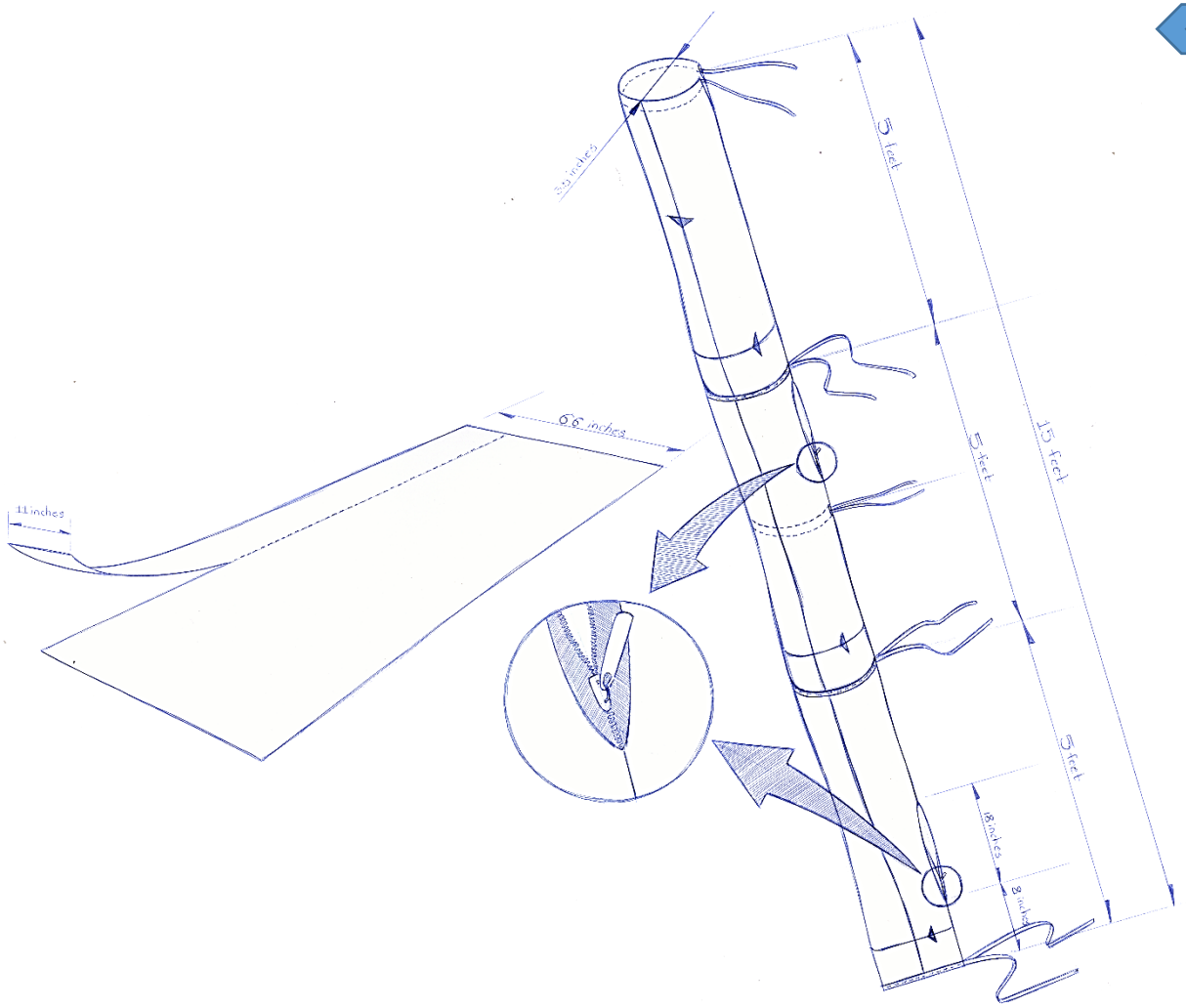


Fig.64: Modified collection bag

Modified collection bag:

Fig.64 shows modified design of collection bag. It was made up of polyester material. This cloth was available in market in the form of role of width 66 inches. The required diameter of bag was 3.5 inches with circumference 10.9 inches [approx.]. Hence while cutting cloth, 11 inches was taken as optimum width for each piece which gave [11x6=66 inches] 6 pieces along the entire width of cloth-role.

Fixed lace was tied to the bag at three places and free lace was tied at two places [at top and at center]. Top free lace was used to tie bag with the collar on cutter pipe; and center free lace was used to reduce the length of bag for plucking drumsticks at lower height [Refer fig.65a and Fig.65b]. Zip was provided at two positions to remove collected pods out of the bag.

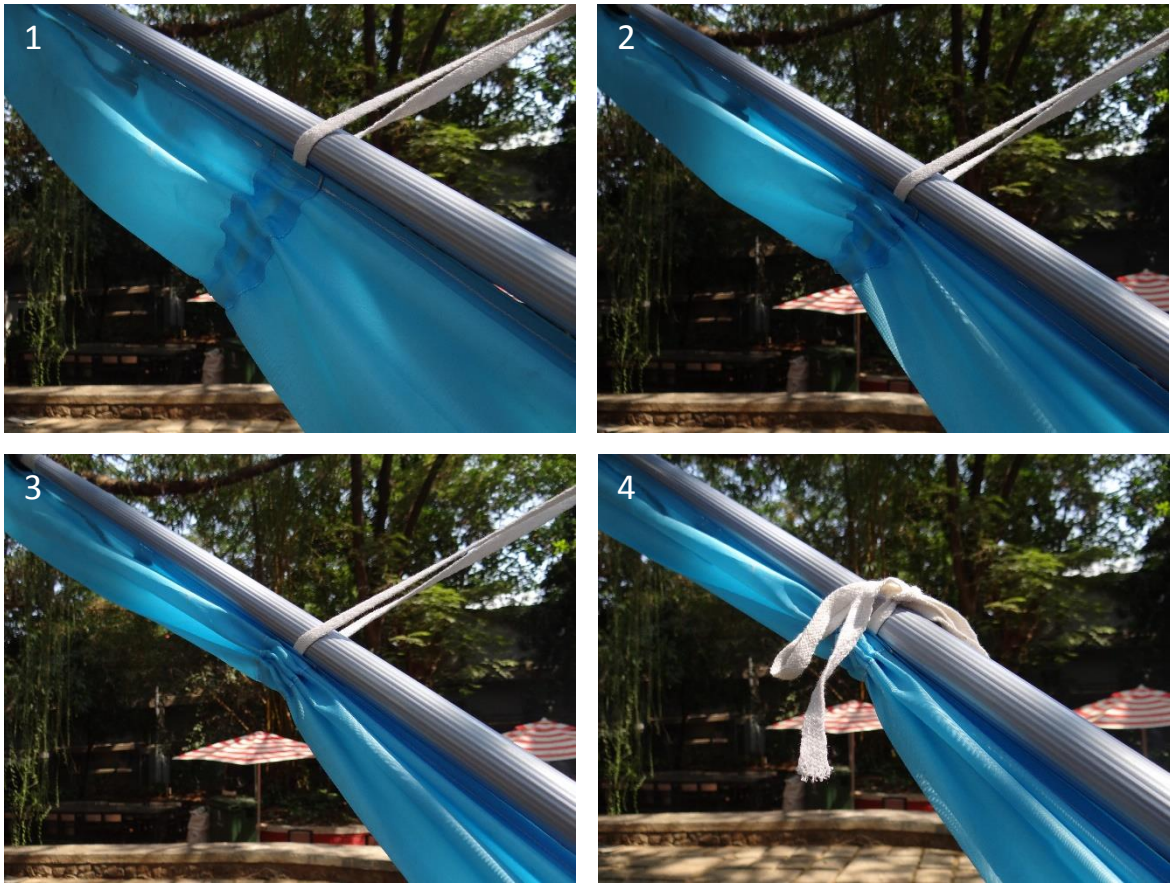


Fig.65a: Modified Collection Bag (detailed)

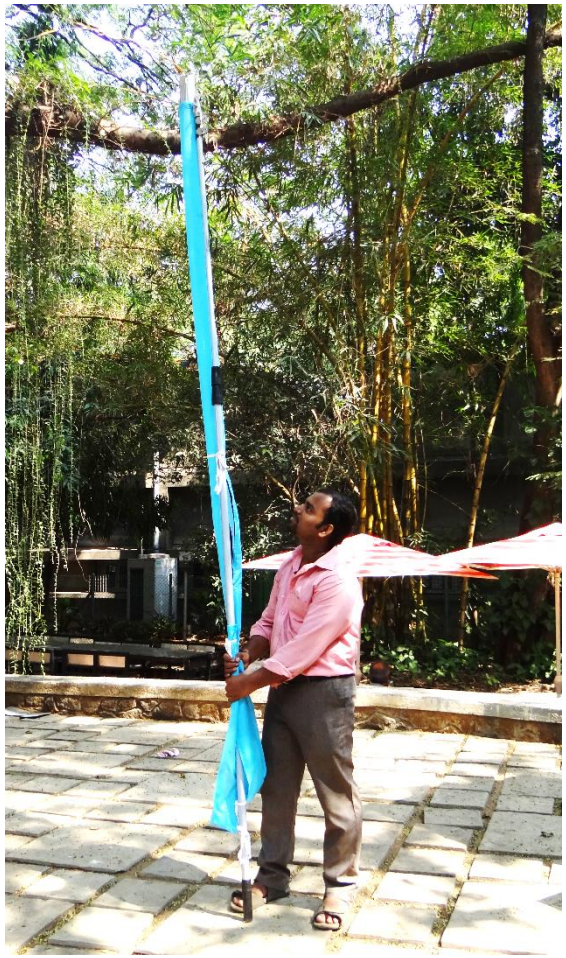


Fig.65b: Modified collection bag (overall)

9.6. Final Prototype

Fig.66a: Prototype 3

Fig.66b: Prototype 3- Cutter blade

Fig.66c: Prototype 3- Collection bag

Fig.66a shows final prototype of the drumstick plucker. It had a telescopic pipe, Cutter blade, and a collection bag.

Fig.66b shows the cutter blade made-up of stainless steel having thickness 1mm.

Fig.66c shows the collection bag and how it gets tied with the telescopic pipe.

Fig.67a shows the profile of cutter which was cut by CNC punching operation. Material used is Stainless steel of thickness 1mm. Relief was provided on the clamping area to allow bending of the cutter in one direction and the clamp in opposite direction.

Fig.67b shows clamping details. Multiple holes were provided to accommodate standard diameter pipes and bamboos having different diameters.

Fig.67c shows the collar made by bending lower portion of the cutter. This collar was used to tie collection bag with the cutter.

Fig.67a: Cutter pipe- Profile

Fig.67b: Cutter pipe- clamp details

Fig.67c: Cutter pipe- Collar

10. Costing

Aluminium pipe 0.75 inch 6 ft	Rs.90 [Rs.15/foot]
Aluminium pipe 1.00 inch 6 ft	Rs.108 [Rs.18/foot]
Aluminium pipe 1.25 inch 6 ft	Rs.132 [Rs.22/foot]
Pipe joiner [small]	Rs.50-60
Pipe joiner [big]	Rs.50-60
Cutter [Material cost + manufacturing cost].....	Rs.130-150
Collection bag cloth	Rs.25 [Rs.35/meter]
Labor cost	Rs.30
Other	Rs.50
Total manufacturing cost.....	Rs.665-705
Transportation cost	Rs.10
Total	Rs.675-715
Manufacturer's profit [10 to 12%]	Rs.60-75
Total	Rs.735-790
Shopkeeper's profit [7 to 10%]	Rs.50-80
Plucker price for farmer	Rs.785-870 ‹ 1200

After discussion with farmers, it was realized that, a farmer can invest Rs.1200 [maximum] for drumstick plucker. As, the calculated manufacturing cost of drumstick plucker was found to be less than Rs.700, its market price would range from Rs.800 to Rs.1000.

So, this plucker would be affordable to farmers.

11. Form and Aesthetics

Fig.68a: Form of the cutter

Fig.68b: Stainless steel shows strength

Fig.68a and Fig.68b shows final prototype of drumstick plucker

- The form of the cutter evolved entirely because of the functional aspects of the cutter.
- The diameter was chosen in such a way that, it will help user to take pod in pipe easily as well as it will not block the view of the user.
- The length was chosen such that it will hold the drumstick pod inside it as well as it will not increase the weight of tool.
- A collar was provided at the bottom of the tool, so that the collection bag can be tied to it.
- The shiny surface and texture of stainless steel made it visually more strong and hygienic.

12. Product planning

Fig.69: Logo of the company

Company name: **“Zela”**
Harvesting Aids Manufacturing company

Manufactures harvesting equipment and accessories for fruits, vegetables and flowers.

Business principle: To provide more efficient and affordable harvesting aids for ease of operation and protection to the harvest.

Product planning:
In all types of fruit and vegetable - harvesting equipment the most common part is pipe. Telescopic pipe is best suited solution for this. Telescopic-pipes can be made by using pipes of different cross-sections and pre-fabricated pipe joiners.
The second most common part is collection bag. Best quality cloth material (generally used for bags) which is strong, wear resistant, washable, and light weight can be used and stitched by the tailors.
Designing of drumstick plucker was done. Similarly designing of more efficient cutters/pluckers for other vegetables, fruits and flowers can be done in future.

Indian farmers do not have enough buying power. Some of them can not afford the entire tool kit [Cutter, telescopic pipe, Collection bag]. So, individual parts will also be available for retailing.

Business Strategy:
Use synergy of different industries to manufacture the product.

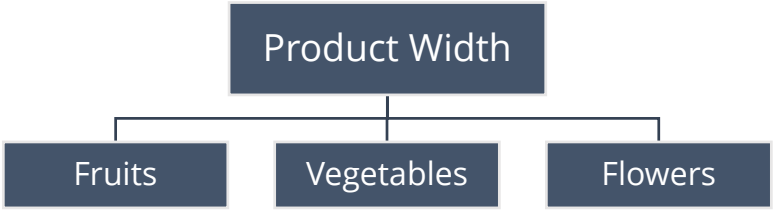


Fig.70a: Logo of the company

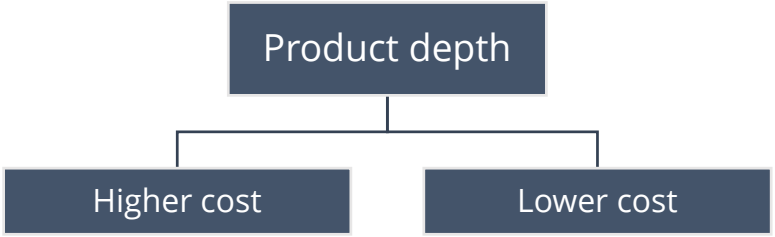


Fig.70b: Logo of the company

The product width of the company will be expanded by developing harvesting tools for other vegetables, fruits and flowers. [refer Fig.70a]

The product depth will also be expanded by introducing harvesting tools of two or more different qualities. For example, two types of drumstick plukers will be made available in the market; one with higher price- made up of stainless steel, second with lower price- made up of Tin.

It will allow farmers to select better harvesting tool according to their requirements.

Zela

Harvesting process will be made easier by developing an efficient and affordable harvesting aids with the help of advanced technology and material

13. Bill of material

Sr. No.	Description	Material	Dimensions	Qty
1	Telescopic pipe	Aluminium	Φ= 0.75 inch, Length=6 feet	1
2	Telescopic pipe	Aluminium	Φ= 1.00 inch, Length=6 feet	1
3	Telescopic pipe	Aluminium	Φ= 1.25 inch, Length=6 feet	1
4	Pipe joiner	Nylon	Φ= 0.75 inch x Φ= 1.00	1
5	Pipe joiner	Nylon	Φ= 1.00 inch x Φ= 1.25	1
6	Cutter pipe	HDPE/PVC/ stainless steel	Φ= 3 inches, Length=7.48 inches	1
7	Collection bag	Polyester	Length=15 feet, Width=11 inches	1
8	Lace	Cotton	Length= 2 feet	4
9	Zip	-	Length=18 inches	2
10	Nut & Bolt	Stainless steel	M6	2

Fig.71: Bill of Material

14. Engineering Drawing

Material:
PVC/HDPE
Thickness- 3mm

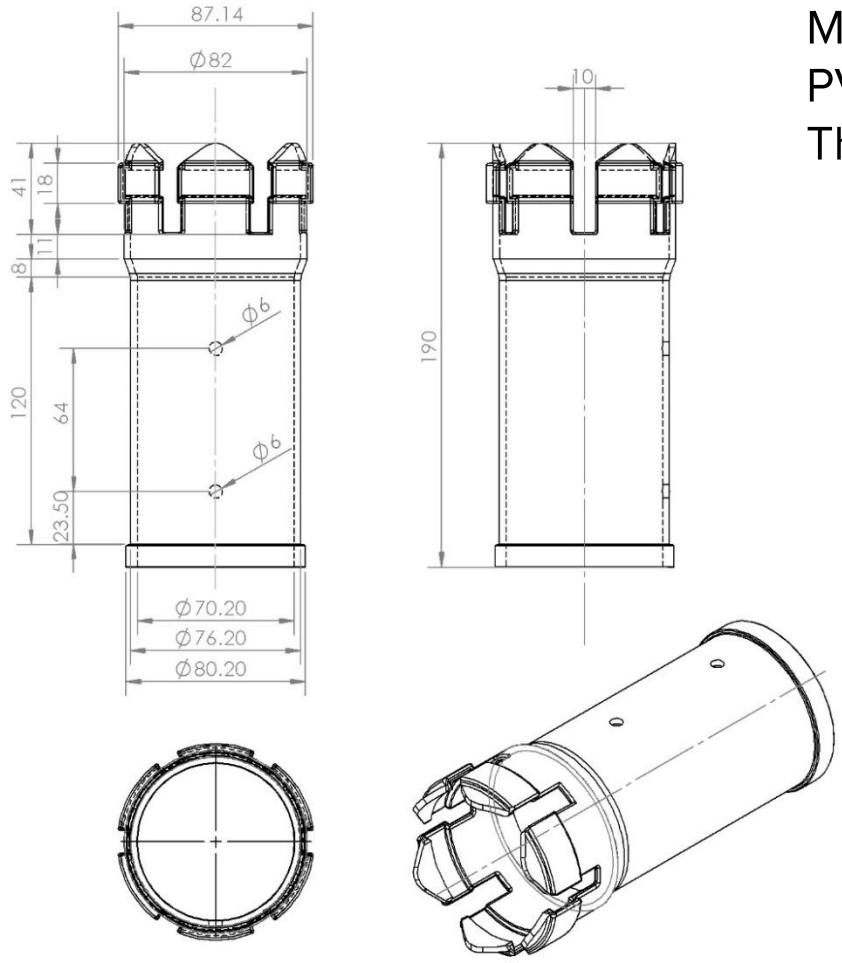
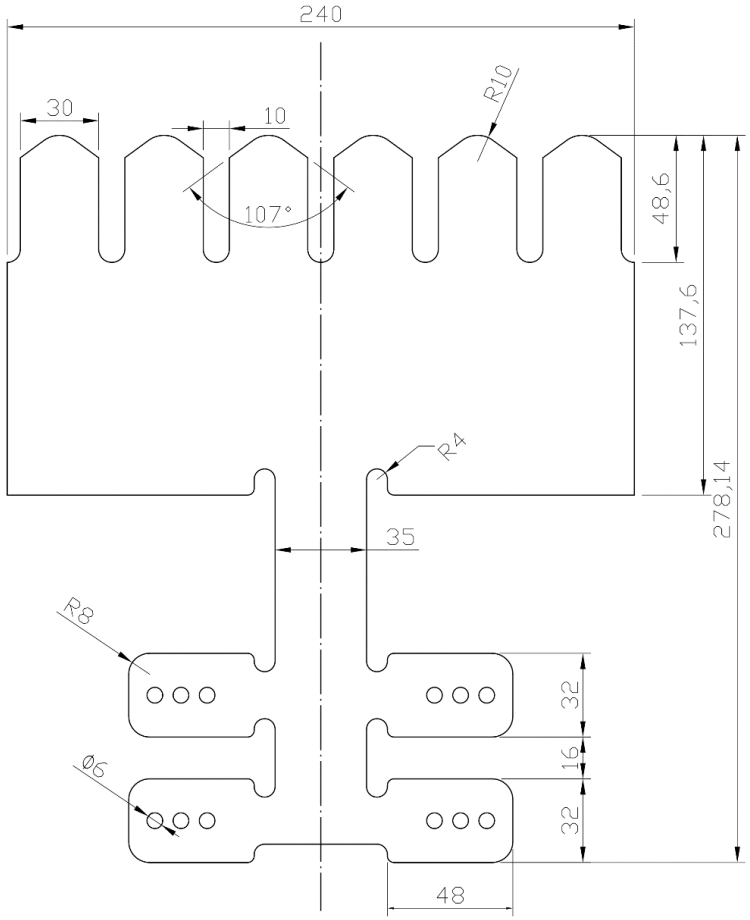


Fig.72: Engineering drawing of cutter pipe – PVC/HDPE



Material:
Stainless steel
Thickness- 1mm

Fig.73: Engineering drawing of cutter pipe - stainless steel

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9 https://web.extension.illinois.edu/cook/downloads/9217.pdf as on 10th Oct, 2014
10 http://www.pickfruit.co.nz/index.php/request-fruit as on 13th Oct, 2014