Design and Development of Mango Grafting Machine

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***Abstract*—Knowing the demand in grafting plant the attention has been made towards the automate the process of grafting. There are numerous research reported in automating the grafting process for various plant like tomato, vine, watermelon etc. but this machines working on hydraulic and robotics control system so initial cost of these machines are around 2-3 lacs which is not affordable by farmers. so our aims to finding a solution for grafting operation which operate automatically and also require less initial cost.**

Looking current demand in India our focus of study to design and develop automatic grafting machine for mango plants. Generally Mango grafting usually done manually, so there is reduction in production and skills requires to perform operation In order to solve the problems of manual grafting and increase the degree of mechanization and low operation efficiency of this machine design a vision base automatic upper and lower seeding devise of grafting machine. To provide the technical support for further design of automatic grafting machine the device is mainly composed of the manipulator and control system, the end clip mechanism. This machine is smaller than the previous automatic machines which include the design of Geneva mechanism, gripper mechanism, punch mechanism, clipping mechanism. This machine assumes to be produce 700 plants per hour. The developed model with experimental facilities will be further tested for its performance.

Keywords—Mango grafting, Geneva mechanism, punch mechanism, scion, rootstock

I. INTRODUCTION

Grafting is a technique of combining two plants or pieces of plants so they grow together. This allows you to combine the qualities of a strong, disease-resistant plant with the qualities of another plant, usually one that produces good fruit or attractive flowers. While there are many methods of grafting, the methods described here should allow you to graft almost any vegetable or fruit seedling, flowering bush, and even certain trees such as citrus trees.

Understanding the purpose of grafting, Fruit plants, including tomatoes and others sometimes thought of as vegetables are bred and cross-bred over many generations to improve their attributes. However, no one variety is perfect. By removing a section of a plant that produces great fruit and grafting it onto a variety that absorbs nutrients well and resists disease, you can create a plant with the benefits of each. Because you're trying to combine specific attributes, there's no advantage to grafting two plants of the same variety together. The resulting plant will not produce offspring with the same mix of qualities. The seeds are produced by the top grafted portion only.

II GRAFTING TECHNIQUES

A. Cleft Graft:

Cleft grafting is used to propagate varieties of camellias that are difficult to root. This type of grafting is usually done during the winter and early spring while both scion and rootstock are still dormant. Cleft grafting may be performed on main stems or on lateral or scaffold branches.[4]

The rootstock used for cleft grafting should range from 1 to 4 inches in diameter and should be straight grained. The scion should be about 1⁄4-inch in diameter, straight, and long enough to have at least three buds. Scions that are between 6 and 8 inches long are usually the easiest to use.[4]

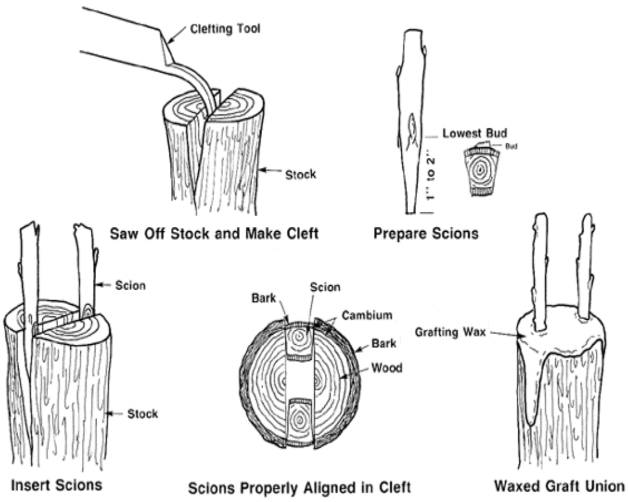

Fig 2.1 Cleft Graft[4]

B. Saddle Graft

Saddle grafting is a relatively easy technique to learn and once mastered can be performed quite rapidly. The stock may be either field-grown or potted. Both rootstock and scion should be the same diameter. For best results, use saddle grafting on dormant stock in mid- to late winter. Stock should not be more than 1 inch in diameter.[4]

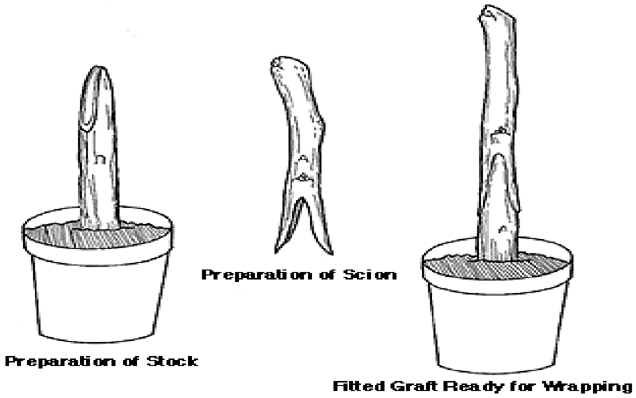

Fig 2.2 Saddle graft[4]

C. Side-Veneer Grafting

At one time the side-veneer graft (Figure 2.3) was a popular technique for grafting varieties of camellias and rhododendrons that are difficult to root. Currently, it is the most popular way to graft conifers, especially those having a compact or dwarf form. Side-veneer grafting is usually done on potted rootstock. [4]

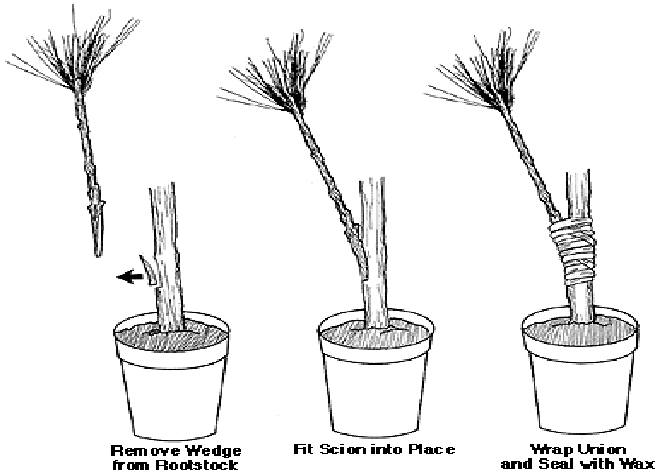

Fig. 2.3 Side-Veneer Graft[4]

D. Splice Graft

Splice grafting (Figure 2.4) is used to join a scion onto the stem of a rootstock or onto an intact root piece. This simple method is usually applied to herbaceous materials that callus or "knit" easily, or it is used on plants with a stem diameter of ½-inch or less. In splice grafting, both the stock and scion must be of the same diameter.[4]

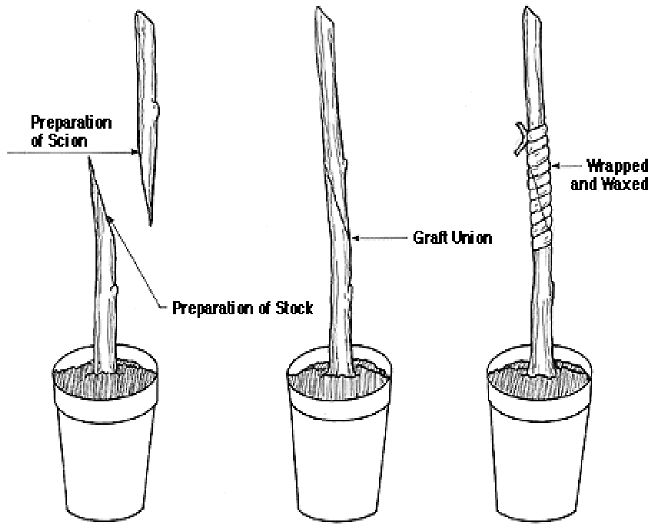

Fig. 2.4 Splice Graft[4]

III SELECTION OF MECHANISM AND DESIGN

A. Geneva mechanism

In these mechanism we use Geneva for intermediate motion of both root and scion arm which is operated by motor. Motor is rotate at 12 rpm. Geneva consist of four slot wheel after each revolution of motor Geneva wheel rotate by 90º and scion/ rootstock arm move to next stage. Motion of Geneva, transfer to shaft by using gears. Scion and root stock arms connected to shaft which are driven by gears these arms rotate in opposite direction.[1]

B. Gripper mechanism

Gripper is use to hold scion and root stock throughout the operation initially gripper is in close position by spring force and this spring force is enough for holding scion/root stock while feeding . When scion and rootstock are feed to gripper it will expand by compressing the spring. Gripper mechanism consist rack and gear arrangement. Grippers are control by rack and pinion action. When rack moves it will open and closed gripper respectively. After completion of grafting operation opening of gripper need to release grafted plant for that purpose hydraulic actuator is provided to give motion to the rack.

C. Punch mechanism

Punch is use to cut scion and rootstock. After feeding operation, Geneva moves by 90º and scion and rootstock come in punching stage initially punch at upward (open) position by spring. For cutting operation downward motion of punch (blade) required for this downward motion cam mechanism is used.

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IV CALCULATION

Geneva Mechanism

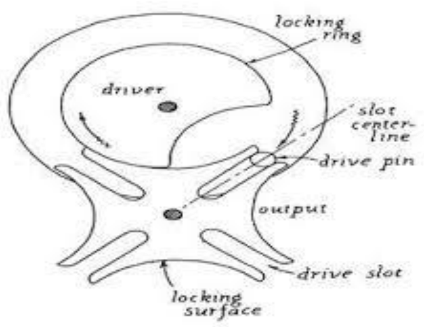

Fig. 4.1 Geneva mechanism

C = Center distance
b = Geneva wheel radius
n = no of slot
t = Clearance
s = Slot length
w = Slot width
t = Thickness of wheel

Center distance is fixed according to size of machine = 60 mm

Geneva wheel radius:

$$b = C \times cos\, cos \frac{180}{n}$$

$$b = 90 \times cos\, cos \frac{180}{4}$$

$$b = 63.63\ mm$$

Drive crank radius (a)

$$= \sqrt{c^2 - b^2}$$

$$= \sqrt{60^2 - 42.42^2}$$

= 63.64 mm

Assuming pin diameter p=5mm

Stop arc radius (y):

= a – 1.5 p

= 63.63 -1.5 x 5

=56.13mm

Stop disc radius (z)

= y – t

=56.13- 0.2

=55.93mm

Slot length:

S= a + b - c

= 42.42 + 42.42 - 60

= 42.84mm

Width of slot (w):

= p + t

= 5 + 1

= 6 mm

Center distance (c)= 60mm

<u>Selecting standard Geneva wheel and drive</u>

Geneva wheel radius (b)=75mm
Drive crank radius(a)=45mm
Pin diameter (p)=10mm
Stop arc radius(y)=30 mm
Slot length(s)=36mm
Slot width(w)=22mm
Thickness of wheel and drive(e)=8mm [1][2]

4.2 Motor selection:

Required RPM 12
Therefore to complete in revolution it will require
i.e. 1 min – 12 revolution
i.e. 60 sec – 12 revolution
therefore
5 sec for 1 revolution
Standard motor selected - speed-12 rpm
torque- 20kg-cm

4.3 Linear actuator calculation:[1]

Calculating the torque and speed requirement
Cutting force required to cut stem of mango-100N
Stroke speed -10 mm/sec
Torque calculation:

$$Torque = \frac{load * pitch * no.of\ starts\ of\ screw}{2 * \pi * efficiency\ of\ screw * gear\ ratio}$$

$$Torque = \frac{100 * 1.5 * 1}{2 * \pi * 0.5 * 1}$$

Torque=47.74 N-mm

4.4 Speed calculation:

$$N = \frac{linear\ velocity\left(\frac{mm}{sec}\right) * gear\ ratio}{pitch\ of\ screw * no.of\ start}$$

$$N = \frac{10 * 1}{1.5 * 1}$$

N=6.66 revolution per sec i.e.400 rpm

Now selecting std motor to fulfill requirements

Our primary requirement is stroke speed which should be 10 mm/sec or more than that

Therefore selecting the motor having speed of 500 RPM having torque 10 kg-cm

Recalculating the torque and stroke speed again

$$Torque = \frac{load * pitch * no.of\ starts\ of\ screw}{2 * \pi * efficiency\ of\ screw * gear\ ratio}$$

$$1000 = \frac{load * 1.5 * 1}{2 * \pi * 0.5 * 1}$$

Actual load=2094.39 N

$$N=\frac{linear\ velocity\left(\frac{mm}{sec}\right)*gear\ ratio}{pitch\ of\ screw*no.of\ start}$$

$$8.333=\frac{linear\ velocity\left(\frac{mm}{sec}\right)*1}{1.5*1}$$

Linear velocity=12.5mm/sec

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VI CONCLUSION

Grafting technique is very rapidly growing in Agriculture field. Our willingness and improvements in technologies will give it a higher success rate as compare to manual grafting.

By doing small changes in gripping mechanism, machine can be used for different types of plants. Presented machine will decrease human interaction with grafting process. The machine will increase the output of process by 7 times. This machine used for profit purpose in agriculture business.

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