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## Wangyuan ZONG -6.27-Design and Simulation of Jujube Sapling Transplanter

Wangyuan ZONG, Wei WANG, Yonghua SUN, Hong ZHANG

*School Of Mechanical And Electric Engineering, Tarim University Alar, Sinkiang843300, P.R China*

### **Abstract**

*This paper is aiming at designing a novel jujube transplanter with mechanic arms, which can support the sapling for a while when other operations is going on. It improves uniformity and stability. Pro-E software has been used for the design process, by which transplanting process has been analyzed and simulated.*

*Key words: Density Jujube Plantation; Sapling Transplanted; Bionic Manipulator; Kinetic Simulation*

### **1 Introduction**

As a Chinese special economic fruiter, the cultivated area of jujube trees has increased rapidly in southern Sinkiang in recent 7 years. The cultivated area of the jujube of southern Sinkiang has reached about 300,000 hm<sup>2</sup> by the end of 2009. The higher and more extensive demand to the corresponding machinery equipment for jujube planting was put forward (Liu Lei et al, 2008). This project developed a kind of jujube transplant machine for the high-density planted model of jujube to adjust to the requirements of jujube industry rapidly development in southern Sinkiang.

### **2 Features and Requirement**

The high-density planted model of jujube is the generally adopted model in southern Sinkiang. The high-density planted model is able to realize early results and yield and improve the utilization ratio of land in early and the economic benefit. There are two forms of the high--density planted model: Single-density whose space between trees is 2×3m、2×4m、1.5×1.0m; Wide connect narrow row whose space between trees is 1.5×1.5×4 m. The protection for trees furrow should reservation 1.5m and the inner diameter should be 1m and the both sides of the ridge width is 25 cm. It can not intercropping other crops either in the reservation or on the ridge. The ditch and ridge should be treaded solidly and flatly. Use the way that buried first, extracted second and trampling down third to plant. The roots should be ensuring to be stretch in planted process. The planting depth should be above the root 2~3 cm (Wang Jianxun et al, 2007; Si Yanjiang et al, 2007; Zhang Changjiang et al, 2006).

The design selects the technical requirements and process characteristics as Fig 2-1 and Table 2-1 shows according to the demand of jujube high-density planted model.

First Author: Zong Wangyuan(1969- ) Male, Wuhan in Hubei, Associate Professor, Research Direction: Agricultural Mechanism. E-mail:zwyzx@sina.com  
Corresponding Author: Wangwei(1979- ) Male, Lecturer, Phone: 0997-4683859 13031270332  
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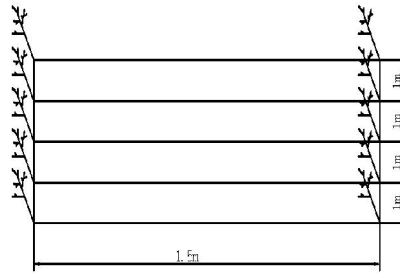


Fig 2-1 High-Density Planted Model

Table 2-1 Planted Technological Requirement of Jujube

Technical Parameter	Row Distance (m)	Planted Spacing (m)	Planted Ditch (m)		Jujube	
			Ditch Width	Ditch Depth	Primary	Secondary
Technological Requirement	1.5	1	200~300	300~400	Sapling Height $\geq 1m$ Distance Land $\geq 1cm$ Root Diameter $\geq 2mm$ Taproot length $\geq 20cm$ Quantity of Lateral Root $\geq 6$ strips	Sapling Height $\geq 0.8\sim 1m$ Distance Land $\geq 0.8\sim 1cm$ Root Diameter $\geq 2mm$ Taproot length $\geq 15cm$ Quantity of Lateral Root $\geq 6$ strips

### 3 Working Principles and Structure Design of Jujube Transplanter

#### 3.1 Working Principle

The work of this mechanical equipment is to perform planting in transplanting process. The furrow opener will complete furrowing in the planting area first before this machine working. Table 2-1 shows the concrete parameter.

The tractor mounted jujube transplanter, with specially designed mechanic arms to support sapling while soil compacted. The mechanic arms can support the jujube a minute after it planted to maintain the trees orthostatic in covering soil and compacting in working process. The manipulator will move reversely with the whole equipment by the same velocity in working. Therefore, the jujube sapling's

movement is the composite movement  $v_{\text{合}}$

resulted by  $v_1$  that the forward movement of

whole equipment and  $v_2$  reverse movement of

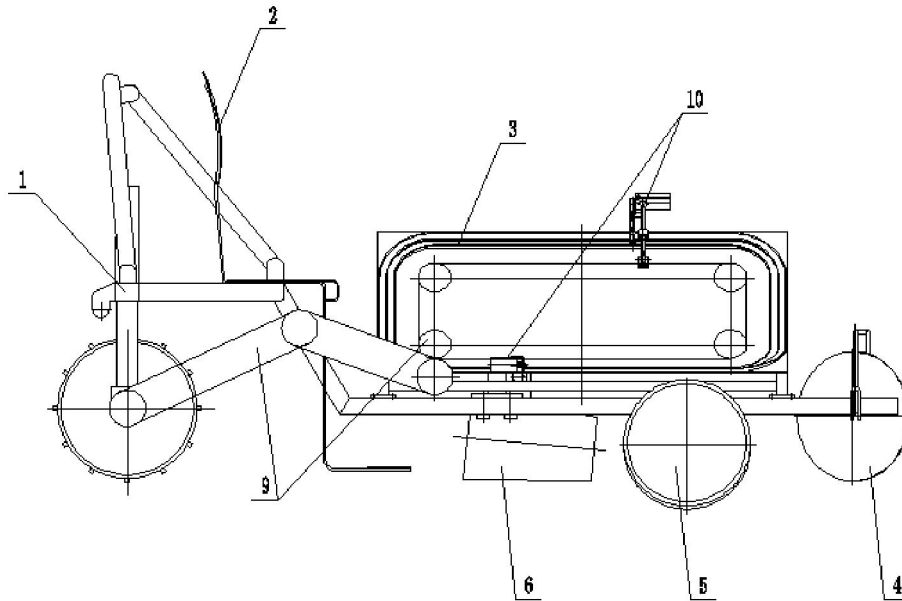
manipulator. That is  $v_{\text{sum}} = v_1 + v_2 = 0$  this

makes the process of seedlings planting in the ground remained relatively static. The manipulator will release the sapling and back in situ to prepare the next working after that the roots have been landfill by the coverer and compacting drum. The retractable and trajectory of the manipulator is function by the inner adjusting spring and the track of sapling supported system together and drive by chain

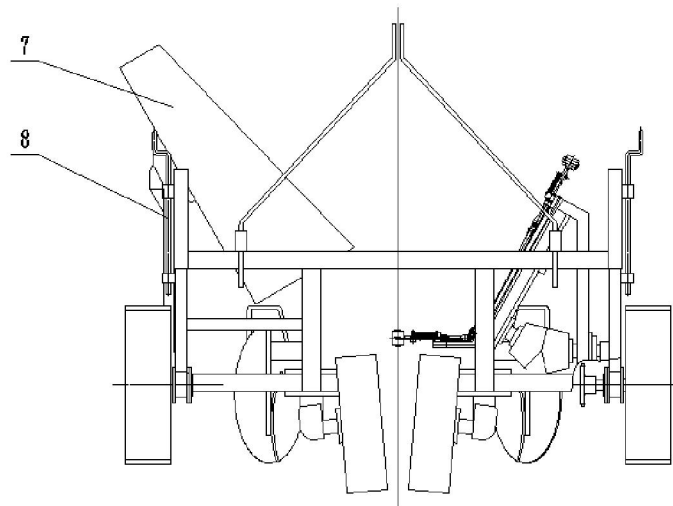
conveyor belt.

The Fig 3-1 shows the structure principle of the jujube transplanter.

### 3.2 Design of Structure



(a)



(b)

**Fig3-1 Structure Principle of Jujube Transplanter**

1Frame 2Seat 3Sapling Supported System 4Back Coverer 5Press Wheel 6Front Coverer 7Seedling Chamber 8Adjusted Device of Depth Limited 9Transmission System 10Bionic manipulator

The operator will sit in the seat 2 and put the sapling stored in seeding chamber 7 into the bionic manipulator 10 of the supporting system 3. Then the sapling will be planted into the planting

trench by manipulator 10 transmission with the chain. At this time, the manipulator started to move reversely relative to the whole equipment to maintain the sapling vertical. The quality soil

of planting trench will be covered on the roots by the front coverer. After that, the press wheel 5 will compact the soil covered. Afterward, the manipulator releases the sapling under the function of adjusting spring because of the changing of the moving track. Finally, the back coverer 4 mulches the rest of soil to the around of the roots and now complete once work of sapling transplanting. Next step, the manipulator will restore in situ along the track to clip the saplings and wait the recycling operation. There are two plant holder of the sapling supported system and the moving distance is the same as the plant spacing. The adjusted Device of Depth Limited 8 can be use to regulated the depth of the trees planted. Thanks to that the distance between the manipulator and land, as a reason it

assures the trees planted have an overall height. The velocity of manipulator relative to the whole machine and the spacing insures the unity of planting spacing and the upright degree of the trees.

### 3.3 PROE Simulation Model and Structure Parameter

Draw three-dimensional model as the Fig 3-2 shows in the Pro/E software when the structure sizes of the transplanter determined. Do dynamics stability through simulation in the institutional environment of Pro/E for the main components. Shows the simulated reason that there is no interference between each component of the whole machine.

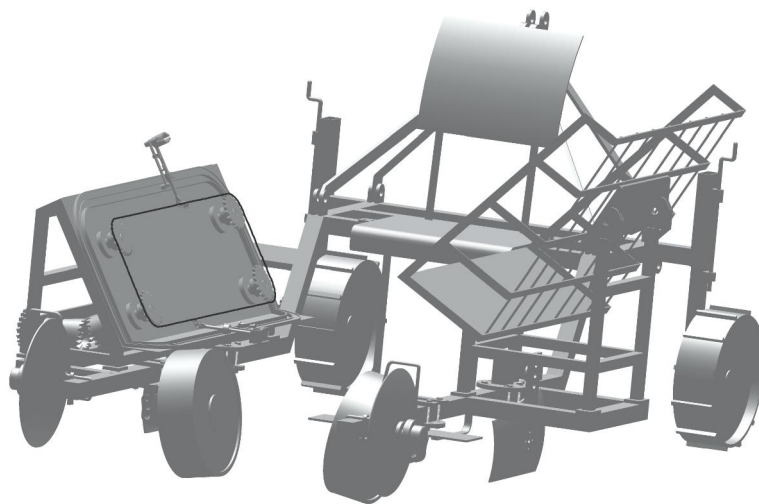


Fig 3-2 Pro/E Simulation Model

The main technical performance of transplanting machine is as follows:

The size of whole equipment ( length×width×height ): 2017 mm×1214 mm×965 mm

Weight:

About 210 kg

Mating Power: Variety of wheeled tractors

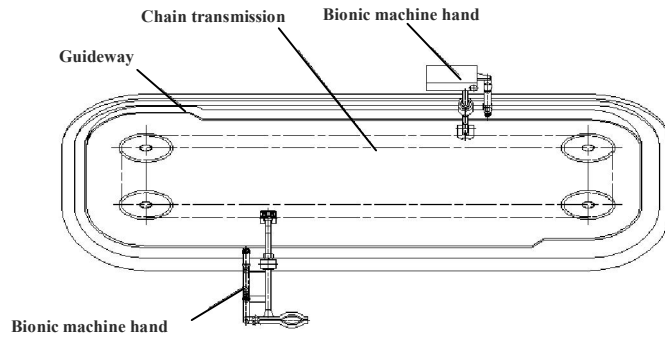
Efficiency: Related to the velocity of the tractors

Adjustment Range of Spacing:  $\geq 800$  mm

Plant Spacing: 1.0m

Planted Depth: 300~400 mm

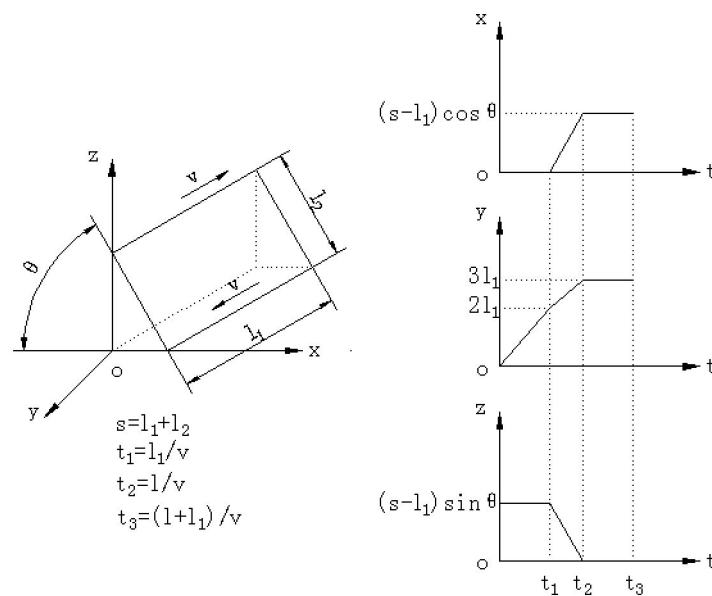
## 4 Trajectory Analysis of Sapling



**Fig-1 Structure Chart of Sapling Supported System**

The sapling supported system of the transplanter is the most important component in this equipment. It can move along the rail surface transported by the chain and be able to complete the motion of grasping seedling, feeding seedling, supporting seedling and dropping seedling. Design the angle of the guide structure is  $\theta=60^\circ$  according to the design of theory and structure requirements. Therefore, The movement of the sapling is qualitative that has a certain trajectory. In this design, the plant spacing as  $s=1$ , length of guide in horizontal as

$L_1$ , length of inclined plane as  $L_2=S-L_1$ , velocity of pull tractor as  $v$ . The displacement of direction of coordinate system Fig 4-2 shows is obtained on the base that the seedling folder position as the point of movement. The guide and the structures of manipulator determine that the angle of manipulator with the ground as  $\beta = 90^\circ - \theta$  before dropping seedling and  $\beta = 0^\circ$  after dropping.



**Fig 4-2 Movement Analysis Within Coordinates Of Sapling**

## 5 Conclusions

The mechanical transplanting can be able to reduce the labor intensity of farmers, increase production and income. The jujube transplanter for the high-density jujube plantation can be capable of reducing the labor intensity and

guaranteeing planting perpendicularity and jujube's neat and unity because of the new principle and structures.

(1) According to the technological program, design the sapling supporting system that complete planting automatically and the

process of sapling folder—sapling sending—sapling investing—sapling releasing.

(2) Design the transmission to ensure that the movement relationship of the manipulator with the machine so that seedlings planted in the upright;

(3) Design the whole machine to be sure of completing all the operation for casing and compaction preliminary in the stage of sapling supported.

(4) Design the adjusting device of depth limited to regulate the plating depth in a certain range according to the quality of the saplings.

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