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Design, Development and Evaluation of Pepper Harvester

NISHANTH M STANLY[1*], JAYAN P R[2], PANKAJ MALKANI[1] AND RATNAKIRAN D WANKHADE[3]

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ABSTRACT

Kerala is the leading producer of Black Pepper, king of spices in India. The harvesting of pepper is of great concern to the farmers. The shortage of labour during harvesting and their high wages causes a burden to pepper farmers. The delay in harvest reduces quality. The machine developed was expected to bridge the gap between supply and demand of pepper. The machine consists of a motor, mainframe, harvesting and conveying unit and collecting bag. Initial testing of the developed model was conducted under field condition. The tests revealed that the developed model was successful and effective for harvesting pepper due to its better conveying mechanism towards the collecting bag. With few modifications, the harvester could be made available for commercial production.

KEYWORDS

Black pepper, labour shortage and pepper harvester.

INTRODUCTION

In India significant share of agriculture is contributed by fruits, vegetables, cereals, pulses, tuber crops and spices (Pedapati *et al.*, 2014). In spices, black pepper is known as 'King of Spices' (Joy *et al.*, 2007). It plays a significant role in the Indian export economy and is of great historical importance. Generally speaking, black pepper has stayed the most unavoidable and precious form of spices. In the array of spices, it is the 3rd most added element in food. India ranks among leading producers of black pepper, after China and Vietnam. Indian state (Kerala) accounts for nearly 90% of the total black pepper production in India (Hema *et al.*, 2007). The plant of pepper is a perennial hard vine rising to 4m in height on bearing trees or on support poles. It can attain a height of 6m or more, but for commercial purposes, it is limited to 3.6m. The plant is vegetative propagated by cuttings and grown near to the base of support trees which has a rough, gripping bark to hold them. By the age of 3-4 years after planting, they start to bear fruits and lasts up to fifteen years. The berries are picked up as soon as they turn into red and before maturing; then they are sun-dried.

Indigenous to India, king of spices is one of the ancient and well-known spices in the whole world. It is grown in the rain forests along the coasts of Malabar in Southern India (Farooqi *et al.*, 2005). This natural climatic advantages and organic cultivation methods leads to the excellent aroma and quality berry. Two major trade varieties of black pepper in India are 'Malabar Garbled' and 'Telichery Extra Bold'. More than 75 named-varieties are known to be cultivated in India. They are distinguished by the names of the areas of cultivation. Introductions from one area to another have also taken place, resulting in the same variety being known by different names at different locations. The popular varieties of pepper cultivated in India are Panniyur series (Panniyur 1 to 8), Subhakara and Sreekara. Of these, Panniyur-1is to be grown in relatively open places. Kerala is renowned as the producer of the good quality peppers from the historic times even though the cultivation of pepper is less compared to the past. Dried fruits of pepper are usually known as peppercorns. Based on harvesting time and processing, peppercorns may be of different colours, mainly black, white, green and red (basically, reddish brown) in colour. The conventional types are black and white; dried green peppercorns are innovated recently. The harvesting season of pepper is from November to February. Harvesting is usually done manually, by hands. In Kerala, the wage for a harvesting labourer is around Rs. 150 for 10 kg harvested pepper. But Kerala is going through a big labourer shortage problem. At the time of harvest, the labourer experiences drudgery in his hands, especially in his nails after prolonged working hours and there is a harvest loss of 10% during manual harvesting. For commercial production, black pepper is collected from whole, unripe but fully developed berries and stored as heap to start browning. Then they are threshed and spread on the suitable ground for sun drying. During sun-drying, proper mixing is done to have uniform colouring and prevent mould development. Drying of the berries for 3-5 days brings down the moisture content to 10-12 per cent. Then dried berries are garbled, sorted and packed in gunny bags. Blanching the berries in boiling water for one minute before the sun drying speed up the browning process as well as the rate of drying which also gives a uniform shining black colour to the product and help to prevent mouldiness (Thankamani *et al.*, 2008). But extended

[1]Ph.D. Scholar, Division of Agri. Engg. ICAR-Indian Agricultural Research Institute, New Delhi, India
[2]Prof. & Head, Department of Farm Power Machinery and Engineering, KCAET, Tavanur, Kerala Agricultural University, Kerala, India
[3]Ph.D. Scholar, Department of Farm Machinery and Power Engineering, C.O.T, GBPUAT, Pantnagar, Uttarakhand, India
*Corresponding author email : nishanthmstanly@gmail.com

blanching should be avoided, since it can deactivate the enzymes responsible for browning process. Various researchers developed different mechanism and prototypes for harvesting the jackfruits, mangoes, sapota (Muhammed, 2005); and peppers (Aneesha, 2010). Muhammad *et al.* (2004) conducted a study on improved fruit plucker. The improved fruit plucker was an improved hook type plucker for plucking fruits like mangoes, sapota etc. The net of common plucker was lengthened and extended downwards like a chute. The lower end of the net was opened but kept folded upwards so that the fruits could be stored in a sack. After detachment, the fruits were conveyed downward at a safe velocity and stored at the bottom of the chute. The advantage is that more quantity can be plucked in a batch since the fruits are stored in the net at the bottom of the pole, thereby giving a better balance than the conventional top-loading type. The equipment cost is about Rs1000/- for 12 m long; it weighs about 6 kg. The delay in harvest reduces quality (Jyoti, 2018). Aneesha (2010) developed a manually operated pepper harvester which was a handy and simple tool which can ensure safe handling of pepper. The developed pepper harvester so far were not successful because of visibility, early fatigue and time-consuming operation. Keeping these factors in mind, a black pepper harvester was developed and evaluated.

MATERIALS AND METHODS

The concepts and techniques on the development of pepper harvester model were thought off, and their practical feasibility wene studied.

Test Model

The model developed for harvesting the pepper was tested in KCAET farm. The basic concept was to develop simple equipment which is easy to handle and minimum damage to wines. The materials selected for the model were mild steel flat, stainless steel blades, nylon rod, and one side grooved rubber belt.

Development of pepper harvester model

Pepper harvester consisted of the following components, i.e. power source, a battery, switch, main frame, harvesting and conveying unit, pulleys, dc motor and a Collection bag. The Power Source consisted of a 12 V battery placed in a bag. The battery provides power to the motor for harvesting and to convey the pepper stalk. The supply was controlled by a switch provided on the equipment. The main frame of the harvester made of two mild steel bars (250 mm × 16 mm ×3mm). The motor is fixed at the rear end of the equipment. The harvesting and conveying unit consisted of two stainless steel blades are fixed on one of the two front pulleys which is driven by motor cuts the pepper stalk by shearing action. The Cutting part consisted of blade made of mild steel plate; 0.5 mm thick selected was having the required efficiency. It cut the stalks with relative easiness (Fig.1). The Conveying section directly conveys the cut stalks into the collecting bag due to its rotation in opposite direction. It leads to the pepper stalks into the collecting bag which fixed below the conveyor belts. It also collects the dropped berries from the stalks while cutting and moving through the conveyor belt. It was found that it effectively collected all berries into the collecting bag. Pulleys made out from nylon rod are used to rotate the conveyor belt to convey the harvested pepper stalk. The conveyor system consisted of four pulleys mounted vertically on the spindles with two pulleys are fixed at each end of the frame. Of the four pulleys, each pair of pulleys is connected by a belt. Similarly, the other two pulleys are connected and placed aside from the first belt. Three pulleys are mounted on the frame and the fourth pulley is mounted directly on the motor spindle in which motor is fixed on the main frame. The bottom portion of the equipment is covered with MS sheet to collect separated pepper balls and slope is provided to convey the pepper. Two rubber belts (130mm× 20 mm×2 mm) were used for conveying the harvested pepper stalk into the collection bag. Each belt is fit on a pair of pulleys of one flat. The projections on one side of the rubber belts provide grip for holding the pepper stalk. The dc motor (12 v, 60rpm at 0.7- 0.9 A) was used to convert electrical power to mechanical power. Collecting bag made of nylon net made into a shape of long bag was used to collect the harvested pepper stalk and separated pepper balls. The separated pepper balls and pepper stalk which fall inside the equipment was conveyed through a separate pipe which was connected to the collection bag. Details specification of components of pepper harvester is shown in Table 1. Each individual component was designed in AUTOCAD (Fig. 2) and assembled.

Table 1: Details of the components of pepper harvester

Items	Material	No. of Items
Main frame	Mild steel	1
Pulley	Nylon rod	4
Belt	Rubber	2
Motor	Motor	1
Blade	Stainless steel	2
Collecting bag	Nylon net	1

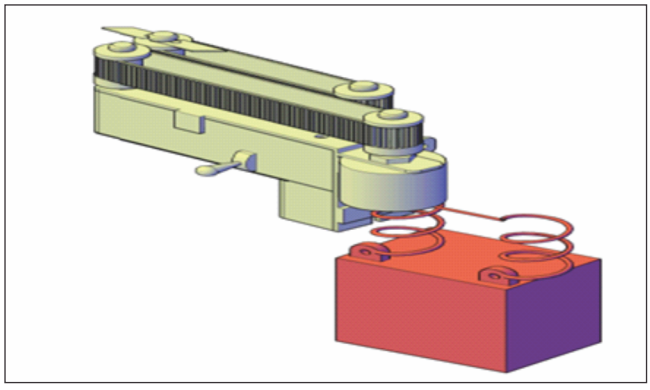

Fig. 1: Computer Aided design of harvesting mechanism

Fabrication and working of pepper harvester

All the components were procured from the local market and assembled in the Divisional workshop of KCAET. Fig. 3 shows the final prototype of pepper harvester prototype. When the motor is switched- ON, the belt starts running and the blade begins rotating. There are two belts one directly connected to the motor and the other connected parallel to the first by another two pulleys. These belts are placed closely to each other, so the second belt rotates by the force of the first

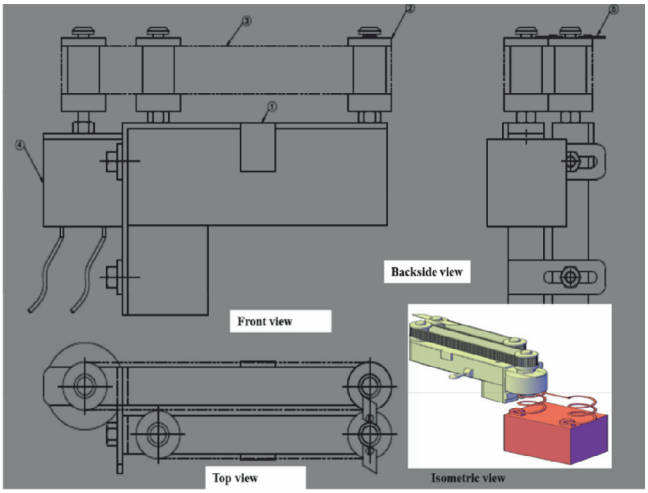

Fig. 2: Schematic diagram of pepper harvester prototype

belt. When the switch is ON of the motor the first belt rotates in clockwise direction and the second belt rotate by the pulling force of the first belt, so it rotates in the opposite direction of the first. A pulling force is developed at the tip of the equipment. This pulling force plucks the pepper stalks from the pepper wines with the help of rotating blades fixed on the front pulleys. By the pulling force developed by the belts conveys the cut pepper stalks into the collecting bag which placed bottom of the equipment. By the movement of pepper stalks through belts cause shedding of berries from the stalk to collect these berries an envelope is provided at the bottom of the belt which collects the dropped berries.

Fig. 3: Developed pepper harvester model

Statistical analysis

t–test was used to find the significant difference between the number of pepper panicles harvested per unit time manually and mechanical way at 5 % level of significance with the help of graph pad software.

RESULTS AND DISCUSSION

The developed model was tested and the results are discussed in terms of easiness in operation, amount of harvesting etc.

The model was also tested on Panniyur variety pepper. The pepper harvested prototype was analysed to study its performance and compared with the manually harvesting method.

The results of the harvest are shown below in Table 2 and Fig. 4. The result showed the average number of panicles harvested with the model was 784 / has compared to the manual 744/h.

Table 2: Harvesting details of model with manual method

Replication	No of panicles per hour	
	Manually	Model
R1	720	780
R2	744	768
R3	768	804
Average	**744**	**784**

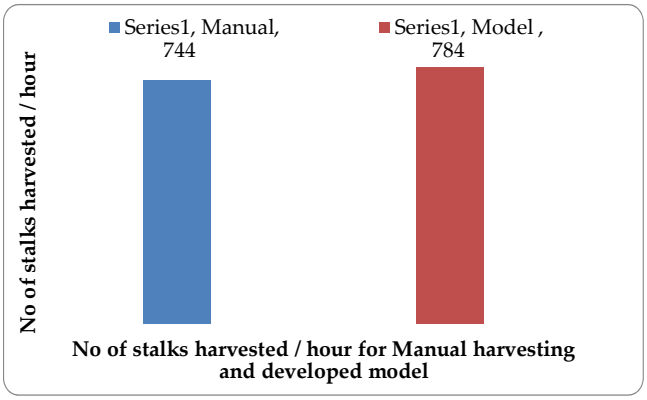

Fig. 4: Comparison of number of stalks harvested per hour by manual and developed model

Statistical analysis using t-test showed that there is a significant difference between the yield collected as compared to the manual method (Table 3).

Table 3: Statistical analysis result using t test

Mean	Manual	Model
	744	784
Standard deviation	24.000	18.330
Observations	3	3
P(one tail)	0.0317	
t value	3.780	
Significance	significant	

The developed prototype model the panicle could be easily harvested and collected at the same time. The percentage of loss was very less compared to the previous model. A similar result was obtained by different researchers such as Klaoudatos *et al.* (2019) and Dale *et al.* (2010) for strawberry harvester, Varlamov *et al.* (1990) for sea buck and Aneesha (2010) for pepper harvester. It is due to the effect of the conveyor belt which rotates on the pulleys. It directly conveys the cut stalks into the collecting bag. Due to this conveyor it can be used to harvest more than one stalk at a time. It was more user friendly with its simple working and efficient cutting action. From the field tests done, it was evident that the proposed model was good for the Panniyur variety which was popular in the institute campus.

CONCLUSION

From the field tests done for the model, it was evident that the proposed model was suitable for Panniyur variety which was popular in Kerala. The developed model is lightweight and easy handling helped for better performance and collection of the panicles with not much losses. This model consists of cutting mechanism and conveying mechanism so that the panicles cut are easily conveyed to the collecting bag with least damage. Few modifications on the existing pepper harvesting model are suggested to overcome certain drawbacks experienced during its operation viz. the handle should be made telescopic so that it can be used to harvest panicles certain height and suitable mechanism should be incorporated with the tool to deflect the leaves which cause hindrance to harvesting.

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