Design and Testing of Semi-Automatic Harvesting Machine for Root Vegetables

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***Abstract*- Root Vegetables (Example: Ginger) are the potential agricultural commodity to be manufactured in India. When the harvest comes, people still use a very simple method for harvesting ginger by using hoes, pickaxe, and other farming equipments. The farmers complain about the need of so many work forces for harvesting while the labour cost is getting increased and the time spent for harvesting process is too long. Although there is an alternative of imported ginger harvesting machines, those machines are not compatible with the farming environment in India, having a high initial and maintenance cost. This machine can be used in any farming condition in India and can be prepared at village level. This machine has three main parts namely, ginger digger, screener, and power transmission system. This project is focusing on design and fabrication ginger harvesting machine. The screener will not only separate ginger from soil but also not let the ginger get harmed. The screener also uses for collectible part, to make this machine need some power transmission system from the engine. This machine needs Auto front petrol engine with rotation speed 20 - 25 rpm approximately with the aid of gear reduction.**
Keywords - Ginger, Farming Environment, Digger, Screener and Power Transmission System.

I. INTRODUCTION

India is a leading producer of root vegetables in the world and during 2012-13 the country produced 7.45 lakh tones of the spice from an area of 157,839 hectares. They are cultivated in most of the states in India [1]. However, states namely Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh and Gujarat together contribute 65 percent to the country's total production. Specially, Ginger originated in Asia and now grows in several parts of the world. The root of the plant is harvested for many culinary and medicinal uses. It can be used in many forms and is edible raw as well as cooked. One of the most common uses of ginger is to relieve nausea and other gastric ailments. A flowering plant is actually the root of the ginger plant that is harvested. A single root can have many offshoots above ground. The portion of the plant above ground has slender stalks with long leaves that come to a point. The flowers grow in clusters and are green and purple. Ginger is a tropical plant that is found in the Caribbean, India, Southeast Asia, and West Africa. Though the full name is root ginger, it is usually just called ginger. Traditionally ginger plant is harvested manually to get the ginger out of ground. But it consumes more time and more physical exertion of worker. It is necessary to introduce machine to harvest to reduce time consumption and human efforts. A machine of this nature can be fabricated at village level application in India such as to harvest at minimum time and a minimum cost, to get ginger as quickly as possible from the field, to reduce the physical exertion, to avoid physical damage to Ginger, to reduce manpower and to ensure the safety to labours.

II. LITERATURE REVIEW

The tractor drawn ginger harvester cum elevator was developed with an objective to have mechanical means for harvesting of ginger crop. The components were designed and developed keeping in view the relevant crop, soil and machine parameters. The machine consisted of a main frame, digging blade, depth gauge wheel, vibration unit, power transmission system, and conveying mechanism. The performance evaluation of developed machine was evaluated at Chitta village of Bidar district of Karnataka State. The experiment was undertaken in red clay soil; the observed moisture content was 13.50 per cent moisture content (db.) at the time of harvesting. The size of the experiment plot was 0.2 ha was taken for observations. During field testing of machines, draft, digging efficiency, per cent damage of ginger rhizome and fuel consumption, separation index and conveying efficiency were calculated. The theoretical field capacity, actual field capacity and field efficiency were also measured. The ginger harvester cum elevator was tested at a forward speed of 2.5 km h-1. The draft and power requirement for harvesting ginger crop using harvester cum elevator was found to be 2625.82 N and 1.82 kW respectively. Fuel consumption for particular operation was observed to be 5.03 l h-1. Theoretical field capacity, effective field capacity and field efficiency of ginger harvester cum elevator was calculated 0.22 ha hr-1, 0.18 ha hr-1 and 81.80 ha hr-1 respectively. The digging efficiency, damage of rhizome, separation index and conveying efficiency of ginger harvester cum elevator was recorded to be 99.18 ha hr-1, 1.06 per cent, 85.38 per cent and 99.72 per cent respectively.

Due to the influence of population and environment, the traditional vegetable production methods in China are undergoing changes, and soilless cultivation techniques are gradually receiving attention. The soilless culture of vegetables is neatly arranged and suitable for automatic management. However, in actual production, the harvest of such vegetables is still mostly harvested and the efficiency is low. This design is aimed at the problem of high labour intensity and low efficiency of planting vegetables, combined with manual process analysis and harvesting machinery research, and innovatively designed harvesting institutions for planting vegetables. In the design process, solid works was used to design the scheme. This paper focuses on the modelling, parameter estimation, and model validation in open and closed-loop of an experimental forestry machine manipulator. Symbolic Newton-Euler and linear graph methodologies are used in deriving mathematical models of the swing boom and stick subsystems. Actuation dynamics are integrated with manipulator dynamics to result in a complete manipulator and actuation model. Identification procedures employed in estimating physical parameters are discussed. Model validation studies show good agreement between model predictions and experiments. The models will be used for designing a controller for coordinated end-point motion and for a real-time graphical training simulator. There are no mechanical harvesters for the fresh market apple industry commercially available. The absence of automated harvesting technology is a critical problem because of rising production costs and increasing uncertainty about future labour availability. This paper presents the preliminary design of a robotic apple harvester. The approach adopted was to develop a low-cost, `under sensed' system for modern orchard systems with fruiting wall architectures

Novel applications of artificial intelligence for tuning the parameters of industrial machines for optimal performance are emerging at a fast pace. This paper describes a vision-based perception system which has been used to guide an automated harvester cutting fields of alfalfa hay. The system tracks the boundary between cut and uncut crop; indicates when the end of a crop row has been reached; and identifies obstacles in the harvester's path. The system adapts to local variations in lighting and crop conditions, and explicitly models and removes noise due to shadow. In field tests, the machine has successfully operated in four different locations, at sites in Pennsylvania, Kansas, and California. Using the vision system as the sole means of guidance, over 60 acres have been cut at speeds of up to 4.5 mph (typical human operating speeds range from 3-6 mph). Future work largely centres around combining vision and GPS based navigation techniques to produce a commercially viable product for use either as a navigation aid or for a completely autonomous system.

III. DESIGN AND FABRICATION

Ginger (Zingier officinal Roscoe,) is one of the most important cash crops and principal spice of India and abroad (Bartley and Jacobs, 2000). It is a perennial plant that grows to a height of 600 to 900 mm from underground rhizomes in tropical and subtropical climate (Mendi et al., 2009). Ginger is believed to be a native of South East Asia from where it was introduced to Africa and Caribbean regions and used in food and medicines for over 5000, years (Purse glove et al., 1981). The total production of ginger in the world was 20, 95,056 tones with the total acreage of 3, 22,157 hectares. India, China, Nepal, Nigeria and Thailand are the major producers of ginger in the world (Anon, 2014). In India, it is grown in an area of 1, 53,450 hectares with the production of 7, 99,860 tones (Nair, 2017). Ginger is one of the spices that support large number of farmers in the states of Kerala, Karnataka, Arunachal Pradesh, Orissa, West Bengal, Sikkim and Madhya Pradesh (Karthick et al., 2015). However, Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh and Gujarat together contribute 65 per cent of the country's total production. In Karnataka, the ginger production was 0.019 million tonnes from an area of 0.0524 million ha, with an average productivity of 2.80 tonnes per ha (www.indiastat.com). Harvesting is one of main important operation in ginger cultivation. In India, it is performed by manual method with the help of hand tools i.e., special fork type of spade/ pick axe, bullock drawn and power operated devices and by using traditional diggers drawn by tractors or power tillers. It was found that there is a noticeable damage to the crop during harvesting. However, most of the digging operation during ginger harvesting is done manually due to non-availability of suitable devices. The post-harvest studies of ginger indicated that, about 70 per cent of the rhizomes are spoiled and wasted due to the storage rots caused by rough harvesting and handling practices resulting in injury of skin and flesh of the rhizomes (Rattan et al., 1988).

IV. MATERIALS AND METHODS

Designed and developed a ginger harvester cum elevator for harvesting ginger crop by considering soil, biometric and machine parameters utilizing PTO power of the tractor.

The main purpose was to design the machine for harvesting ginger crop with minimum draft requirement, maximum digging efficiency, low damage to rhizome and less fuel consumption along with greater soil separation and conveying efficiency at economic cost of operation. The fabricated machine consisted of main frame, gear box housing, power transmission system, depth gauge wheel, digging unit, vibrating unit, ground wheel, elevator conveyor system and windrower. The machine consisted of a main frame having dimensions 1640 x 1200 mm for mounting digging blade, vibration unit, power transmission system depth gauge wheel and elevator conveyor systems. Digger blade having length, width and thickness of 1000 x 200 x 10 mm respectively. The blade was mounted at an angle of 20 degree with the horizontal two depth gauge wheels having diameter of 450 mm were mounted at both sides of the blade with the spacing between two wheels being 1200 mm. A vibration unit was provided immediately after the digging blade for loosening of soil from the dug crop by providing vibrations in the system. The length and diameter of the vibrator rod was 1180 and 40 mm respectively. The lifting rakes curved in structure were provided above the vibrator rod at a distance of 100 mm and the length of the rakes were 83 mm. Vibration unit receives the drive from PTO shaft of the machine through gear box. The power transmission system has been made at two stages, first from PTO to machine gear box from which power is transmitted to the conveyor by a belt mechanism system and the same power is transmitted to the vibration unit. A machine support over the ground wheel made of pneumatic wheel was provided at centre both sides of the harvester. The diameter and width of the wheel are 320 and 100 mm, respectively. An elevator conveyor was attached behind the vibration unit. The soil-rhizome separating unit consisted of conveyor having dimensions of 1115 x 1100 mm. The conveyor unit consisted of MS rods spaced at 30 mm. The angle of the elevator was kept at 20 degree to the vibration unit. Windrowers are provided in the conveying system for separation of soil particles from the rhizome and windrowing in one row at the rear of the machine. The power to the elevator conveyor was provided through a gear box by belt and pulley drive system. The detailed specifications of the harvester cum elevator.

Table.1 Specification of major components of ginger harvester cum elevator

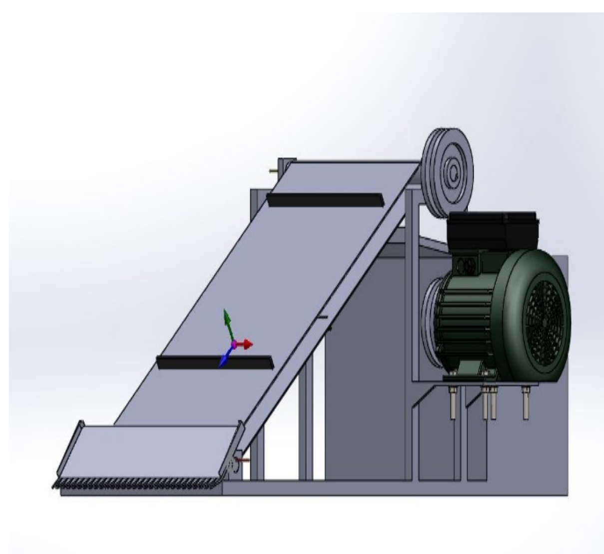
Sl. No.	Components	Specifications
1	Main frame	
	Length, mm	1640
	Width, mm	1200
	Height, mm	750
2	Overall dimensions	
	Length, mm	1880
	Width, mm	1550
	Height, mm	1150
3	Digger blade	
	Length, mm	1000
	Width, mm	300
	Thickness	10
4	Depth Gauge wheel	
	Number of wheel	2
	Diameter of wheel, mm	450
5	Power Transmission system	
	Gear reduction in gear box	1:4.5
	Diameter of output shaft from the gear box, mm	30
	Speed reduction by the sprocket	2:3
6	Ground wheel	
	Diameter of wheel, mm	320
	Width of wheel, mm	100
7	Conveyor unit	
	Length, mm	1100
	Width, mm	1115
8	Windrower	
	Length, mm	500
	Width, mm	80
9	Weight of the harvester, kg	490

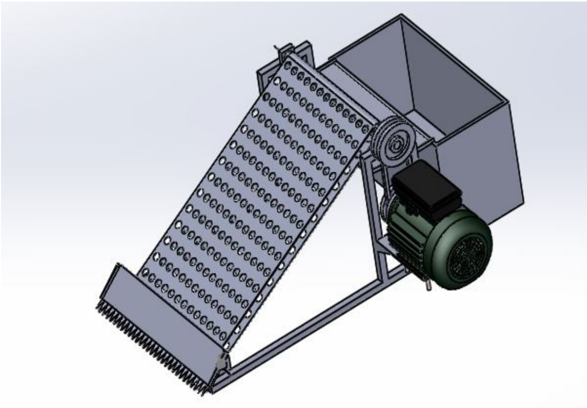
V. TESTING AND EVALUATION OF HARVESTER CUM ELEVATOR

Ginger (Mahima-2) crops were cultivated in the research field at Chitta village of Bidar district, Karnataka state, as per recommended. Agronomical practices. The total area of experiment was 4000 square meters. Matured crop was harvested using experimental set-up of mechanical ginger harvester cum elevator. The observations on performance parameters were recorded for each test run. All the test runs were replicated thrice to eliminate any experimental bias. As mentioned in Table 2 and 3. the experiments on test set-up were planned by varying blade type (Straight, Inverted V and Crescent,), rake angle (15°, 20° and 25°) and speed of operation (2.0, 2.5 and 3.0 km.h-1) and these independent variables were tested with dependent variables like: draft, digging percentage, per cent damage of rhizome and fuel consumption. Optimized the tool on the above parameters and further optimized tool were tested with independent variables of conveyer unit viz., angle of elevator and speed ratio of elevator and determined the performance parameter like soil separation index and conveying efficiency with their three replications. The moisture content of the soil was maintained constant at desired level by allowing the field to dry after irrigation and depth of operation was also optimized based on biometric properties. Soil bulk density was also measured randomly at five different places. All the experiments were conducted for each one bed lengths for every replication according to the plan of experiments. The first test of experiment was carried out at straight blade with rake angle kept at 15 degree and the data was recorded at three different speeds of operation. The rake angle was next fixed at 20 degree and observations were recorded for three levels of speed of operation by keeping all other variables constant. Similarly, tests were conducted for rake angle of 25 degree and all performance observations were recorded. Each test run was replicated thrice. Similar set of experiments was carried out using inverted V blade and crescent blade. Thus, a total number of 81 runs were completed and performance data was recorded. Ginger harvester working under test conditions is shown in Plate 1. Data were recorded for weight of ginger plants harvested, weight of ginger plants not harvested, wt of rhizome damaged and weight of soil collected with ginger plant mass for a test length of 10 m. From this test data, the following performance parameters were determined to evaluate the machine.

VI. ISOMETRIC VIEW

3-D DESIGN





VII. CONCLUSION

It is concluded that in the present study, a tractor drawn ginger harvester cum elevator was designed and developed. The major components of the harvester were main frame, digging blade, depth gauge wheel, vibration unit, power transmission system, and conveying mechanism. The developed prototype was tested at a forward speed of 2.5 km h-1. The draft and power requirement for harvesting ginger crop using harvester cum elevator was measured and it was found to be 2625.82 N and 1.82 kW respectively. Fuel consumption for particular operation was observed to be 5.03 l h-1. Theoretical field capacity, effective field capacity and field efficiency of ginger harvester cum elevator was calculated 0.22 ha hr-1, 0.18 ha hr-1 and 81.80 ha hr-1 respectively. The digging efficiency, damage of rhizome, separation index and conveying efficiency of ginger harvester cum elevator was recorded to be 99.18 ha hr-1, 1.06 per cent, 85.38 per cent and 99.72 per cent respectively. The developed ginger harvester cum elevator was found very suitable for harvesting the ginger crop.

REFERENCES

[1] Ajav, E. A. and Ogunlade, C. A., 2014, Physical properties of ginger (Zingiberofficinale).Global J. Sci., 14(8): 0975-5896.
[2] Akinbamowo, R. O., 2013, modelling the performance of a tractor – mounted cocoyam harvester, Res. Rev.: J. Agri. Allied Sci., 2(2), 1-4.
[3] Bilanski, W. K., White, P. H., Roy, R. C. and Graham, W. D., 1989, High moisture peanut harvester. Appl. Engg. Agri., 5(4): 457-462.
[4] Devesh kumar and Ashok Tripathi, 2017, Performance evaluation of tractor drawn potato digger cum-elevator, Int. J. of Agri. Sc. and Res., 7(2): 433-447.
[5] Gupta, C. P., Stevens, W. F. and Paul, S. C., 1999, Development of a vibrating cassava root harvester. Agri. Mech. Asia, Africa, Latin America, 30(1): 51-55
[6] Hazarika, D. J. and Kakoti, M., 2013, Study on the indigenous varieties of ginger of Golaghat District (Assam), and its economic viability as aroma ingredients. J. Nat. Prod. Plant Resour., 3(1): 24-29.
[7] Kathirvel, K. and Manian, R., 2002, Effect of tool geometry on harvesting efficiency of turmeric harvester. Agri. Mech. Asia, Africa, Latin America, 2002. 33(1): 39-42.
[8] Kepner, R. A., Bainer, R. and Barger, E. L., 2005, Principles of Farm Machinery, Third edition CBSC Publisher, New Delhi., 464-478.
[9] Kowalczuk, J. N., Leszczynski, and Zarajczyk, J., 2001, the effect of the working speed of Alina harvester for the harvest of carrot on the losses and damage of the roots. Annales-UniversitatisMariae-Curie-Skodowska-Sectio-E,-Agri., 56: 221-227.
[10] Singh, M. C., 2014, Development and performance evaluation of a digger for harvesting onion (Allium cepa L.), Int. J. Agri. Engg., 72(2) 391-394.
[11] Maw, B.W., Hung, Y. C., Tollener, E.W., Smittle, D. A. and Mullinix, B. G., 1996, Physical and mechanical properties of fresh and stored sweet onions. Trans. ASAE, 39(2): 633-637.
[12] Sadeeq, A. M. and Al-Rajaboo, S. A., 2008, Effect of separating systems design of potato diggers on quantitative and qualitative loss of crop. Dirasat Agri. Sci., 35(1): 33-43.
[13] Sukhwinder, S., R., Sanjay, and Manjit, S., 2007, Design and development of offset type digger for sugarcane plus potato intercropping. J. Ind. Potato Assoc., 34: 3-4.
[14] Shirwal, S., Mani, I., Sirohi, N. P. S. and Kumar, A., 2015, Development and performance evaluation of carrot harvester. Agri. Mecha. Asia, Africa Latin America, 46(1): 28-34.
[15] Khura, T., Mani, I. and Srivastava, A. P., 2011, Design and development of tractor-drawn onion (Allium cepa) harvester. Ind. J. Agri. Sci., 81(6): 528-32.