Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2021, Volume 34, Issue 2, Page 236-242

Development and Performance evaluation of a Power Tiller Operated Ginger Planter

Pramod Chandra Dihingia[1] • C.B. Khobragade[2*] • G.V. Prasanna Kumar[3] • Amlandeep Saikia[4]

[1]Department of Agricultural Engineering & Technology, Nagaland University, Dimapur, Nagaland
[2]Department of Agricultural Engineering, Assam University, Silchar 788011, Assam
[3]Department of Agricultural Engineering, Assam University, Silchar 788011, Assam
[4]IRI Project, KVK, Mangaldoi, Darrang, Assam

ARTICLE INFO

Article history:
Received: 06 December, 2021
Revision: 21 December, 2021
Accepted: 29 December, 2021

Key words: custom hiring, field capacity, metering mechanism, missed planting.

ABSTRACT

Planting season of ginger in India coincides with the cultivation of rice and other crops, and therefore faces an extreme shortage of labourers. A power tiller operated 2-row ginger planter was developed to alleviate the problem of the labour shortage. The machine consisted of two trays, a horizontal rotary disc with cell type metering mechanism, seed drop tubes, shovel type furrow openers, plate type soil covering devices, and a chain drive, dog clutch, depth adjustment wheel, and a hitching arrangement. The planter was designed to plant the seed rhizomes at 30 cm inter-row spacing and 22.5 cm within-row spacing. The ginger planter was tested under field conditions employing one skilled and two semi-skilled companion labourers. The average field capacity of the ginger planter was 0.03 ha/h with a field efficiency of 68.44%. The Labour requirement for mechanical planting of ginger was 100 man-h/ha. Mechanical planting resulted in the saving of 90% of productive time and 85% total labour involved in conventional manual ginger planting. The average planting rate of the ginger planter was about 37 seed rhizomes/min. Percent missed planting was about 1%. About 99% of seed rhizomes were planted perfectly. The cost of mechanical ginger planting was less than the conventional manual method of planting when the annual use of ginger planter was more than 0.57 ha or 19 hours. Mechanized ginger planting can be accepted in the power tiller operated farms having a ginger cultivation area less than 0.57 ha if custom hiring services for ginger planter are available.

1. Introduction

Ginger is one of the important spice crops of India, and it has numerous applications in the food, beverage, and pharmaceutical industries. Ginger is propagated by portions of rhizomes known as seed rhizomes. The seed rhizomes are cut into small pieces of 2.5-5.0 cm length weighing 20-25 g each having one or two good buds. The seed rate varies from 1500 to 2500 kg/ha. In conventional methods for planting ginger, seed rhizomes are planted in small pits made with a hand hoe and then covered with soil. Planting is done immediately after pre-monsoon showers, and rhizomes sprout after 15-30 days. The planting operation requires about 200-250 man-hours per hectare. Mathanker and Mathew (2002) had revealed that the major ginger growing states face labour shortages during planting season, as it coincides with the field operations of rice and other crops. Thus, mechanized planting is essential to overcome labour shortages, improve the timeliness of operations, and reduce cost, drudgery, and yield losses.

Previous researchers developed a picker wheel type metering device for automatic ginger planters and a horizontal disc cell type metering device for semi-automatic ginger planters (Mathanker and Mathew 2002). Optimum linear speed in the range of 10–12 m/min for picker wheel type metering device and 5–8 m/min for horizontal disc cell type metering device were recommended. A tractor-mounted planter was developed for ginger and turmeric with adjustable row spacing of 135 to 165 cm (Khas 2015). It consisted of a feeder, metering mechanism, chain drive, bevel gears, rotating discs, adjustable furrow openers etc. A wheel was

*Corresponding author: khobragadechetan@gmail.com

provided at the base which could be used to adjust the plant to plant distance of 15, 22.5 and 30 cm. Madhukumar (2017) designed, developed and evaluated the performance of a tractor drawn semi-automatic rhizome planter for ginger and turmeric. It used horizontal disc type metering mechanism. The rhizome planter had the arrangement to open the furrows, apply manure, plant rhizomes, cover rhizomes by soil and form ridges in single pass. The field evaluation of rhizome planter indicated the mean spacing of 21.66 to 32.63 cm and 20.53 to 31.13 cm for ginger and turmeric, respectively. The optimum performance for planting ginger and turmeric were at a forward speed of 0.97 km/h and transmission ratio of 1:1.25. The average field capacity and efficiency was 0.14 ha/h and 78.76%, respectively. The savings in cost and time for mechanical planting was about 59.52% and 96.57% as compared to manual planting. Pandey and Sawant (2020) developed a tractor operated 3-row ginger planter for precise planting of seed rhizomes. It consisted of a hopper, metering disc for picking of rhizomes, agitator, seed tubes, furrow openers, bottom ridger to form ridges, ground wheel and a frame. Field evaluation of the ginger planter for planting single rhizome at 20-25 cm spacing in rows at the seed rate of 1200 kg/ha was carried out at the forward speed of 1.5-2 km/h. It was found that the mechanical planting of ginger required 8 man-h/ha labour, and that for rhizome cutting and grading required 50 man-h/ha. Total cost of operation was ₹ 642/h or ₹ 3206/ha. Only 67% of the seeds were planted in the range of 20-25 cm spacing.

In small holdings and small plots, lack of funds with growers to invest on high horsepower tractors and small size plots does not allow the use of tractor operated machines. Patel et al. (2021) designed and developed an engine operated mini ginger planter considering the requirements hill agriculture like lightweight, economical and portable machine. It consisted of a chain and bucket type of metering mechanism. The semi-circular bucket type metering mechanism was fabricated and tested for performance at a forward speed of 0.75 km/h. Various performance parameters like percent missed seeds, percent bucket filling, percent seed damage, theoretical field capacity, actual field capacity, field efficiency, depth of planting and seed spacing were tested. Average seed spacing was 25 cm, depth of operation was 2.5 cm and 4.5 cm and actual field capacity was 0.074 ha/h (ICAR, 2020).

Power tiller with engine power of 6.75–10.58 kW has become a vital source of farm power for seedbed preparation in smallholdings in India particularly in farms with light-textured soil with rice as the major crop (Kathirvel *et al.,* 2000; Gupta *et al.,* 2001; Dihingia *et al.,* 2018). A suitable planting equipment for sowing ginger as an attachment to power tiller is not available. Therefore, there is a genuine need to develop a power tiller operated ginger planter, and test its feasibility and performance for planting ginger in power tiller operated farms.

2. Materials and Methods

2.1 Development of ginger planter

2.1.1 Prime mover

VST Shakti 130DI Power tiller (make, M/s VSTTillers Tractors Ltd., Bengaluru) was used as the prime mover for the ginger planter. The power tiller had the single cylinder, direct injection diesel engine with maximum BHP of 13.0 at 2400 rpm engine speed, and produced maximum torque of 4.2 kg-m at 1600 rpm. It had 6 forward and 2 reverse speeds. The total weight of power tiller was 405 kg.

2.1.2 Metering mechanism

The metering mechanism is an important component of the ginger planter, and it determines the effectiveness of planting of ginger rhizomes. In tractor operated ginger planters, horizontal rotary disc with cell type metering mechanism has been used, and reported as the most suitable metering mechanism for ginger (Khas 2015, Madhukumar 2017, Pandey and Sawant, 2020). Horizontal rotary disc type mechanism has the disc with 10 cells on disc, and the plate below the disc had the opening to allow the rhizomes to fall down. As the disc is rotated about the vertical axis, the rhizomes carried in each cell moved over the plate, and get dropped through the opening of the plate into the furrow at equal spacing from each other. The horizontal rotary disc type metering mechanism was selected for the power tiller operated ginger planter because it can be easily operated from the wheels of the power tiller using a chain drive, it is compact and it can be easily attached to the power tiller in the space after the detachment of rotary tiller assembly from the power tiller.

2.1.3 Computer modeling and development

Considering the functional requirements of the ginger planter, and the constraints of space and tractive power available from the power tiller, a 2-row ginger planter with a horizontal rotary disc with cell type metering mechanism was developed. Dimensions of various components were fixed by developing a 3-dimensional solid model of the ginger planter in the computer using SOLIDWORKS® 3D CAD software (Dassault Systems Solid works Corporation, 2012). It is shown in Fig. 1.

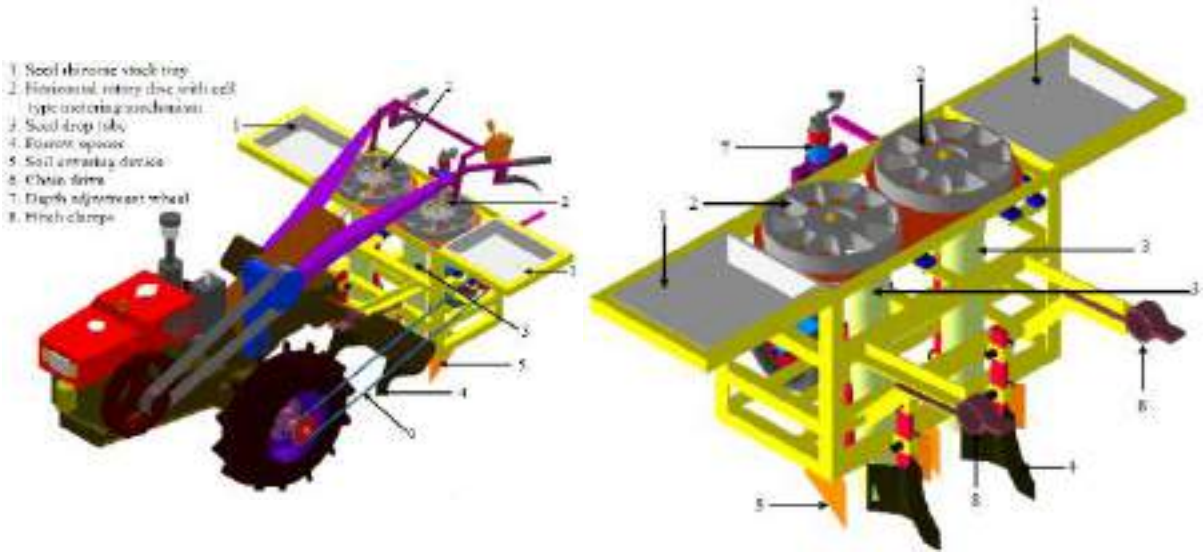

Fig 1. Three-dimensional drawing of 2-row power tiller operated ginger planter

The 2-row ginger planter was fabricated in the Mechanical Workshop as an attachment to VST Shakti 130DI power tiller. The ginger planter was developed to plant the rhizomes at the inter-tow spacing of 30 cm. The metering discs were operated by the drive wheel shaft of the power tiller using a bevel gear set and a chain drive with an overall velocity ratio of 0.77. A dog clutch was provided as a power cut-off device to disengage the power to the discs when the power tiller takes the turn at the headland. The drop tube was provided below the plate of the metering disc to allow the seed rhizomes to fall in the furrow. Each row of the machine was provided with a seed rhizome stock tray to carry 100-150 seed rhizomes.

2.1.4 Furrow opener, soil covering device and depth adjustment wheel

Reversible shovel type furrow openers were provided with shanks to adjust the depth of operation. The boots were attached behind the furrow opener on either side to prevent the entry of soil into the furrow immediately after the formation of the furrow. A pair of long vertical rectangular plates converging at the rear end was used as a soil covering device. The depth adjustment wheel available with the power tiller was used for the ginger planter.

For the attachment of the ginger planter to the power tiller, rotary tiller tynes were removed. The ginger planter was attached to the shroud of the gearbox output shaft of the power tiller using clamps. The overall view of the ginger planter is shown in Fig. 3. The ginger planter after attaching to power tiller is shown in Fig. 4.

2.2 Calibration of metering mechanism

The calibration of the metering mechanism of the ginger planter was performed on a sticky belt test stand in the laboratory. The metering mechanism was detached and placed on the belt stand. The length of the belt was 15 m and supported on two pulleys. The shaft of the metering mechanism was operated using a variable speed electric motor to maintain the uniform within row seed rhizome spacing of 22.5 cm. The 2 discs were separately calibrated by operating the sticky belt at the speed corresponding to the forward speeds of 0.90, 1.20 and 1.50 km/h of the power tiller. Miss index, multiple index, mean seed rhizome spacing and precision in spacing were determined (Mandal et al., 2018).

The calibration of the ginger rhizome metering mechanism indicated that the miss index significantly increased with increase in forward speed of 1.20 km/h and above. There was no multiple seed drop. The manual placing of ginger rhizomes in the cells of the disc has to be done at the faster rate with increase in forward speed to maintain uniform rhizome spacing. Keeping these facts in view, the forward speed of 0.9 km/h was considered for the field evaluation of the power tiller operated ginger planter. The mean seed rhizome spacing was found to be almost 22.5 cm, and the precision in spacing was about 5%.

1.	Depth adjusting handle	2.	Metering mechanism
3.	Seed box	4.	Sprocket
5.	Power transmitting shat	6.	Clutch lever
7.	Frame	8.	Seed tube
9.	Soil covering device	10.	Depth adjustment wheel

Fig 2. Overall view of the power tiller operated ginger planter

Fig 3. Ginger planter hitched with a power tiller

2.3 Measurement of draft requirement

The draft requirement of the power tiller operated 2-row ginger planter was evaluated in the field by preparing soil to fine tilth condition which is suitable for sowing ginger rhizomes. The power tiller in neutral gear was connected to the single point hitch of the 35 HP tractor using a rope and a spring dynamometer. The forward speed of the tractor was maintained at 0.9 km/h. The average force (F_1) required to pull the power tiller operated planter was measured by lifting up the furrow openers and soil covering devices, and disconnecting the chain drive to the metering mechanism. The average force (F_2) required to pull the power tiller operated planter was measured by setting the average depth of placement of ginger rhizomes at 10 cm below the surface

of the tilled soil and adjusting the soil covering devices to place sufficient amount of soil on the rhizomes. While measuring the force, the angle of inclination of the rope and spring dynamometer from the horizontal line (α) was measured using an abney level. The average draft was calculated as $(F_2-F_1)\cos\alpha$.

2.4 Performance Evaluation

The prototype 2-row ginger planter was tested under field conditions according to the procedure outlined in the RNAM Test code and procedure for sowing equipment (RNAM, 1995). Testing was done in a plot of size 10 × 6 m, with sufficient area of the headland for turning. The texture of field soil was inceptisol sandy loam. The field soil was tilled to fine tilth using a power tiller. The field was leveled and lightly irrigated. The ginger planter was operated along the length of the plot. Ginger rhizomes were planted at a spacing of 22.5×30 cm.

The forward speed, wheel slip, fuel consumption, inter-row, and within-row plant spacing, depth of planting, field capacity, and field efficiency were measured. The Labour requirement was calculated. The quality of work was assessed in terms of planting rate, missed plantings, planting efficiency, and soil coverage above and around the seed rhizomes. The cost of operation was determined by calculating the fixed and operating costs (Singh 2017). The initial cost of the power tiller and ginger planter was assumed as ₹150000 and ₹34000, respectively. The power tiller was assumed to have an average of 800 hours of annual use in small and medium holdings. The life of the power tiller and the ginger planter was 10 years. The annual rate of depreciation, interest on capital, insurance and taxes, housing, and repair and maintenance for both power tiller and ginger planter were assumed to be 10, 9, 2, 1, and 6% of the initial cost, respectively. The price of fuel (diesel) was ₹70/L. The lubrication oil cost was 30% of the fuel cost. The Labour wages for the operator of the power tiller, companion worker with power tiller, and all the unskilled workers were ₹450, ₹400, and ₹300 per day (8 hours), respectively. The cost of operation at various levels of annual use was calculated. This was compared with the conventional method of manual planting using spade and rope for similar stand establishment. In the manual ginger planting, seed rhizome was planted with the same plant spacing as that of mechanical planting for the purpose of better comparison of cost of operation. The graphical method was used to identify the minimum area to be planted per year using the machine to obtain the cost of mechanical planting less than the manual planting.

3. Results and Discussion

3.1 Output capacity

The output capacity of the ginger planter is presented in Table 1. The observed speed was less than the set forward speed of 0.9 km/h due to the wheel slip of the power tiller. The wheel slip reduced the within-row plant spacing. Low forward speed resulted in low field capacity of the machine and high Labour requirement. In the present work, 2 companion workers were employed to ensure that there are minimum missed plantings. Well, maintained power tillers have a general tendency to move straight if soil conditions are uniform. The attention of the companion workers is needed whenever the tires encountered hidden obstructions that make the power tiller to change its straight course of travel. The field capacity of the ginger planter was low because of the high density (close spacing) of the seed rhizomes. The lower field capacity and higher field efficiency were due to time losses in the field during the planting operation. Total time loss in the field during mechanical planting operation was 30.54%, off which turning of the machine at the headland and adjustment in machine accounted for the 22% time loss, and loading of seed rhizomes to the seed stock trays accounted for 8.54% of time loss. The small size of plots and the requirement of loading seed stock trays with ginger rhizomes consumed productive time and reduced the field capacity of the machine.

Table 1. Output capacity parameters of ginger planter under actual field conditions

Performance parameters	Mechanical planting	Manual planting
Average forward speed, km/h	0.72	-
Average draft requirement, kgf	42.8	-
Wheel slip, %	5.20	-
Average seed spacing, cm	21.33	22.46
Field capacity, ha/h	0.03	0.0029
Field efficiency, %	69.44	-
Fuel consumption, L/h	1.42	-
Labour requirement for planting, man-h/ha	99.99	685.87
Percent time saving, %	90.28	-
Percent labour saving, %	85.42	-

In general, the ginger planter worked well under actual field conditions. Mechanical planting improved labour productivity and resulted in the saving of 90% of productive time and 85% total labour involved in conventional manual ginger planting.

3.2 Quality of work

The quality of work of the ginger planter is presented in Table 2. The use of individual labourers for feeding the planting device required additional cost for labour but resulted in negligible missed plantings. The soil covering efficiency of the soil covering device was higher due to the longer length of the blades which gradually pushed the soil above and around the seed rhizomes for effective contact with soil. The soil covering device was properly set to provide a sufficient quantity of soil above and around the seed rhizomes.

3.3 Cost of operation

The cost of mechanical planting of ginger at various levels of annual use is presented in Fig. 4. It indicates that the cost of mechanical ginger planting decreased with an increase in annual use. The cost of mechanical ginger planting was less than the conventional manual method of planting when the annual use of ginger planter was equal to 0.57 ha or 19 hours.

Farmers allocate a relatively low proportion of area for the ginger crop. Hence, smallholder farmers (less than 2 ha area) can own and use the developed ginger planter for planting in their own fields. To increase profit, farmers have to go for custom hiring. The cost of operation considering 100 hours of annual use was found to be ₹ 416/h. Thus, mechanized ginger planting can eventually be accepted in the power tiller operated farms having a ginger cultivation area less than 0.57 ha, if custom hiring services for ginger planter are available. However, owning the 2-row ginger planter was also justified if the farmer operates the machine on custom hiring basis after planting his own fields. Thus, the ginger planter developed in the present study has the potential for use in small and medium farm holdings.

4. Conclusions

The prototype 2-row power tiller operated ginger planter developed in the present study was found to be technically and economically feasible in the power tiller operated farms having a ginger cultivation area of more than 0.57 ha. The average field capacity of the ginger planter was 0.03 ha/h at a forward speed of 0.72 km/h. The labour requirement for mechanical planting of ginger was 100 man-h/ha. Mechanical planting improved labour productivity and resulted in the saving of 90% of productive time and 85% total labour

Table 2. Quality of work of ginger planter

Performance parameters	Value
Planting rate, Number of plants/min.	37.02
Percent missed plantings, %	0.96
Planting efficiency, %	99.04
Percent sufficiently soil covered plants, %	97.36
Percent inadequately soil covered seed rhizomes, %	2.64

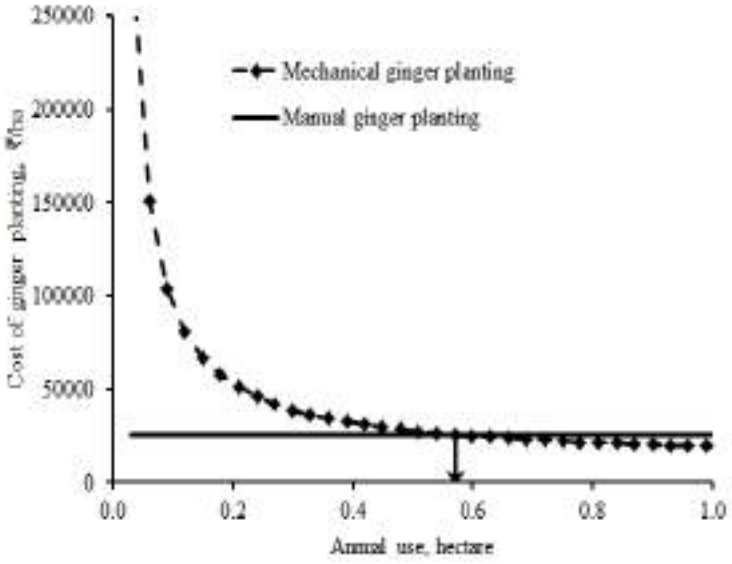

Fig 4. Variation in cost of ginger planting by mechanical and manual methods

involved in conventional manual ginger planting. The average planting rate of the ginger planter was about 37 seed rhizomes/min. Percent missed planting was about 1%. About 99% of seed rhizomes were planted perfectly. More than 97.36% of seed rhizomes were covered with a sufficient quantity of soil. Smallholder farmers (less than 2 ha area) can own and use the developed ginger planter for planting in their own fields. To increase profit, farmers have to go for custom hiring.

5. References

Dihingia P C., Kumar P G V., Sarma P K., Neog P. (2018) Hand-fed vegetable transplanter for use with a walk-behind-type hand tractor. International J. of Vegetable Science 23(3): 254-273.

Gupta J P., Kumar S. (2001) Status of power tiller use in Bihar: A case study of Nalanda district. Agricultural Mechanization in Asia, Africa and Latin America 32(1): 19–22.

ICAR. (2020) Annual Report 2020. Department of Agricultural Research and Education, Govt. of India, New Delhi. pp: 91.

Kathirvel K., Job T V., Manian R. (2000) Development and evaluation of power tiller operated ladder, Agricultural Mechanization in Asia, Africa and Latin America 31(1): 22–27.

Khas I B. (2015) Turmeric/Ginger Planter Innovation Catalogue. Accessed 6 March 2021. National Innovation Foundation Ahmedabad <http://nif.org.in/innovation/turmeric-ginger-planter/743>

Madhukumar D M. (2017) Design, Development and Testing of a Tractor Drawn Semi-Automatic Rhizome Planter for Ginger and Turmeric. Kelappaji College of Agricultural Engineering and Technology, Tavanur, Kerala.

Mandal S., Kumar G V P., Tanna H., Kumar A. (2018) Design and evaluation of a pneumatic metering mechanism for power tiller operated precision planter. Current Science 115 (6): 1106-1114.

Mathanker S K., Mathew M. (2002) Metering mechanism for ginger planters. Agricultural Engineering Journal 11(1): 31–39.

Pandey H S., Sawant C. (2020) Tractor operated ginger rhizome planting machine. Accessed 13 February 2022 <https://www.ropanonline.com/2020/06/tractor-operated-ginger-rhizome.html>

Patel T., Dewangan K.N., Chhetry B S K., Thokchom S., Ningthoujam B. (2021) Design and development of mini ginger planter suitable for hilly region agriculture. Design for Tomorrow, Vol. 3, Springer, Singapore.

RNAM. (1995) RNAM Test Codes and Procedures for Farm Machinery. United Nations. Economic and Social Commission for Asia and the Pacific. Regional Network for Agricultural Machinery (United Nations), Bangkok.

Singh T P. (2017) Farm Machinery. 1st Edn. PHI Learning Pvt. Ltd. Delhi.