Performance Evaluation of Digger for Ginger Crop

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Authors' contributions

This work was carried out in collaboration between both authors. Author Narender designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AKS managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The ginger (*Zingiber officinale*) rhizome is harvested manually by different types of spade, fork or bullock drawn plow. These methods consume more time, cause drudgery, losses and low field capacity. Therefore a tractor drawn digger was evaluated for ginger crop. The performance parameters (exposed, cut, bruised and digging efficiency) of the digger were studied at 3 forward speeds and 3 blade angles. The performance of the digger was found satisfactory in respect of digging efficiency of 98.01%, and undug crop of 2.38 % at an average depth of operation of 15.75 cm. The damage was 1.98 per cent which was much low as compared to manual digging of ginger crop (9.73%). The machine takes 7.4 hours to dig one-hectare area of ginger crop with field efficiency of 87.82%.

Keywords: Machine; performance; digging efficiency; digger; ginger crop.

1. INTRODUCTION

India is the larger producer of ginger, accounting for 50 per cent of the world production. Other major ginger producing countries are Jamaica, Nigeria, Sierra Leone, Thailand, Taiwan and China. Jamaican ginger is valued much because of its lemon-like odor qualities. Indian ginger is

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regarded as Cochin ginger in the world market and is considered next best to Jamaica. Ginger is cultivated in tropical and sub-tropical areas. It needs good rainfall, high temperature and high relative humidity throughout the crop period. In India, ginger is cultivated in light sandy loam soil to black soil. Throughout India, the best quality ginger finds in Kerala as there is congenial climate and rich in soil nutrients which is favorable for growth of ginger. On the other hand, the production of ginger crop in India was 1118 thusand metric tonnes with an area of 160 thousand hectares during the year 2017-18 [1]. India exports nearly 22605 metric tonnes of ginger annually and gets income of 21607.49 lakh rupees earning which accounted for 1.20 per cent of the total exporters from spices (Indian Spice Board, 2017-18). In Madhya Pradesh, the production of ginger crop was 20.20 thousand metric tonnes with an area of 12.50 thousand hectares and productivity of 1.62 MT/ha during the year 2016-17 [1].

The ginger rhizome is harvested manually by different types of spade, fork or bullock drawn plow. These methods consume more time, cause drudgery, losses and low field capacity. Generally, the rhizomes spread down at 14 to 20 cm deep in the soil, it will not be possible to achieve digging of the entire rhizomes by manual digging and hence, the considerable quantities of rhizomes are damaged and remains undug. Therefore, it is need to develop a mechanical means of digging for ginger crop. So, it is necessary to introduce a machine that could dig ginger crop and reduce the digging time, human efforts and increases the mechanization on farmer's ground level. Taking these points into account, it was therefore, decided to evaluate the digging machine for ginger crop in the field.

2. MATERIALS AND METHODS

The experiment was conducted at the Horticultural Research Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (M.P). Experiments were conducted according to the plan of the experiment. For each test, three replications were taken at each combination of the variables. The crop was grown in the farm as per recommended agronomical practices. The matured crop was dug by using diggers. The observations on the soil type, moisture content and bulk density were recorded. The method for the determination of water content, recommended by the Indian standards institution (I.S.I.), as set out in "IS: 2720 (Part-II)-1964: [2]

Methods of test for soils-Part-II Determination of Moisture Content." was followed. Bulk density of soil is measured as the mass of soil of a unit volume. The bulk density of soil was determined by core cutter method. Before conducting the experiments, the tops of the crop were removed manually before digging, which might increase load on the digger and also reduced the efficiency of digging the crop.

2.1 Performance Parameters

Exposed crop, %

The exposed crop was observed on the surface of the soil after the digging by machine. It was defined as total weight of visible crop to total weight of digged crop.

Undug crop, %

Undug crop was calculated as the ratio of the weight of the crop remained undug which was digged manually after the operation of the digger.

Digging efficiency, %

Digging efficiency was calculated to find how efficiently the digging unit digs the crop. It was defined as weight of digged crop to the total weight of the crop collected after the digging operation.

Damage crop, %

Damage crop was calculated as the ratio of the weight of the damaged crop to the weight of the total crop digged.

2.2 Effective Field Capacity

The actual operating time along with time lost for the turning of machine was recorded in the field test area. The effective field capacity of the machine was calculated as follows:

$$EFC = \frac{A}{T_p + T_1} \qquad (1)$$

Where

EFC = Effective field capacity of machine, ha/h
A = Area covered, ha;
T_p = Productive time, h and
T_1 = Non-productive time, h.
(Time lost for turning, excluding refueling and machine trouble)

Field efficiency (%)

It was calculated from field test data as follows:

$$E_f = \frac{EFC}{C_T} X\ 100 \qquad (2)$$

Where

E_f = Field efficiency, %
EFC = Effective field capacity, ha/h and
C_T = Theoretical field capacity, ha/h.

$$C_T = \frac{WXS}{10}$$

Where

W = width of operation, m and
S = Speed of operation, km/h.

3. RESULTS AND DISCUSSION

3.1 Evaluation of Machine Variables for Ginger Crop

The tractor-drawn digger was evaluated with tractor New Holland at the optimized value of the ginger crop.

Field experiments were conducted to study the various machine variables and the interaction for the selection of optimum machine parameters. The studies were conducted at different levels of the forward speed and blade angle in accordance with design of experiment given in Table 1. The data was analyzed at 5% level of significance for the entire performance variable by analysis of variance technique/programme given by SPSS statistical software.

3.2 Effect of Forward Speed and Blade Angle on Digging Efficiency

Fig. 1 shows the effect of forward speed and rake angle on the digging efficiency for by

attaching the v-shape of blade. The effect was found significant at a 5 % level. It is observed from Fig. 1, that as the blade angle increased from15^0 to 25^0 of V-shape shape blade, the digging efficiency increased from 95.48 to 97.82 % at forward speed of 2.06 km/h. Similarly the digging efficiency was found to be increased from 93.68 to 95.35 and 92.72 to 95.00 % as the rake angle increased from 15 to 25 degree in V-shape of blade at forward speed of 2.90 and 4.16 km/h, respectively. A similar increasing trend of digging efficiency was found by Shirwal et al. [3] and Narender et al. [4] for other root crops.

3.3 Effect of Forward Speed and Blade Angle on Undug Crop

Fig. 2 shows the effect of forward speed and rake angle on the undug. The effect was found significant at a 5 % level. But mutual interaction of the shape, speed and rake angle was non-significant at 5 % level.

It is observed from Fig. 2, that as the blade angle increased from 15 to 25 degree of V-shape shape blade, the undug crop decreased from 4.52 to 2.18 % at forward speed of 2.06 km/h. The undug crop was also found to be decreased from 6.32 to 4.65 and 7.28 to 5.00% as the rake angle increased from 15 to 25 degree in V-shape of blade at forward speed of 2.90 and 4.18 km/h, respectively.

3.4 Effect of Forward Speed and Blade Angle on Damage Percentage Crop

Fig. 3 shows the effect of forward speed and rake angle on the damage percentage. The effect was found significant at a 5 % level. The mutual interaction of the shape, speed and rake angle was also significant at 5 % level.

Table 1. Plan of the experiment of the digger in field

Sr. No.	Level of variable		Performance parameters
1	Crop	Ginger	Exposed crop (%)
2	Blade	V-shape	Undug crop (%)
3	Speed (3)	2.06, 2.9, 4.18 km/h	Damage crop (%)
4	Angle (3)	15°, 20°, 25°	Digging efficiency (%) Draft, N

Total no of treatment combination in the field= 3x3= 9
Number of replication= 3
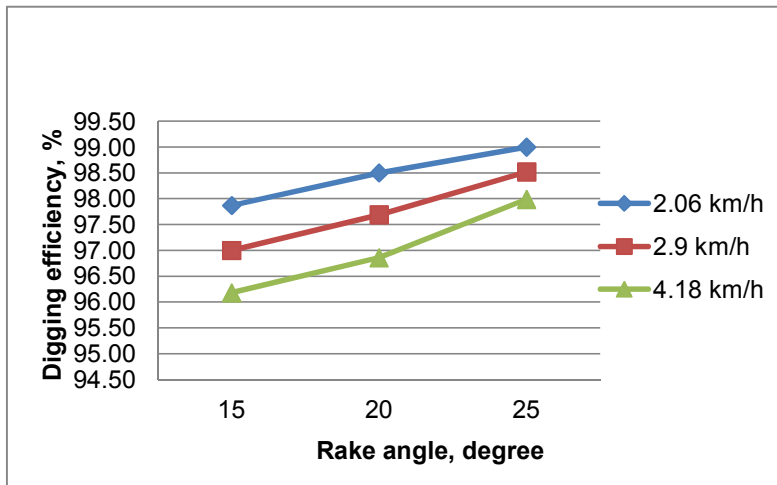*So total no. of experiment= 9x3= 27*

Fig. 1. Effect of blade angle and forward speed on digging efficiency (%) of ginger crop
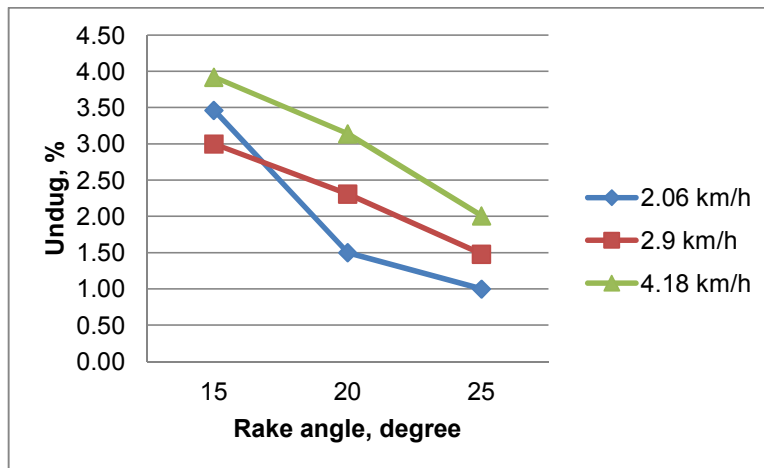

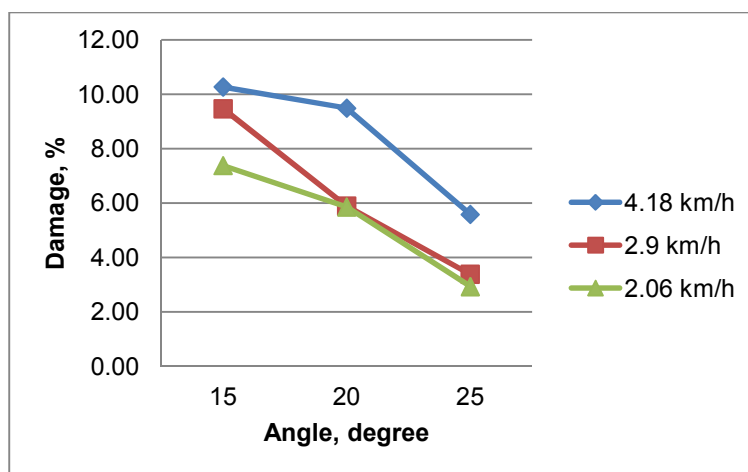**Fig. 2. Effect of blade angle and forward speed on undug ginger crop (%)**

Fig. 3. Effect of blade angle and forward speed on damage (%) of ginger crop

3.5 Effect of Forward Speed and Blade Angle on Exposed Percentage

Fig. 4 shows the effect of forward speed and rake angle on the exposed percentage. The effect was found significant at a 5% level. The mutual interaction of the shape, speed and rake angle was non-significant, but the interaction between shape and speed was significant at 5% level.

It is observed from Fig. 4 that as the blade angle increased from 15 to 25 degree of V-shape shape blade, the exposed crop decreased from 87.24 to 79.02% at forward speed of 2.06 km/h. Also, the exposed crop was found to be decreased from 89.68 to 82.62and 91.21 to 84.41% as the rake angle increased from 15 to 25 degree in V-shape of blade at forward speed of 2.90 and 4.16 km/h, respectively. Similar trend was observed by Katiwat and Khommueng [5].

The performance of the digger was found satisfactory in respect of digging efficiency of 98.01%, and undug crop of 2.38% at an average depth of operation of 15.75 cm. The damage was 1.98 per cent which was much low as compared to manual digging of ginger crop (9.73%). The machine takes 7.4 hours to dig one-hectare area of ginger crop with field efficiency of 87.82 %. 4.92 litre fuel was consumed in one hectare area and 630.25 kgf draft of the machine was recorded during digging operation in the field and. One skilled labour is needed for operation of the tractor with developed digger and four unskilled labours were
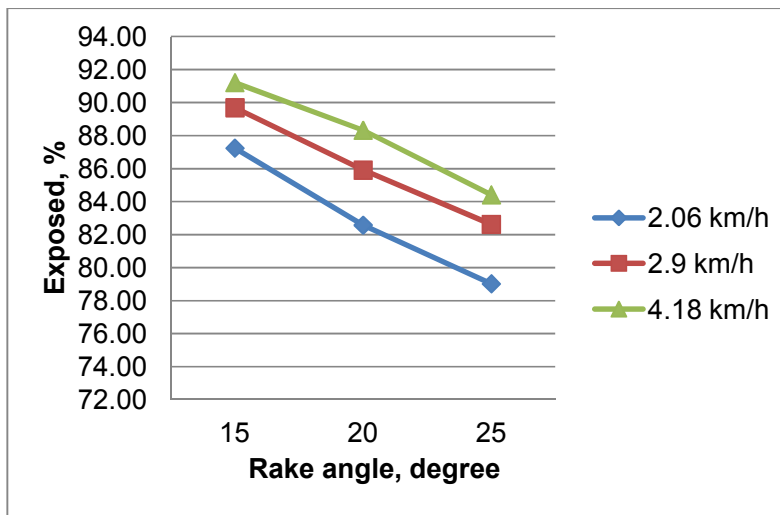

Fig. 4. Effect of blade angle and forward speed on exposed (%) of ginger crop

Table 2. Performance of the digger at the optimized machine variable of ginger crop

Sr. no.	Parameters	Average
1	Depth of operation, cm	15.75
2	Draft requirement, kgf	630.25
3	Digging efficiency, %	98.01
4	Exposed, %	86.42
5	Damage crop, %	1.98
6	Undug, %	2.38
7	Rotary torque, Nm	76.20
8	Fuel consumption, $l\ h^{-1}$	4.92
9	Theoretical field capacity, ha/h	0.154
10	Actual field capacity, ha/h	0.135
11	Field efficiency, %	87.82
12	Labour requirement for operation, man-h ha^{-1}	37.03

required for collection of the digged crop. The labour requirement of the developed digger was 74.07 man-hours per hectare as compared to 483 man-hours per hectare in manual digging. The capacity of the developed machine was found to be 0.135 ha/h. The overall performance of the machine was given in Table 2.

3.6 Performance Evaluation of the Developed Digger

3.6.1 Manual digging of ginger crop

In manual digging of ginger crop, the spade was used for digging the crop. The dry leaves of the crop were removed. Manual digging required 483 man-hours to dig one-hectare area of ginger crop. After digging the crop was collected in one place. The performance of the manual digging was given in Table 3.

The Table 2 has shown the performance of digger at actual field condition for digging of ginger crop. The results of different variables were found satisfactory.

Table 3. Average observations of performance parameters in manual digging for ginger crop

Parameters	Ginger
Digging efficiency, %	100
Damage, %	9.73
Labour requirement, man-h ha^{-1}	483

4. CONCLUSIONS

Considering various performance results, the rake angle of 25° and 2.06 km/hr speed was selected for performance evaluation of the developed digger. The overall performance of the digger at this rake angle and forward speed was superior in respect of minimum damage (2.93%), minimum undug (1.00%) and showing maximum expose (91.21%) and digging efficiency (99%). As the results obtained from the experiment conducted in the soil bin for different shapes of blade, the minimum force was found in V-shape of blade.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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