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Research Article

An Apparatus for Up-Rooting of Turmeric Rhizomes

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Abstract

Present investigation has been formulated to design the suitable farm machine to harvest the turmeric crop. The investigated and developed machine is suitable for the small size tractor. The effective load in relation to the soil and the turmeric rhizomes was calculated and found to be 0.5984 N/cm2. The working draft (4583 N) of the machine for various speed of operation were determined with the power estimated to work the machine properly was comes to be 7.16 hp. The digging efficiency of the machine was found to be 98.82% at which average depth of operation was 20.2 cm .The damage rhizome was found to be 1.32%. Effective field capacity and field efficiency of the machine were found to be 0.129 ha/h and 80.57% respectively in field. The cost of operation was workout and found to be 1913.79/ha, with 33.21% saving over traditional method of harvesting.

Keywords: Soil Load; Design; Development; Evaluation; Economic

The area under turmeric crop in the state of Maharashtra is increasing day by day. In conventional method, rhizomes are dug manually with the help of hand tools. This method of harvesting is highly labour intensive, tedious and time consuming. Besides near about 30 to 40% of the total cost required for this operation alone. Hand digging operation damages the rhizomes and results in poor quality of fingers of rhizomes. It is also a very difficult task on the part of the farmer to get required labour force for the timely harvesting of the crop.

The mechanical harvesting of tuber has advantage of reducing the cost and labour requirement and is conducive to better soil fertility as the blade of the harvesting implement cuts through the root below the pod zone and leaves the remaining root system in the soil itself. Before mechanical harvesting the fields should have sufficient moisture to enable the blade to penetrate to the desired depth [1], and the soil attached to the bulb is loosened in the process. In the view to reduce the drudgery in operation suitable machine has been developed for small size tractor.

Designing methodology

In operation, harvester cut the soil slice including the root crop as per the design calculation. The proposed length of the harvester including the cutting blade and the web was set 80 cm. A large amount of soil was to pass from the blade and the web.

The soil mass is from the soil cut width and the depth of operation of the machine. The density of the soil for the black cotton soil is considered in the range from 1.16 to 1.28 g/cm^3 (low and high) and average density of soil is taken in calculation.

Mass of turmeric rhizome

The mass of rhizome was determined with respect to the row spacing of the crop and the plant to plant spacing. The average plant to plant spacing from the observation was 30 to 60 cm and row to row spacing was considered in the range of 60 to 80 cm. The volume of rhizome was determined by considering the one working rows of the crop. The total number of the rhizome with respect to the individual weight, the mass of root was determined. The average weight of the root from the observation is taken from the field.

Path of soil and rhizome movement

Soil travel on tuber crop harvester at blade to the end of web with inclined direction and soil discharge in the web spacing with rhizome travel on web top of the soil with respect to the various working speed 1.5, 2.0 and 2.5 km/h has been calculated.

Power for tuber crop harvester

The adequate power for the effective working of machine has prime importance. The power requirement for working of harvester was determined over the properties of soil, speed of operation. The proposed machine was to work in the black cotton soil and the travel speed of operation are 1.5, 2.0, 2.5 km/h. Soil Resistance for black cotton soil = 0.75 kg/cm^2 [2]. The draft for the calculation was considered as 500 kg for medium soil [3].

Construction of harvester

The tuber crop harvester overall features was considered for the load of soil on the harvester for various speed, working depth with respect to the turmeric rhizome, crop spacing, row spacing and the power to operate on various speed. Based on the above parameters the machine was developed. The conceptual engineering drawing and the perspective view of the machine is shown in figure 1.

Figure 1: Complete isometric view of tuber crop harvester.

SN: Components

1: Main Frame

2: Three point linkage

3: Hitch unit

4: Soil cutting blade

5: Webs/windrowing

6: Webs supporting Rod

Working of tuber crop harvester

The overall conceptual element diagram of harvester is shown in figure 1. The developed harvester is attached to the small size tractor (18-24 hp) by three point linkage. The machine was operated on forward or pulling force principle to disturb the soil mass effectively. The soil cutting blade of trapezoidal section is inclined at an angle of 250with horizontal surface of ground, which penetrates in to the soil up to the depth of 18-20 cm with the effective working width of 600 mm. The soil mass and rhizomes uprooted by the blade passes over the web which is having an inclination of 100 with upper surface of soil cutting blade and a length of 500 mm. The loosen soil mass and the turmeric rhizomes after travelling at 270 mm raised height at the end of web is fall on the ground surface. The uprooted turmeric rhizomes are easy to collect from the field.

Wearing of tuber crop harvester

After the field operation of tuber crop harvester the data of wearing of various components like soil cutting blade and webs was collected. The soil resistance was reacted on soil cutting blade hence wearing of blade occurred. The soil moves on the webs with friction hence the webs was wearied out. The initial size and the size of component after the working gives the picture of wearing of components of harvester. The reading is taken at different length and different position to analyzed the wearing of blade and webs. Total wearing impact has been evaluated by knowing.

Field performance and economic of design

The performance of tuber crop harvester was evaluated by taking the field tests, as per relevant RNAM and BIS test codes.

Field testing of tuber crop harvester

Field tests were carried out to obtain actual data on overall performance of tuber crop harvester and working capacity in field condition. Figure 2; show the machine while working in the field during the field testing. The following parameters were measured during harvesting of tuber crop.

Figure 2: Small size tractor operated tuber crop harvester in operation.

Digging efficiency

It was determined by taking 1m x 1m sized plot in harvested field. The rhizome dug out after digging by harvester in the plot were collected and weighed. This material was collected and weighed. Addition of both readings is the total weight of rhizomes present in that plot. It is the measure of ability of harvester for digging rhizomes from the soil. The remaining rhizomes in the soil after the using of machine has been collected manually and the percent to damage were recorded from the field.

Operational cost of machine

Operation cost of the machine was determined over the traditional method of harvesting of turmeric crop. Traditional methods included by manual method, bullock plough and partial use of unsuitable tractor machines to dug the rhizomes from the soil. The various costs like fixed cost, variable cost were determined during field test. The operating of machine has been compared with the traditional method of operation.

Results and Discussions

Determination of soil load on tuber crop harvester

The tuber crop harvester has to work in the soil means to cut the soil slice including the turmeric rhizome. The large amount of soil is to pass from the blade, intermediate section and the web/ windrowing unit. The soil mass was determined from the soil cut width and the depth of operation of the machine. The soil load was found to be 0.5984 N/cm^2 of tuber crop harvester.

The mass of turmeric rhizome was determined with respect to the row spacing of 60 to 80 cm of the crop and the plant to plant of 15 to 30 cm spacing. The total number of the turmeric rhizome with respect to the individual weight has been specified. The average weight of the rhizome from the observation was obtained as 350 gm The rhizome load on tuber crop harvester is 6.45 x 10^{-3} N/ cm^2 and the total soil load considering the mass/ volume of soil (0.5984 N/cm2) and the load of turmeric rhizome (6.45 x 10^{-3} N/ cm2) was 0.6048 N/cm^2. The determined load on the harvester is helpful for selection of appropriate materials for it construction.

Path of soil and turmeric rhizome movement

Soil travel of tuber crop harvester at blade to the end of web with inclined direction 25o and soil discharge in the web spacing with turmeric rhizome travel on web top of the soil with respect to the various working speed 1.5, 2.0. 2.5 km/h was calculated.

Table 1 shows that if the operation speed is increased; the soil load on the web increased. The case taken in to consideration is shown that there is extra load (65% more) when the speed increase from 1.5 km/h to 2.5 km/h. Hence, the operation travel speed for the machine is chosen as 2 km/h. The soil working capacity of the harvester for travel speed of 2 km/h was found to 259.38 tone/h (Table 1). Akinbamowo., *et al.* [4], evaluated tractor mounted cocayam harvester for forward speed of 2, 4 and 6 km/h and mean harvest rate (tone/h) was determined. Kang and Halderson [5], discussed about travel speed of the various potato harvesters.

Forward speed, km/h	Draft, N	Drawbar Power, hp	Difference of PTO power, hp
1.5	4519.95	2.52	3.81(71.88%)
2.0	4583	3.41	
2.5	4663.96	4.34	

Table 1: Relation of travel speed and movement of soil as load on the web of harvester.

Power for tuber crop harvester

The adequate power for the effective working of machine was prime importance. The proposed machine has to work in the soil and travel speed of operation was considered as 1.5, 2.0, 2.5 km/h.

The power for working of the machine was greatly influences by the travel speed of the machine. If the machine travel speed was increase with the 1 km/h, then the PTO power requirement of the machine is increase by 71.88%. From the calculation, it is found that the operating speed of 2.0 km/h is suitable at which the drawbar power requirement of the machine is 3.41 hp (Table 2). Hence, the PTO power requirement for the operation of the machine was decided to be 7.16 hp. Onwualu and Watts [6], determined the draft required for plane tillage tool for eight levels of speeds. Younis., *et al.* [7] showed drawbar pull of the developed digger was decreases by 25.17, 25.91, 28.43 and 30.74% at various forward speed.

Travel speed, km/h	Movement of soil volume, m^3/sec	Mass displacement, kg/sec	Soil load at different travel speeds, Tone/h	Difference Average volume of soil, m^3/ sec
1.5	0.044	54.04	194.54	0.029 (65.90%)
2.0	0.058	72.05	259.38	
2.5	0.073	90.06	324.21	

Table 2: Relation of travel speed and the power requirement.

Structural stability of harvester

In tuber crop harvester a total of eleven webs carrying load of 643 N. Hence, the one web acted a load of 58.45 N entire on 0.5 m length. The load on per meter length was 117 N/m. The σb is the bending stress of mild steel not greater than 100 Mpa and the maximum bending moment was 3.65 N-m. Hence, the diameter of the web to sustain the load of 58.75 N is comes to 7.19 mm and selected a diameter of web is 10 mm. The detailed of shear force and bending diagram for the uniform distributed load is given in figure 1. Hence, a total of eleven web selected is justified.

Deflection of webs

The one webs acted a load of 58.45 N entire the 50 cm length. The load on length was 1.169 N/cm. Web diameter of selected webs was determined 10 mm. The maximum deflection of the web is 0.19 cm. There is no deflection was found on total webs of tuber crop harvester, hence the selection of webs diameter and size and length is suitable for tuber crop harvester.

Thickness of soil cutting blade

The thickness of blade should be 1/10 of the width of blade (i.e. 70 mm). The thickness of cutting blade was considered as the standard available which sustain the load action and negotiate the draft of range 450-460 kg. The soil cutting blade thickness is 8 mm.

Laboratory testing of tuber crop harvester

The tuber crop harvester was tested in laboratory of the Department of Farm Power and Machinery, Dr. PDKV, Akola in context to assess the working condition and workability of its different components such as soil cutting blade, windrowing unit/web, three point linkages, and frame. From laboratory testing, it was observed that almost all the components of tuber crop harvester were working properly as far as their performance and working condition is concerned.

Wearing of tuber crop harvester

Wearing of tuber crop harvester was worked out in laboratory of the Department of Farm Power and Machinery, Dr. PDKV, Akola. It was determined over the reduction of dimension of the components by friction in field operation. The wear analysis was worked out for 52 h of operation.

Wearing of soil cutting blade and webs

Wearing of soil cutting blade and webs length is 1100 mm and 500 mm and working depth of soil cutting blade is 200 mm. The soil resistance react the working depth of blade span soil contact parts wearing is occurring which part reading is taken at 50 mm distance horizontal position. The blade span width is 70 mm the vertical position at reading is taken 30 mm distance. The soil moves on webs wearing is occur at different distance at 150 mm with the help of vernier scale hence. The operation of tuber crop harvester is 52 h at which wearing of soil cutting blade and webs was found out. The actual weight of the machine before the operation was 25.01 kg approximately after operation it was 24.90 kg. It was found that near about 100 gm of weight has been wearied out during the operation. The percentage of wearing comes to be 0.2% for 52 h. Based on observation, the machine can be effectively work for the 1000 h of operation and reduction in size of soil cutting blade and webs observation in Table 3.

Field performance of tuber crop harvester

The tuber crop harvester was tested at Dr. PDKV., Akola and at farmer fields. The field performance of the machine included the speed of operation soil moisture, draft, field capacity, field efficiency and digging efficiency as the damage percentage of rhizomes. The various field test i.e. seven field tests was carried out at various located across the University area. The soil type was deep black to clay loam type. The field trials were carried out for various speed of operation. Performance of the tuber crop harvester was done to test its performance for harvesting of turmeric crop.

Parameter	Measuring at different distance/position, 50 mm length of soil cutting blade																		
Side of wearing	Left side wearing				Center side wearing											Right side wearing			
First position	7.32	6.88	7.00	7.02	6.88	6.98	6.88	6.82	6.78	6.86	6.66	7.02	7.06	7.00	6.92	6.64	6.8	6.84	6.8
Second position	7.84	7.8	7.1	7.16	7.5	7.62	7.64	7.56	7.86	7.18	7.32	7.1	7.24	7.44	7.68	6.78	7.1	7.12	7.2
Third position	8.0	7.98	7.98	8.00	7.98	8.00	7.95	7.99	7.99	7.96	7.94	8.00	7.99	8.00	7.99	7.98	7.95	7.98	8.00
Original position	8.0	8.0	8.0	8.00	8.80	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00

Table 3: Reduction in size of soil cutting blade after field operation (mm).

Trials were conducted on seven test plots of total area 6.12 ha. The harvesting of tuber crop was carried out in the month of February, March and April, 2013. The cost of operation is also evaluated to exploit the economic feasibility of the machine.

Speed of operation

The observation for time required for tuber crop harvesting, turning time and the speed of operation of harvesting of turmeric crops are 1.61, 1.65, 1.74, 1.76, 2.00, 2.46, and 2.7 km/h respectively. Average speed of operation was 1.99 km/h. Ibrahim., *et al.* [10] studied the speed of operation of multipurpose digger for harvesting root crops (1.8, 2 and 2.6 km/h), for potato, (1.4, 1.8 and 2.3 km/h), for peanut. Akinbamowo., *et al.* [4] found that the speed of operation of a tractor-mounted cocoyam harvester were 2, 4 and 6 km/h. Younis., *et al.* [7] found that the speed of operation of developed potato digger were 0.9, 1.5, 1.9 and 3.2 km/h. Khater [8] studied effect of working speeds of mechanical harvesting on potato damage in south eastern Qantara was 3.1 km/h. Arfa [9] evaluated a potato harvester for various speed of operation and reported average speed of operation is 3.02, 4.25 and 5.2 km/h.

Depth of operation

The operation depths of turmeric at the time of harvesting from seven tests were observed to be 20.5, 20.2, 20.6, 20.2, 20, 20 and 20 cm. The average operational depth was found to be 20.2 cm. Ibrahim., *et al*. [10] found that depth of operation of multipurpose digger for harvesting of root crops was 22 cm. Munde., *et al.* [1] found that the depth of bullock drawn turmeric digger were in range 19 to 23 cm. Akinbamowo., *et al*. [4] found that the depth of operation of a tractor-mounted cocoyam harvester was 20.02 cm. Al-Jubouri and Mcnultyt [11] found that the depth of operation of potato digging using orbital vibration was 20 cm. Arfa [9] found that the depth of operation for harvesting of potato crop were 10,16 and 22 cm.

Effective field capacity

The effective field capacity was determined during the seven test and it was found to be 0.105, 0.106, 0.108, 0.108, 0.123, 0.165 and 0.186 ha/h for turmeric crop. The calculations revealed that the average effective field capacity was 0.129 ha/h (Table 4). The effective field capacity was determined by considering the productive as well as non-productive time during the field operation of the tuber crop harvester. The average effective field capacity was 0.129 ha/h. Khura., *et al.* [12] found that the field capacity of a developed tractor-drawn onion harvester was 0.32 ha/h. Tapare [13] found that the field capacity of tractor mounted turmeric digger was 0.34 ha/h. Munde., *et al.* [1] found that the field capacity of bullock drawn turmeric digger for various blade was 0.044, 0.053 and 0.052 ha/h. Oyelade., *et al.* [14] found that the field capacity of tractor drawn groundnut digger/shaker was 0.75 ha/h. Ademiluyi., *et al.* [15] found that the field capacity of tractor drawn groundnut digger was 0.41 ha/h.

Theoretical field capacity

The theoretical field capacity depends upon the speed of operation and theoretical width covered by the implement. The theoretical field capacity of the tractor operated tuber crop harvester during the seven test were 0.129, 0.132, 0.139, 0.141, 0.160, 0.197 and 0.216 ha/h. The calculations revealed that the average theoretical field capacity was 0.159 ha/h. Tapare [13] found that the theoretical field capacity of a tractor mounted turmeric digger was 0.54 ha/h.

Field efficiency

The field efficiency was determined for the tuber crop harvester and it is found to be 81.76, 80.58, 77.82, 76.77, 76.92, 84 and 86.13% for seven test (Table 4). The field efficiency was calculated from the values of theoretical field capacity and effective field capacity. The calculations revealed that the average field efficiency was 80.57%. Ademiluyi., *et al.* [15] found that the field efficiency of a tractor drawn groundnut digger was 85.93%. Oyelade., *et al*. [14] found that the field efficiency of a modified tractor drawn groundnut digger was 77.16%. Morad., *et al.* [16] was compare the field efficiency of a manual and mechanical methods for harvesting of sugar beet crop were 69.10 to 90% respectively. Tapare [13] found that the field efficiency of a tractor mounted turmeric digger was 62.96%. Munde., *et al.* [1] found that the field efficiency of bullock drawn turmeric digger for various blade were 89, 74 and 88%.

Digging efficiency

Digging efficiency includes dugout root crop, undug root crop and total weight of root crop. The average harvesting efficiency of tractor mounted tuber crop harvester was observed to be 98.82%. Khura., *et al.* [12] found that the digging efficiency of a tractor-drawn onion harvester was 97.7%. Ibrahim., *et al.* [10] found that the digging efficiency of a multipurpose digger for harvesting of root crops was 93%. Tapare [13] found that the digging efficiency of a tractor mounted turmeric digger was 97.85%. Akinbamowo., *et al.* [4] found that the digging efficiency of a tractor-mounted cocoyam harvester was 84.17%. Munde., *et al*. [1] found that the digging efficiency of bullock drawn turmeric digger were 94, 86 and 91% for various blade. Horia., *et al.* [17] found that the digging efficiency of carrot crop harvest was 86.46%.

Parameter	Test							
	Test-I	Test-II	Test-III	Test-IV	Test-V	Test-VI	Test-VII	Avg./Total
Speed, km/h	1.61	1.65	1.74	1.76	2.00	2.46	2.7	1.99
Actual area covered, ha	0.613	1.365	0.612	1.816	0.400	0.912	0.400	6.12
Total time of operation, min	349	770	339	1008	195	331	129	445.9
Blade width of implement, cm	80	80	80	80	80	80	80	80
Effective working width, cm	60	60	60	60	60	60	60	60
Theoretical field capacity, ha/h	0.129	0.132	0.139	0.141	0.160	0.197	0.216	0.159
Effective field capacity, ha/h	0.105	0.106	0.108	0.108	0.123	0.165	0.186	0.129
Field efficiency, (%)	81.76	80.58	77.82	76.77	76.92	84.00	86.13	80.57
Fuel consumption, l/h	1.80	1.87	1.90	1.83	1.86	1.91	1.88	1.86

Table 4: Field performance results of tuber crop harvester.

Damage percentage

Damage percentage includes total dugout weight root crop and damage root crop. The average damage percentage in mechanical harvesting was observed to be 1.32%. Khura*., et al.* [12] found that the damage percentage of tractor-drawn onion harvester was 3.5%. Horia., *et al*. [17] found that the damage percentage of a developed machine for carrot crop were 0.77 to 1.51%. Ibrahim., *et al.* [10] found that the damage percentage of developing a multipurpose digger for harvesting of root crops was 3.67%. Tapare [13] found that the damage percentage of tractor mounted turmeric digger was 3.85%. Munde., *et al*. [1] found that the damage percentage of bullock drawn turmeric digger was 10.72, 19.62, and 15.46% for various blades [18-20].

Economic of tuber crop harvester

The economic of tuber crop harvester to harvest the turmeric crop was evaluated for the per hour and per hectare cost of operation. The cost of operation of machine has been compared with the traditional method of operation is manual and bullock plough. The cost of fabrication of tuber crop harvester was found to be Rs 2156/-.

The cost of operation of the machine is the function of basic cost of mechanical power sources and the cost of harvester. The initial investment cost of the mini-tractor range of 18-24 hp is considered to determine the operation cost. The cost of newly developed turmeric harvester is came to be Rs. 2156 /- (includes the overhead, profit and royalty). The cost of operation of the harvester during the test conducted was observed to be in the range of Rs 230.68, 235.51, 237.57, 232.75, 234.82, 238.26 and 236.19. (Table 5) per hour respectively, for 1.61, 1.65, 1.74, 1.76, 2.0, 2.46, and 2.7 km/h speed of operation. The average cost of operation per hour comes to be Rs 235.11. The cost of harvesting of turmeric crop per hectare was in the range of Rs 1269.86 to 2221.75. The average cost of operation per hectare was observed to be Rs 1913.79/.

The cost of harvesting of turmeric crop was determined over the traditional method. Traditional method includes digging by manual, digging by bullock plough and was observed to be per hectare for turmeric crop in the range of Rs 28550 to 30050 the average cost of operation per hectare in traditional method observed to be Rs 29533. The net saving over traditional method per hectare of operation was observed to be Rs 9808/-. The average saving of cost over the traditional method of operation was found to be 33.21%.

Summary and Conclusions

The optimum width to depth ratio of 6:2 has been considered for development of harvester and found effective during field operation. According to the row spacing and the type of sowing of crop (i.e. ridge), a trapezoidal type blade was selected to properly failure of soil to enhance the uprooting of turmeric rhizomes.

Once the shape of the blade, depth and width decided, it is easier to define the soil load on harvester. After determining the soil load, a suitable speed has been worked out to estimate the power required to operate the harvester. Based on the soil load on harvester, the web specification was calculated to effective covey of soil mass and rhizomes.

The developed harvester has been tested at various field in the University region for it readability to harvest the turmeric crop. A total of seven tests was carried out on 6.12 ha area. The relation of draft and speed of machine has been worked out during the field

SN	Particulars	Test - I	Test - II	Test - III	Test - IV	Test - V	Test - VI	Test - VII	Avg.
1	Depreciation(10%), Rs/h	34.16	34.16	34.16	34.16	34.16	34.16	34.16	34.16
2	Interest(10%), Rs/h	20.58	20.58	20.58	20.58	20.58	20.58	20.58	20.58
3	Insurance(1% of PP), Rs/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
4	Tax(1% of PP), Rs/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
5	Housing cost(1% of PP), Rs/h	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
A	**Total fixed cost, Rs/h**	63.64	63.64	63.64	63.64	63.64	63.64	63.64	63.64
1	Fuel cost, Rs/h. (Rs. 53 lit/h)	95.4	99.11	100.7	96.99	98.58	101.23	99.64	98.81
2	Lubricants cost(30% of FC), Rs/h	28.62	29.73	30.21	29.1	29.57	30.37	29.89	29.64
3	Repairs and maintenance cost (6% of PP), Rs/h	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02
4	Operators wages, Rs/h. (Rs. 200/day)	25	25	25	25	25	25	25	25
B	**Total variable cost, Rs/h**	167.04	171.87	173.93	169.11	171.18	174.62	172.56	171.47
1	Total cost of operation (Rs/h) = Fixed cost (Rs/h) + operating cost (Rs/h)	230.68	235.51	237.57	232.75	234.82	238.26	236.19	235.11
Cost of operation per hectare (Rs/ha)		2196.98	2221.75	2199.75	2155.09	1909.08	1444.01	1269.86	1913.79

Table 5: Cost of operation of tuber crop harvester

testing. The performance parameters like effective field capacity, theoretical field capacity, field efficiency has been worked out.

The appropriate working speed of the harvester is found to be 2 km/h. Soil working capacity of the harvester was found to be 259.38 tone/h. The effective working soil load on the harvester is come to be 0.6048 N/cm2. The draft required for the machine comes to be 4583 N for the operation speed 2 km/h. If forward speed of the machine is increased by 1 km/h; the soil load on machine is increased by 65.90%. If forward speed increases by 1 km/h, the PTO power requirement increases by more than 71.88%. The average effective field capacity of the harvester was found to be 0.129 ha/h. The average fuel consumption for the operation was found 1.86 l/h. The slippages of wheel during field testing were within limit. The average depth of machine during the field operation was observed to be 20.2 cm. The average digging efficiency of the harvester was found to be 98.82%. The average damage percentage was observed as 1.32%. The average per hour cost of operation was calculated and found to be Rs 235.11/-. The average per hectare cost of operation was calculated and found to be Rs 1913.79/-. Saving cost of harvesting over tradition method of harvesting was observed 33.21%. After the study it was observes that newly developed machine works satisfactory during the field trials. It saves the cost over the traditional method of harvesting. The newly developed machine has large scope to mechanize the uprooting operation of turmeric crop.

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