

DEVELOPMENT AND TESTING OF TRACTOR DRAWN GROUNDNUT DIGGER-SHAKER

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ABSTRACT

The tractor drawn groundnut digger-shaker was developed with an objective to have mechanical means for harvesting of groundnut crop. The components were designed and developed keeping in view the relevant crop, soil and machine parameters. Machines consisted of a frame, digging blade harrow, power transmission from PTO shaft and shaking attachment. The performance of developed machines was evaluated at Instructional Farm, College of Agriculture, JAU, Junagadh. The experiment was undertaken in medium black soil; the observed moisture content was 14 per cent (db) at the time of digging. The size of experiment plot was 104 x 24 m was considered for observations. During field testing of machines, draft, speed, power requirement and digging efficiency were observed. The average draft of digger shaker was 782 kgf at an average speed of 3.8 km/h and an average depth of digging was 12 cm. The power requirement varied between 11 to 12 hp. It was also revealed that the average digging efficiency was 90 per cent. The theoretical field capacity, effective field capacity and field efficiency of digger-cum-shaker was 0.45 ha/h, 0.35 ha/h, and 80 per cent, respectively. The average fuel consumption was 3.7 l/h. The field from which groundnut was harvested by this machine would need no ploughing of land for preparation of seedbed for next crop. The saving in terms of both man-hours requirement and cost of harvesting was quite substantial and justified the use of developed machine.

Keywords: Groundnut, Groundnut digger-shaker

INTRODUCTION

Groundnut (*Arachis hypogaea*. L) or peanut is a major oilseed crop produced on commercial scale in India, China, France, Nigeria, and USA. It is originated from Brazil and in 16th century, it was introduced in our country. The crop can be grown successfully in areas receiving the rainfall ranging from 600 to 1250 mm. The best soils for groundnut crop are sandy loam, loam and medium black

with good drainage system (Reddy, 1988).

The multiple uses of the groundnut make it an excellent cash crop for domestic markets as well as foreign trade. Groundnut is grown on nearly 26.38 million hectares in world with annual production of 36.06 metric tons of nuts-in-shells and the productivity is 1367.1 kg/ha. Groundnut is grown on large scale in India, China, USA, Senegal, Indonesia,

Nigeria, Brazil and Argentina. Groundnut is the kingpin among the oilseed crops of India. The total area under groundnut cultivation in India is 8.0 million hectares, which accounts for the total production of 7.5 metric tons with the productivity of 937.5 kg/ha (FAO Database, 2004). Harvesting of groundnut crop consists of removal of the groundnut plants along with the pods from soil. Harvesting should be done in bright sunshine so that pods and vines can be dried thoroughly in the field. In India, the prevalent methods of groundnut harvesting are (i) By manually pulling out the plants (ii) By animal drawn groundnut digger (iii) By Power tiller drawn groundnut digger and (iv) By tractor drawn groundnut digger.

Generally farmers of Saurashtra region are using bullock drawn blade harrow, improved blade harrow and tractor drawn blade harrow for harvesting of spreading variety of groundnut. Improper penetration of blade due to clogging with vines and working under hard soil is common problems faced in above said implements during the operation, resulting in more per cent of pods left out in the field. There has been great demand for tractor drawn suitable equipments but the growth rate of these matching equipments and tools are at very low level, for most field operation like groundnut harvesting. Keeping above points in consideration the study was undertaken.

MATERIALS AND METHODS

This includes description of the general requirements of digger shaker, their conceptual design, material used for the component, and construction details of machines. It also describes methodology of testing the developed machines in the laboratory as well as in the field.

Design considerations

The development of shaking attachment was based on the three considerations, i. e. (i) Agronomical considerations (ii) Functional requirements and (iii) General considerations

Agronomical considerations

Six agronomical parameters were considered during development of machines, i. e. (i) The spreading and semi-spreading varieties are commonly sown at a row spacing of 60 cm and 72 cm.(ii) The pod distribution zone is 16 to 20 cm on either side of plant at 8 to 10 cm depth.(iii) At the time of maturity of pods the moisture content of soil remains 13-15 per cent.(iv) The proper stage of harvesting is determined by observing the yellowish foliage, dropping of old leaves and pods start to become harder.(v) The maturity of crop is likely to happen generally 100-120 days after sowing and (vi) The soil resistance is more for heavy soil i.e. 0.7 kg /cm² which is considered while designing the machine.

Functional requirements

The functional requirements considered during developing new machines are (i) Blade should penetrate 12 -14 cm and cover about 35 to 40 cm at the top and 45cm extra projection was given at bottom to penetrate deep in pod zone area and recover nearly all pods (ii) The harvesting losses should be minimum (iii) Its working should be less troublesome as possible (iv) The power consumption should be low within the capacity of available tractor (v) It should give maximum efficiencies (vi) It should harvest two rows of groundnut at a time (vii) It should be simple in fabrication and easy to manufacture using local available materials and (viii) All parts can be easily assembled and dismantled for inspection and repair.

General considerations

It should be simple in design and safe in operation and have sufficient power requirement compatible with existing tractor. It should harvest and expose pods at a higher rate than the existing methods. The cost wise it should be as cheaper as possible, the same time it should be strong enough and durable.

Existing tractor drawn groundnut digger

The existing groundnut digger consists of frame with three point linkages, tynes, depth control wheels and blade. The frame is made from a 65×65×5 mm MS angle. The length and width of frame is 2000 mm and 460 mm respectively. The tynes are made from 25 mm MS plate. The three tynes are bolted with angles iron frame through brackets. On the frame 15 mm diameter holes were drilled at 50 mm spacing such that required spacing of tynes can be adjusted as per the length of blade. The blade is mounted on the bottom of tynes with the help of 10 mm nuts and bolts having cutting width of 1200 mm and made from 50 × 12 mm spring steel flat. The groundnut pod development lies at 380 mm radius so the extra projections of 450 mm width were provided on either side of blade so that it makes better penetration at the center of plants rows. The details of groundnut digger shaker, blade and tynes were shown in Fig. 1.

Constructional features of machine

Developed attachment consisted of a frame, digging blade harrow, power transmission from PTO shaft and shaking attachment.

Shaking attachment

Shaking attachment consisted of round shafts, round bars and lifting rods. Two MS round shafts of size 25 mm diameter having length of 600 mm were fitted in between three tynes with the help of bushes and oscillate. On

either side of blade three pieces of 20 mm MS round bar each having 300 mm length and 20 mm diameter were welded with shaft. On the each round shaft seven lifting rods were fitted above the round bars with help of bolts-nuts, which were made from 20 mm diameter of conduit pipe. The lengths of lifting rods were ranged in between 600 to 400 mm. These lifting rods were welded on shaft at 70 mm spacing with help of bolts-nuts. The lifting rods were bended downward at rear end with the help of suitable fixture so that a groundnut plant after digging passes backward easily. The 20 mm diameter of MS round bar was laterally attached to lifting rods in such a way that all lifting rods remain separated at same spacing. The side view and back view of developed shaking attachment with tractor were shown in Figure 2, 3, and 4 while the schematic representation was shown in Fig 5.

Eccentric arrangement

Eccentric is used for transmitting power from tractor PTO to the shaking attachment. It consisted of two pedestals with bearings, shaft and adjusting link.

Power transmission system

The power to operate various units of groundnut digger shaker is obtained from PTO shaft located at the back of the tractor. The power from PTO is transferred to the digger shaker, telescopic shaft with universal joint.

Experimental procedure

The working performances of the developed shaking attachment to groundnut digger were tested in terms of field parameters, operating parameters and performance parameters as per standard procedure given by ISI test code.

Field Parameters

Three field parameters were determined with the help of standard

procedure, which are (i) Experimental field: The experimental field was selected on the instructional farm of Junagadh Agricultural University, Junagadh. The size of each test plot was 0.25 ha as per the recommendation of the ISI test code. The field was divided into three equal test plots. (ii) Moisture content of soil: The soil moisture was determined by gravimetric method. Five samples were collected randomly from the test plot. The samples were kept in oven for 24 h at the temperature of 105⁰ C. The samples were weighed before and after drying. (iii) Bulk density of soil: Metallic core sampler was used to take soil samples from field. The samples were weighed and dry weights of the samples were also measured. From the moisture content (db), the ratio of dry weight of soil to volume gave the bulk density of soil.

Operating parameters

The three operating parameters were determined for digger shaker with the help of standard method i. e. (i) Depth of cut (ii) Width of cut (iii) Operating speed and (iv) wheel slip

Performance parameters

Performance parameters for digger shaker were determined with the help of standard method i. e. (i) Fuel consumption: The fuel consumption for digger shaker was measured as per the standard prescribed method. (ii) Draft measurement: The draft was measured with the help of a dynamometer (iii) Power requirement: The power requirement for digger shaker was calculated with standard prescribed formula (iv) Field capacities: Theoretical field capacity, Effective field capacity and Field efficiency were calculated from standard prescribed formulae. The respective observations were given in Table 1.

Determination of pod losses for groundnut digger shaker

After completion of digging operation, three plots were demarked randomly for determining harvesting losses, having size of 2 X 1.44 m. From all sample areas, the harvested plants along with pods were collected and the damaged pods were separated. The exposed pods, which were lying on the surface, were collected. The buried pods and undug pods were also collected to determine the harvesting losses. The losses were calculated with the help of standard formulae. The respective observations were given in Table-2.

i) Total Quantity of Pods $A = B + C$

Where,

A = Total quantity of pods collected from plant in a sample area.

B= Quantity of clean pods collected from the plants dug in the sample area, exposed pods lying on the surface and the buried pods.

C=Quantity of damaged pods collected from the plants in the sample area.

ii)Percentage of Damaged Pods = $\frac{C}{A} \times 100$

iii) Percentage of Exposed Pod Loss = $\frac{G}{A} \times 100$

Where,

G=Quantity of detached pods lying exposed on surface

iv) Percentage of Buried Pod Loss = $\frac{H}{A} \times 100$

Where,

H=Quantity of left out pods buried into the soil in the sample area.

v) Percentage of Undug Pod Loss = $\frac{K}{A} \times 100$

Where,

K=Quantity of pods remained undetached from the undug plants in the sample area.

vi) Determination of Digging Efficiency:
Digging Efficiency = 100 – Total Percentage of Pod Loss

Where,

Total Percentage of Pod Loss =
Percentage of Exposed Pod Loss +
Percentage of Buried Pod Loss +
Percentage of Undug Pod Loss

Cost calculation

The cost calculation was carried out by straight line depreciation method and compared with manual harvesting.

RESULTS AND DISCUSSION

The attachments were developed on the basis of the crop and functional parameters as well as farmers' requirement. The field trials were conducted in semi-spreading variety of groundnut GG-20 in Kharif season as per the standard procedure. The working performance was evaluated in terms of depth, width of cut, operating speed, wheel slip, fuel consumption, field capacity, field efficiency, draft requirement, power requirement, pod losses, and digging efficiency.

Pre-test observations

Before the field testing of machines observations were taken, like (i) Experimental Plot : The plot size for testing purpose was selected, as per ISI test code No. IS: 11235-1985 and it was as 0.25 ha of crop area. The length and width of plot were 104 m and 24 m respectively. (ii) Moisture content of soil : Moisture content was determined by oven drying method. It was found to be 14.26 % (db) at the time of digging. (iii) Bulk density : The bulk density of soil was found 1.42 g/cc. (iv) Plant density : The semi-spreading variety (GG-20) of groundnut was grown 72cm row spacing. The plant density was found around 9 plants per meter of length. The scientific recommendation of plant population for groundnut crop is 9 plants per meter (Basu and Devidyal, 2003). (v) Pod distribution pattern : The lateral pod distribution pattern in the soil was

found to be 20 cm on either side of tap root. The maximum depth of pod setting was found to be 10 cm. About 96.8 % of pods were set inside the periphery of 35 cm. The remaining percentage of pods was situated in between 35 to 40 cm of periphery.

Field observations for evaluation of developed machine

During field trials of machines eight field observations were taken for its performance evaluation like depth of cut, speed of operation, draft of machines, power requirement, effective field capacity, field efficiency, fuel consumption and wheel slip (Table 1)

Depth of cut: In case of groundnut digger shaker depth obtained was in the range of 11 to 13 cm with an average depth of 12 cm. This was adequate for digging the groundnut plants without any damage because the pod zone depth of groundnut was up to 10 cm (Anon. 1996)

Speed of operation: the speed of digger shaker was found in between 3.67 to 3.91km/h with an average speed of 3.79 km /h.

Draft of machines : The average draft observed in case of groundnut digger shaker was in the range 700 to 814 kg with an average of 782 kg at the working depth of 12 cm. The draft required for operating machines were well within the capacity of power developed by 35 hp tractors.

Power requirement: the power required in case of digger shaker was ranged in between 10.8 and 11.75 hp with an average 10.96 hp. Since the average available drawbar horsepower of 35 hp tractors was approximately 21 hp (Kepner *et. al* 1978). So the implement can be operated even under condition required for higher draft.

Effective field capacity: The effective field capacity of digger shaker was in the range of 0.35 to 0.37 ha/h with an

average of 0.36 ha/h. The effective field capacity low in case of digger shaker because the time consumed for cleaning the blade due to clogging of vines. The effective field capacity could have been increased by increasing the length of plot.

Field efficiency: The field efficiency of digger shaker was calculated and found in between 78 to 84 per cent with an average field efficiency of 80 per cent.

Fuel consumption: The average fuel consumption in case of digger shaker was 4.14 l/h.

Wheel slip: The average wheel slip was in case of groundnut digger shaker was 8.97 per cent. The slip increased with increase in forward speed of operation.

Pod losses and digging efficiency

Pod losses were determined in case of digger shaker with the help of standard test code procedure. The average pod losses and digging efficiency were given in Table 2. The pod losses were calculated by taking sample area randomly. The total losses include exposed pod losses, buried pod losses and undug pod losses.

As presented in Table 3 the average exposed pod losses, buried pod losses and damaged pod losses were observed as 5.04 per cent, 2.67 per cent and 2.29 per cent respectively. Thus, the average total pod losses were obtained 10 per cent with average digging efficiency of 90 percent. Those pods remained during digging operation was recovered during exposing operation.

Cost of harvesting

Considering the material requirement and labour charges the cost of developed attachment was considered Rs. 25,000, and the cost of operation of tractor and machine was

calculated. As far as the cost of operation is concerned the machine requires less cost than local method. It was Rs. 1350 /ha as against Rs. 1850 /ha. This was mainly because the developed machine reduced the human labour considerably during digging operation of groundnut crop. The developed machines required only two labour while for manually harvesting required 10 labour per ha.

The above results and findings are in accordance with the findings of tractor operated groundnut digger-shaker developed by the various scientists earlier. Sadhu and Sadhu (1972) developed tractor mounted groundnut digger-shaker. A four feet long single piece curved blade was provided to cut the roots below the pods level. It lifts the plants along with the pods on an elevator conveyer, shakes the soil down and left behind the fluffy windrow of vines with pods to dry up. The dried plants were then collected manually in a tractor trolley. This machine was provided with two adjusting disc coulters on both the sides of blade, which cut the vines before digging. This avoided problem of clogging of plants and therefore this implement could be used for both spreading and semi spreading varieties. Singh (1986) developed a tractor-operated digger and tested at different forward speeds, moisture contents and operating depths. It was found that the forward speeds, depth of operation and moisture contents of soil affected the percentage of pod losses. It was observed that the performance of machine was optimum at forward travel speed of 5 km/h, operating depth of 12 cm and moisture content of the soil 12 per cent. Draft of machine was found between 557 to 990 kg. The performance of the groundnut digger was found satisfactory. Subramanym and Sudhakar (1989) developed a

groundnut digger that could be hitched to the tractor through three-point linkage. A 116 cm long spring steel blade was fixed to mainframe. The depth of penetration could be adjusted either by changing angle of the blade or by adding weights on mainframe. The blade could penetrate 15 cm and covered a width of 116 cm. The field capacity of the digger was found to be 0.27 ha/h. the pod losses were negligible. The operating speed was 3 km/h. Garg and Verma (1990) compared the economics of mechanical digging with manual digging. He evaluated a groundnut digger-shaker-windrower with manual harvesting. The groundnut digger-shaker-windrower provided 89 % pod recovery at 2.5 km/h forward speed and field capacity was 0.22 ha/h. He observed that labour requirement in manual digging and digging with digger-shaker-windrower was 150 man-h/ ha and 59 man-h/ha respectively. The cost manual harvesting was 375 Rs/ha. While in case of mechanical digging the cost observed was Rs. 246-262 per ha.

CONCLUSION

1. Developed attachment used for digging of groundnut crop from the soil.
2. The saving in man-hours requirement and in term of cost of harvesting was quite substantial and justified the use of machines.
3. The digging efficiency of developed machines was 90 per cent with minimum pod losses.
4. The average draft requirement of machines was ranged 691 to 782 kg, which is well within 35 hp tractor.
5. The average field capacity of machines was 0.40 ha/h with

average field efficiency of 81 per cent.

6. Two laboures were required for harvesting of groundnut which ultimately resulted in reduced labour requirement, time and the cost of harvesting.
7. The field from which groundnut was harvested by machines would need no ploughing of land for preparation of seedbed for next crop.

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Table 1: Observation during field test of groundnut digger shaker

Sr. No	Observations	Field Trials			
		I	II	III	Average
1	Depth of cut (cm)	13	12	11	12
2	Width of cut (cm)	120	120	120	120
3	Time required for 50 m run	46	47	49	47.33
4	Starting time (AM), Hr.	9.00	9.50	10.45	--
5	Finishing time (AM), Hr.	9.41	10.38	11.26	--
6	Net Total Time (min)	32	33	29	31.33
7	Total time loss (min)	9	10	11	10
8	Total working time (min)	41	43	40	41.33
9	Pull with tractor (kg)	450	421	409	426.66
10	Pull with Tractor and	1150	1253	1223	1208.66
11	Net Pull (kg)	700	832	814	782
12	Draft (kg)	700	832	814	782
13	Speed of operation (km/h)	3.91	3.81	3.67	3.79
14	Power requirement (hp)	10.8	11.75	11.07	10.96
15	Theoretical field capacity	0.46	0.45	0.44	0.45
16	Effective field capacity	0.36	0.35	0.37	0.35
17	Field efficiency (%)	78.26	77.77	84	80.10
18	Fuel consumption (l/h)	4.36	3.94	4.12	4.14
19	Percent slip (%)	5.45	10.34	11.13	8.97

Table 2 : Observations of field losses during groundnut digger shaker

Sample Area: - 2m x 1.44m

Sr. No.	Observations	Fields Trials			
		I	II	III	Average
1	Quantity of damaged pods collected from the plant in a sample area. (g)	8.3	9.6	7.2	8.4
2	Quantity of left-out but exposed pod in	18.7	20.8	15.8	18.4
3	Quantity of left-out but buried pod in the	8.3	11.6	9.4	9.8
4	Quantity of left out but pods with un-dug	----	----	-----	-----
5	Quantity of undamaged pods collected	330.3	325.2	338	331.2
6	Total quantity of pods collected from the	365.6	367.2	363.6	365.5
7	Percentage of Damaged pods	2.27	2.61	1.98	2.3
8	Percentage of Exposed pods	5.11	5.66	4.35	5.0
9	Percentage of Buried pods	2.27	3.16	2.59	2.7
10	Percentage Un-dug pods	---	---	---	-----
11	Total Percentage of pod losses.	9.65	11.43	8.92	10.0
12	Digging Efficiency, (%)	90.35	88.57	91.08	90.0

Table 3: Observations of pod losses and digging efficiency for tractor drawn groundnut digger shaker

Sr. No.	Particulars	Groundnut Digger Shaker
1	Damaged Pods (%)	2.29
2	Exposed Pods (%)	5.04
3	Buried pods (%)	2.67
4	Undug Pods (%)	---
5	Total Pod Losses (%)	10.00
6	Digging Efficiency (%)	90.00



Fig. 1: Existing Tractor Drawn Groundnut Digger with Depth Control Wheels



Fig. 2: Gear box assembly with cranks



Fig. 3: Back view of tractor drawn ground nut digger shaker

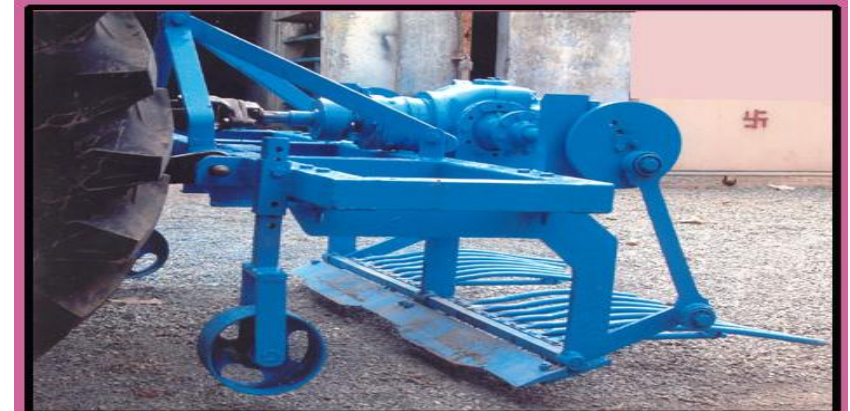


Fig. 4: Side view of tractor drawn ground nut digger shaker

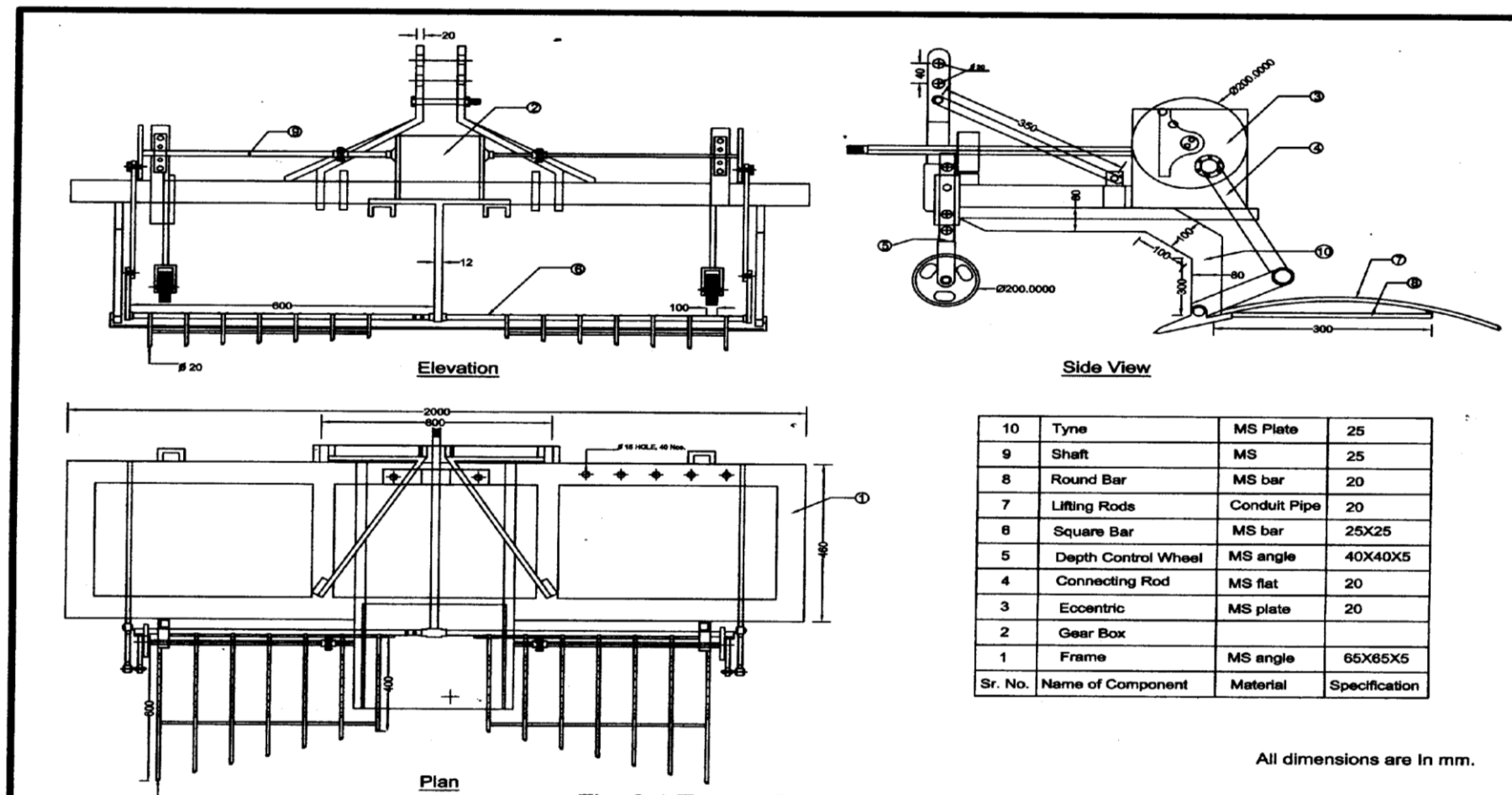


Figure 5 : Tractor drawn ground nut digger with shaking attachment

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