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Development and evaluation of petrol operated digger for subsoil fertilizer application for horticulture crops

■ **S.L. RATHOD AND D.J. SHRINIVASA**

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See end of the Paper for authors' affiliation

Correspondence to :

S.L. RATHOD
Padmashree Dr. D.Y.Patil College of Agricultural Engineering, Talsande, KOLHAPUR (M.S.) INDIA
Email : shriniv70@gmail. com

■ **ABSTRACT :** Farming is an important feature of our way of life. The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way. As long as agriculture remains a soil-based industry, major increases in productivity are unlikely to be attained without ensuring that plants have an adequate and balanced supply of nutrients. To achieve healthy growth and optimal yield levels, nutrients must be available not only in the correct quantity and proportion, but also in usable form at the right place in the soil. Hence, subsurface application of fertilizers at varying depth is the need of time so that nutrients will be placed at the different depth in subsoil to provide adequate amounts of minerals at the different growth stage of the plant, therefore, problem of leaching is avoided. Hence, a mechanical digger (petrol operated) was developed and evaluated under coconut, banana and sapota plants for subsoil fertilizer application. The results obtained were digging capacity at 25 to 30 cm depth, minimum fuel consumption and digging cost incurred were 450 holes/h, 0.520 l/h and Rs. 105/h, respectively.

■ **KEY WORDS :** Digger, Digging, Fertilizer application, Subsoil application

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Farm mechanization has always played vital role in Indian economy because of the great reduction of laborious work in agriculture sector. The mechanization of Indian agriculture has proceeded along the time tested two prolonged approach based on improved equipment and enhanced power supply. Agricultural mechanization helps in production, productivity and profitability in agriculture by achieving timeless farm operations, reducing unit cost of produce, enhancing profitability and competitiveness.With increasing concern for fuel conservation and energy management, farmers might wish to estimate the amount of fuel required to perform specific farming operations. By knowing the amount of fuel used, farmers can select best conservation practices to manage farm equipment. Farming is an important feature of our way of life. The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way. Declining soil fertility and mismanagement of plant nutrients have made this task more difficult.The higher the yield, the greater is the nutrient requirement (Prasad, 2008). A shortage of one or more nutrients can inhibit plant growth. Effective and efficient management of the soil storehouse by the farmer is thus essential for maintaining soil fertility and sustaining high yields.To achieve healthy growth and optimal yield levels, nutrients must be available not only in the correct quantity and proportion, but in a usable form and at the right time. Hence, subsurface application of fertilizers at varying depth is the need of time. Sustainable agricultural production incorporates the idea that natural resources should be used to generate increased output and incomes, especially for low-income groups, without depleting the natural resource base. Balanced application of appropriate fertilizers is a major component. Fertilizers need to be applied at the level required for optimal crop growth based on crop requirements and agro climatic considerations. At the same time, negative externalities should be minimized.Fertilizer application to many horticultural crops have been arbitrary and often erratic. A fertilizer also influences the physiology of plant and thereby determines the composition of fruits and vegetable produce and the resistance of these plants to environmental stress. Horticultural crops contribute to national income by sharing almost one fifth of the total income from agricultural produce. It is widely recommended that horticultural crops can play a vital role in competing problems of malnutrition, generating greater employment potential in rural areas and bringing nutritional security. Smaling (1993) concluded that simplified version of nutrient cycle of plant growth has two parts: “inputs” that add plant nutrients to the soil and “outputs” that export them from the soil largely in the form of agricultural products.

Justification of proposed study :

Fertilizers, as source of plant nutrients, have major role in enhancing productivity and production of field crops.It is proved that, crop does not get required amount of fertilizer dose throughout the growing period and situation is worst in Indian condition causing the low productivity. Hence, design of such machine is need of time for the countries of high population such as India. Black (1968) concluded that volatilization of ammonia into the atmosphere due to surface fertilizer application can account for a large share of the lost nitrogen. This machine will give the right amount of placement of fertilizer and integrated irrigation technology will help in making layer of fertilizer causing increase in nutrient base around the crop with all the depth in sufficient amount. This technology will help to minute problems happening to the crop such as pest, draught, etc. due to increase in biological strength of the plant. The machine is designed to provide the appropriate technology of fertilizer placement at the different depth in subsoil to provide adequate amounts for minerals at the different growth stages of the plant. The present study was undertaken to design and fabricate the petrol operated digger, to apply the solid fertilizers at variable and appropriate root zone depth of plant crop, to give the best root management practices for the plant crops. The efficient utilization of machines and equipment in farming system will not only economize the energy, but also direct interest to the farmer in producing higher economic returns from the field crop. Neller and Hutton (1957) stated that to replenish the removal and to supply sufficient amount of nutrients at each stage of crop growth, adequate rates are needed in the fertilizer application programme of horticultural crops. Smaling and Braun (1996) and Sweeney *et al.* (1996) reported that over application of fertilizers was inexpensive for some farmers in developed countries, induces neither substantially greater crop nutrient uptake nor significantly higher yields. Kulbhusha and Amit (2005) concluded that organic manures such as animal and green manures also aid soil conservation by improving soil structure and replenishing secondary nutrients and micro nutrients. Prasad (2008) analyzed that better timing, and fertilizers, nutrient uptake efficiency can be expected to improve by as much as 30 per cent in the developed world and 20 per cent in developing countries by the year 2020. Kulbhusha and Amit (2005) concluded that recorded drilling times may show significant variations from one well to another even for the same total drilling depth, in the same field. Apart from the formation properties, drilling engineers’ technical ability plays a significant role in required drilling time. Hence, the present study was carried out with the following objectives,

– To design and fabricate the petrol operated digger.

– To apply the solid fertilizers at variable and appropriate root zone depth of plant crop.

■ METHODOLOGY

Design considerations :

Following factors were considered for designing the petrol operated digger,

– Engine power
– Depth and diameter of the earth hole to be drilled
– Material of the blades used

– Angle provided to the blade of the auger
– Weight of the machine

Components of petrol operated digger and their functions :

Engine:

The petrol operated engine was used for the machine. It was the main driving agent of the machine. It gives rotational drive to the auger body. Low weight engine for handy operation was taken for the experiment (Fig. A).

Frame with handle:

Frame and handle assembly was designed keeping in the mind the design of the engine body. The frame is the backbone of the machine. The frame gives space for attaching the different components of the machine. Handle is the part of the machine by which we can operate the machine. On the handle the accelerator is provided and it is connected to the engine assembly (Fig. B).

Auger:

Auger is the main soil penetrating and rotating component of the machine. It has the screw shape structure for better penetration in the soil. It cuts the soil profile and throws the soil out of the hole (Fig. C and Fig. D).

Earth blade:

Earth blade is the hard blade connected on the periphery of the auger and at the upper position to the penetrating blade. It continuously cut the soil as it rotates and makes the hole in the earth.

Fig. A : **Petrol engine**

Fig. B : **Frame with handle**

Fig. C : **Auger of 100 mm diameter**

Fig. D : **Auger of 70 mm diameter**

Penetrating knife:

It is the triangular knife like part attached to the tip of the auger. It is the first penetrating part of the auger body. It creates the small hole in the soil before the earth blade penetrates in the soil.

Experimental details :

A Field experiment wascarried out to evaluate the performance of petrol operated digger in respect of each of its independent units. The testing was carried out for three types of plants *i.e.* coconut, banana and sapota plants grown on the Padmashree Dr. D. Y. Patil College of Agricultural Engineering and Technology, Talsande farm having different soil moisture conditions. The soil moisture content and bulk density were calculated. Various instrument, materials and equipment which were needed for the testing were petrol operated digger, measuring cylinder, measuring tape, digital stop watch, core soil sampler, soil sample containers, weighting balance, electronic oven, tool box.

Working and testing of the machine :

This petrol operated digger was working on the principle of impact force on the rotating auger. The machine was attached with auger having rotary motion. It was getting penetrated into the soil while rotating because of the angle provided to the blades and sharpness of the cutting edge. The variable diameter augers were provided for making earth holes of different dimensions. The machine was tested for three different types of orchard crops, those are coconut (Fig. F), banana and sapota (Fig. E) for their fertilizer management practice in the subsoil. Two different types of auger with 100 mm and 70 mm diameter were used for testing on different crop root zone. The time required for making holes and fuel consumption was also calculated.

Fig. E : Digging by the machine around the Sapota plant

Fig. F : Digging by machine around the Coconut plant

RESULTS AND DISCUSSION

The digging operation was done for the purpose of fertilizer application operation in sub soil and following observations were taken. The depth of the whole and distance of the whole from plant was taken by studying the root system of the crop.

It was observed from the Table 1 that, the depth of the hole, diameter of the hole, distance of the hole from the plant and the time required to drill one hole around the plant with 100 mm diameter auger were 25 cm, 14.67 cm, 46.17 cm and 15 seconds for coconut and 23.5 cm, 14.67 cm, 28.67 cm and 13.33 seconds for banana and 21.5 cm, 13.5 cm, 55 cm, 14.83 seconds for sapota plant, respectively. From the Table 2, the depth of the hole, diameter of the hole, distance of the hole from the plant and the time required to drill one hole around the plant with 70 mm diameter auger were observed to be 27.83 cm, 11.5 cm, 41 cm and 8.67 seconds for coconut and 29.67 cm, 11.17 cm, 41.33 cm and 9.33 seconds for banana and 25.5 cm, 11 cm, 51.5 cm, 10.67 seconds for sapota plant, respectively.

From the results, it is clear that the diameters of holes were larger than the diameter of auger for both 100 mm and 70 mm diameter digger auger. The reason behind this may be inability of operator to hold digger vertically due to vibration occurred during digging. It was observed from Table 3 that the variable cost of digging operation was averaged to be Rs. 60/h. The cost of digger alone per hour is assumed to be Rs. 45/h. Therefore, the total digging operation cost was Rs. 105/

Table 1 : The parameter recorded for the digging of holes using 100 mm diameter auger around the coconut, banana and sapota plant during fertilizer placement

Sr. No.	Plant No.	Depth of hole (cm)	Diameter of hole (cm)	Time required/hole (second)	Distance of the hole from the plant (cm)
1.	C_1	26	15	15	45
		23	14	14	43
2.	C_2	27	15	17	50
		25	15	13	42
3.	C_3	25	16	16	45
		26	13	15	52
	Average	25	14.67	15	46.17
4.	B_1	25	17	14	30
		20	14	12	32
5.	B_2	22	13	13	30
		24	15	12	27
6.	B_3	24	14	14	25
		26	15	15	28
	Average	23.5	14.67	13.33	28.67
7.	S_1	20	13	14	50
		24	14	16	55
8.	S_2	18	13	17	57
		23	15	13	60
9.	S_3	21	12	14	55
		23	14	15	53
	Average	21.5	13.5	14.83	55

Note: C_1, C_2, C_3, B_1, B_2, B_3 and S_1, S_2, S_3 are coconut, banana and sapota plants, respectively.

Table 2 : The parameter recorded for the digging of holes using 70 mm diameter auger around the coconut and banana plant for fertilizer placement

Sr. No.	Plant No.	Depth of hole (cm)	Diameter of hole (cm)	Time required /hole (second)	Distance of the hole from the plant (cm)
1.	C_1	28	13	9	42
		27	11	8	41
2.	C_2	30	10	10	43
		28	12	8	39
3.	C_3	28	12	9	40
		26	11	8	41
	Average	27.83	11.5	8.67	41
4.	B_1	30	10	10	42
		28	11	9	40
5.	B_2	32	12	11	43
		28	10	8	41
6.	B_3	29	11	8	42
		31	13	10	40
	Average	29.67	11.17	9.33	41.33
7.	S_1	24	11	10	52
		25	10	11	51
8.	S_2	26	11	10	53
		27	12	12	50
9.	S_3	26	10	11	52
		25	12	10	51
	Average	25.5	11	10.67	51.5

Note: C_1, C_2, C_3, B_1, B_2, B_3 and S_1, S_2, S_3 are coconut, banana and sapota plants, respectively.

Table 3 : Variable cost of digging operation for coconut, banana and sapota plants

Sr. No.	Name of plant	Fuel consumption (l/hr)	Fuel price (Rs./l)	No. of holes/hr	Operator cost (Rs./h)	Digging cost (Rs./h)
1.	Banana	0.450	68	420	25	53.9
2.	Sapota	0.570	68	480	25	63.76
3.	Coconut	0.540	68	450	25	61.72
Average		0.520	68	450	25	59.79

h. As compared to traditional (manual) method of digging, it is far better to use this digger as digging process is faster, requires less cost/hole for placement of fertilizer and manure in the hole made around the tree plants.

Summery and Conclusion :

The fuel (petrol) operated digger was developed and was evaluated to test its affordability under horticultural crops (particularly for coconut, banana and sapota plants) for subsoil fertilizer application. From the results, those found were, the fuel consumption of 0.520 l/h, maximum digs/h of 450 at 25 to 30 cm depth and digging operation cost of Rs. 105/h.Hence, this petrol operated digger will help in placing the organic and inorganic fertilizers in subsoil for proper management of nutrients in the effective root zone depth of the soil.It will reduce per ha fertilizer requirement of the crops in large extent. Also, it is possible to place the fertilizer in variable depths in the root zone helping the plant growth vigorously at its different stages of growing.

As a further study, there is a need to be carried out evaluation of the petrol operated digger ergonomically and intervention of need to be placed to have safe vibration range to be experienced by the operator.

Authors' affiliations:

D.J. SHRINIVASA, Padmashree Dr. D.Y.Patil College of Agricultural Engineering, Talsande, KOLHAPUR (M.S.) INDIA

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