SOIL AND CROP PARAMETERS RELATED TO THE DESIGN OF A POWER TILLER-OPERATED GROUNDNUT DIGGER

Abstract

Groundnut (*Arachis hypogea* L.) is a major oilseed crop and holds an important place in the Indian agricultural economy. Odisha occupies 6th place in the major groundnut-producing states of the country with a total production of 0.388 MT and is grown in both Kharif and Rabi seasons. Harvesting is one of the major unit operations in groundnut cultivation and is mechanically harvested bytractor-operated diggers but their use is limited because of small land holdings and high capital costs and is not economical for small and marginal farmers of the state. However, the groundnut diggers to match with power tillers are not commercially available; therefore, efforts were made to develop a single-row groundnut digger operated by a power tiller.Thestudy was conducted to relate the soil and crop parametersfor thedigger design, which influences the harvesting of groundnut.The design of a power tiller-operated groundnut digger to harvest a single row of groundnut requires the data of soil parameters (soil type, bulk density, cone index and soil moisture content) and crop parameters (plant population, plant height, pod zone, pod spreading radius, taproot length, taproot diameter, pod-vine ratio), suitable for different groundnut varieties. It was found that the majority of groundnut of varieties were grown in sandy soils and harvested at 12-15 % soil moisture, 5.68-7.97 kg/cm^2 cone index and 1.52 g/cm^{3}bulk density for more yield with a minimum power requirement.It was observed that for all types of groundnut varieties the plant population, plant height, pod zone, pod spreading radius, taproot length, taproot diameterandthenumber of pods per plant varies from 24-29/m^2, 31-49.18 cm, 5.79-6.86 cm, 11.74-16.30 cm, 11.70-13.78 cm, 4.64-5.84 cm and 11-27/plant, respectively.

1. Introduction-

Groundnut or peanut is popularly known as the poor man's nut. India is the second-largest producer of groundnuts in the world after China. In India, groundnut is grown over 4.89 million hectares with a total production of 10.1 million tons and productivity of 2065 kg/ha [2]. It is mainly grown because of its high protein (25–32%), oil (42–52%) and carbohydrate contents [1].

Groundnut is a tropical crop, which requires a long and warm growing season. The most favourable climatic conditions for groundnut are a well-distributed rainfall of 650-1000 mm during the growing season, an abundance of sunshine and relatively warm temperatures. The minimum and maximum temperature requirements of groundnut are not well established but it germinates more

quickly within a range of 20-35 □C with optimum temperature between 30-33□C for most rapid germination and seedling development [10]. Low temperature at sowing delays germination and increases seeds and seedling diseases [11].

Groundnut thrives best in well-drained sandy and sandy loam soils, as light soil helps in easy penetration of pegs and their development and also for harvesting [6]. Groundnut gives good yields in the soil with a pH between 6.0–6.5 [10]. Various studies have shown that the optimum depth of groundnut planting is 4-5 cm [11]and the pods penetrate an up-to-the depth of 4-7cm [10]during maturity, though it is usually affected by the parameters like type of soil, compaction of soil and moisture content. Hence, it is necessary to uproot the main root of the plant below the depth of pod development and at the same time, all pods should be brought up along with the vines onto the soil surface.

The major unit operation in groundnut cultivation is seedbed preparation, sowing, fertilizer application, plant protection, irrigation, harvesting and threshing. Harvesting is one of the major operations which accounts for23% of the total cultivation cost [9]. The prevalent methods of groundnut harvesting are manual uprooting using hand tools or using diggers powered by animals, power tillers, tractors, etc. The manual digging of groundnut requires 240–250 man-h/haand is labour intensive, time-consuming and less economical. Though animal power-based harvesting system is more useful than manual methods, it still involves higher cultivation costs that can be reduced by using mechanical powered diggers. To realize these, groundnut harvesters were developed as an attachment to tractors and power tillers.

Tractor-operated groundnut harvesters have been developed by many researchers and manufacturers and are available in the market. Though tractor-operated diggers are commercially available, their use is limited because of small land holdings and high capital cost, tractor operated diggers are not economical for small and marginal farmers. Very few research works have been carried out on the design and development of power tiller operated groundnut diggers and they are neither popular nor commercially available. Due to the high cost of harvesting operation, there is a need for a suitable groundnut digger that can fulfill the requirements of small and marginal farmers, reduce the cost of operation, and drudgery and ensure timeliness of operation. The main objective of this study is to determine and understand the soil and crop parameters which influences the harvesting of groundnut and should consider while designing the groundnut digger.

2. Materials and Methods

The present study was conducted at Barpali, Bargarh district (western part)and Bhubaneswar, Khordadistrict (Coastal part) of Odisha. For better understanding, two different regions of Odisha were selected to determine the soil and crop parameters of commonly grown groundnut varieties in that part of the state.The study was conducted to correlate the soil and crop parameters with the design of the machine. Development of a power tiller operated groundnut digger to harvest a singlerow of groundnut requires the data of soil parameters (soil type, bulk density, cone index and soil moisture content) and crop parameters (variety, plant population, plant height, pod zone, pod spreading radius, taproot length, taproot diameter, pod to vine ratio). So, the present study was undertaken todetermine the soil and crop parameters for designing the power tiller operatedgroundnut digger.

The crop parameters of the AK-12-24 and Barapatria groundnut varieties were obtained from the Bargarh (western part) of Odisha, while the crop parameters of the Kalinga-101, IVT-VG-1 Devi, Dharni, and Malika groundnut varieties were obtained from the AICRP on Groundnut in Bhubaneswar, Khorda (Coastal part) of Odisha.

2.1 Soil parameter

The soil parameters influencing the harvesting of groundnut crops were identified and measured as shown in Fig.1. The soil properties related to the design of the digging unit for the groundnut digger were identified as soil type, soil moisture content, cone index and bulk density. The methods of measurement and characterization of these properties are explained under the following headings.

2.1.1 Soil type

The draft requirement and the maximum penetration depth of the tool depends on the soil type. The experiments were conducted in the experimental field of CAET, OUAT, and Bhubaneswar, having a clay loam soil and AICRP on groundnut farm, OUAT, Bhubaneswar, having a red sandy soil textural composition. The groundnut is grown majorly on sandy soil. However, in some places, it is cultivated on heavy soil. Hence, these two types of soil were selected in the study. The groundnut crop is primarily grown in sandy soil, since light soil facilitates easy penetration of pegs and their development and favors easy harvesting as a result of lesser resistance.

2.1.2 Soil moisture content

Soil moisture plays a vital role in the growth and development of groundnut [4, 11]. The soil moisture content tends to significantly impact the draft of the implement and slip [5,7]. Groundnut is generally harvested at optimum soil moisture content in order to minimize field losses and enhance the

efficiency of energy input. The moisture content of the soil was measured at different locations on the field using a digital soil moisture meter and by taking the samples from different locations and measured by oven drying method as shown in Fig. 1 (a) and (b). Experiments were conducted at three different moisture levels viz. one after irrigating the field three days before harvest, the other after irrigating the field six days before harvest and the third one after irrigating the field twelve days before harvest of the crop. The moisture content of the soil was calculated by using following formula,

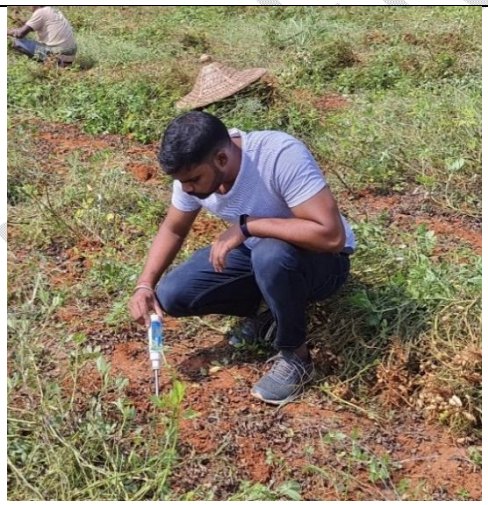
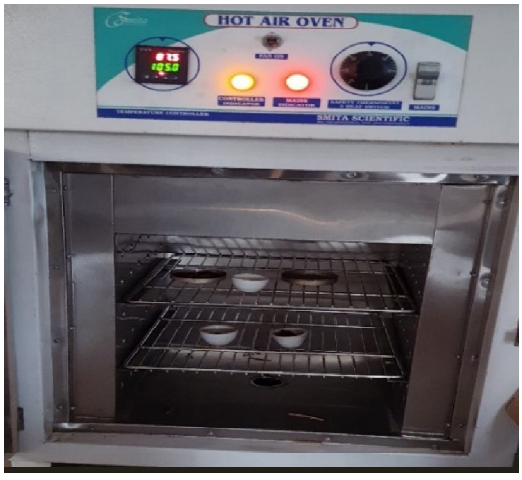
$$\text{Moisture content, wb, (\%)} = \frac{\text{Change in weight of smaple after drying}}{\text{Initial weight of sample}} \times 100 \quad \ldots(1.1)$$

2.1.3 Bulk density of soil

Bulk density of the soil is a measure of compaction of the soil condition influencing the tool parameters, draft and groundnut development[8]. The volume of undisturbed soil core from the field during harvest was taken at six different places selected at random and the mass per unit volume was calculated using the core sampler method (Fig. 1 (c)) and the mean value was calculated.

2.1.4Cone Index

The cone index is a measure of penetration resistance of the soil, which is useful in the calculation of motion resistance and power required by the power tiller with a digger to propel itself without generating any drawbar pull. Hence it was measured at aup to the depth of 100 mm to define the soil condition. The cone index of the soil or the penetration resistance of the soil was measured by using a Vicksburg cone penetrometer (Fig. 1 (d)) at ten different places selected at random during harvest at all the moisture levels and the mean values in each level were calculated.

	
(a) Soil moisture using soil moisture	**(b) Soil moisture using hot air oven in**

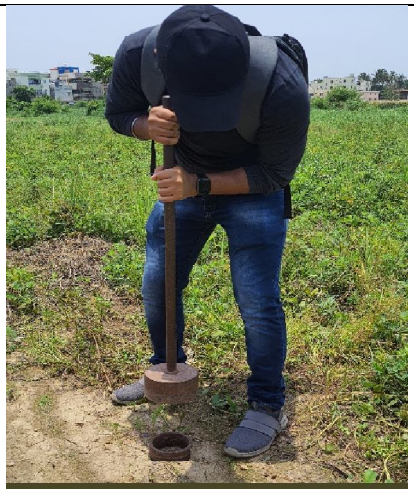
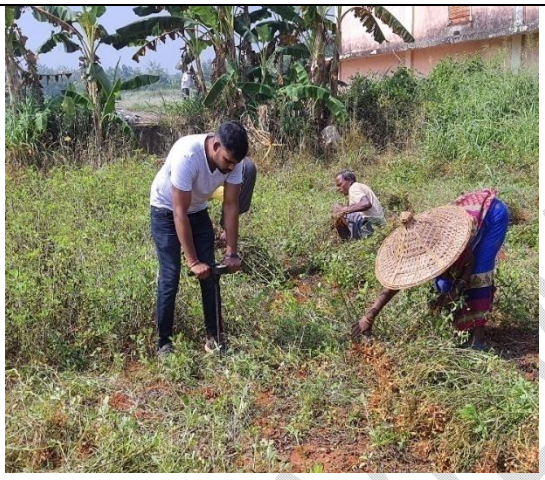
meter in the field	the laboratory
	
(c) Bulk density using core cutter	**(d) Cone index using cone penetrometer**

Fig. 1 Measurement of soil parameters

2.2 Crop parameters

The crop parameters which influence the groundnut harvesting were considered as variety, plant population (R-R spacing and P-P spacing), plant height, pod zone, pod spreading radius, number of pods per plant, taproot length&taproot diameter, total weight of the plant (Fig. 2). These parameters are discussed in the following sub-sections.

2.2.1 Variety

Crop variety is an important parameter, which influences mechanical digging since the growth factor and foliage vary for each variety. Therefore, different varieties (Fig. 2 (a)) of groundnut crop were selected for the study which is generally grown in this region.

2.2.2 Plant population

The plant population (R-R spacing and P-P spacing) is a measure of the number of plants in a specific area. It was measured by taking the average value of the number of plants available in a one-meter square area at different locations as shown in Fig. 2 (b).The row to row spacing (Fig. 2 (c)) of groundnut is an important parameter for deciding the working width of the digger i.e., the width of the blade. The plant population of the crop is used in determining the volume of the crop handled by the

machine per unit width of the tool per unit time and speed. This helps in the calculation of power requirements by the conveying unit of the digger.

2.2.3 Plant height

The plant height of the crop varies from variety to variety, the season of sowing the crop and also spacing provided for the plant to plant and the climatic conditions. The plant height of the vines above the ground surface is important to decide the height of the shank and clearance between tool, frame and conveyor parameters. The height of the vines above the ground surface was measured for ten different plants selected at random for different varieties using a scale (Fig. 2 (d)) and the mean value was calculated.

2.2.4 Pod zone

The depth of the pods below the soil surface is a measure of the tool to penetrate just below the depth of the pods for digging the plant without damage. The pod depth of ten plants selected at random of different varieties was measured using a scale by digging the soil adjacent to the plant (Fig. 2 (e)). The data was tabulated and the mean value was calculated.

2.2.5 Pod spreading radius

The pod spreading radius is the spreading pattern of pods on either side of the taproot. The spreading radius is important for deciding the working width of the blade to cover the entire spreading pod without any pod damage and losses. The pod spreading radius of ten plants selected at random of different varieties was measured using a scale by digging the soil adjacent to the plant on both sides as shown in Fig. 2 (f). The data was tabulated and the mean value was calculated.

2.2.6 Number of pods per plant

The number of pods per plant is an important parameter in the determination of digging efficiency and percentage of pod damage. Ten Numbers of plants from the field were selected randomly and the number of pods per plant is counted and mean values were calculated.

2.2.7Taproot length and diameters

The digging of groundnut is coupled with either cutting or pulling by diggers and the conventional method of harvesting. The length and diameter of the taproot of the crop were measured to ascertain the nature and condition of the roots to resist the cutting or pulling force. The length of the taproot was measured by measuring scale and diameter was measured by the Vernier Caliper (Fig. 2 (g) and (h)) and the mean values were calculated.

2.2.8 Total weight of the plant

The plant's total weights considered to determine the weight of material handled by the conveyor during operation and was useful in the calculation of power required by the conveyor for material handling. One groundnut plant of the Devi variety was selected at random in the field along with pods. The weight of the plant was determined using an electronic balance(Fig. 2 (i) and (j)). The experiment was repeated for nine more plants of the same variety and the mean values were recorded.

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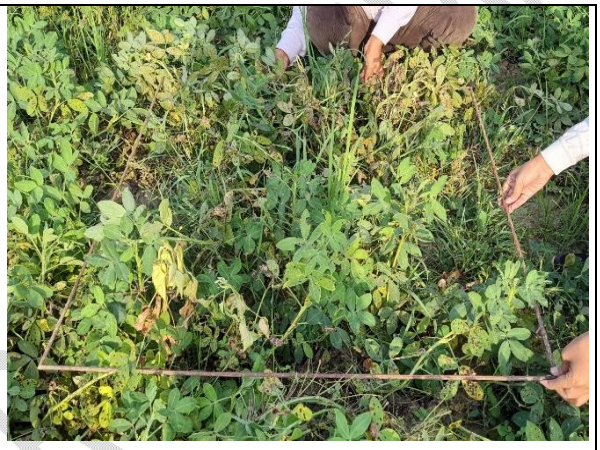
<tr><td>  </td><td>  </td></tr>
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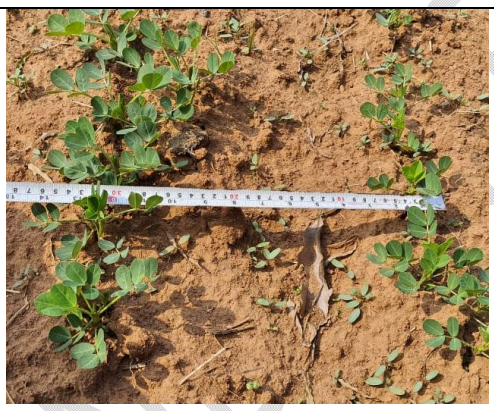
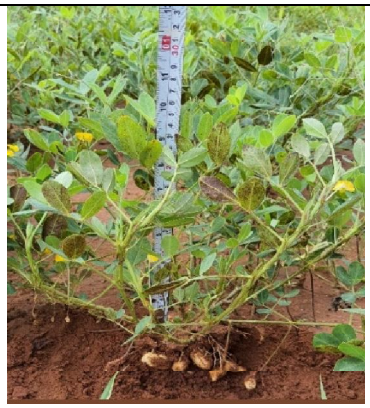
<tr><td>  </td><td>  </td></tr>
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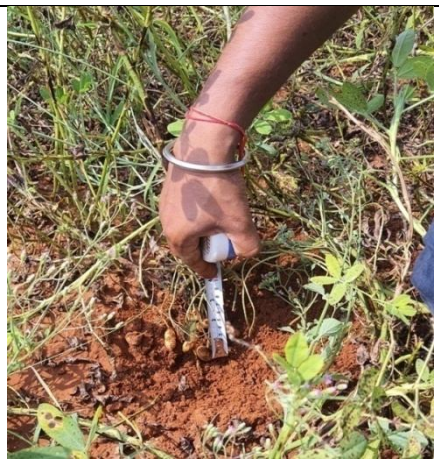
<tr><td>  </td><td>  </td></tr>
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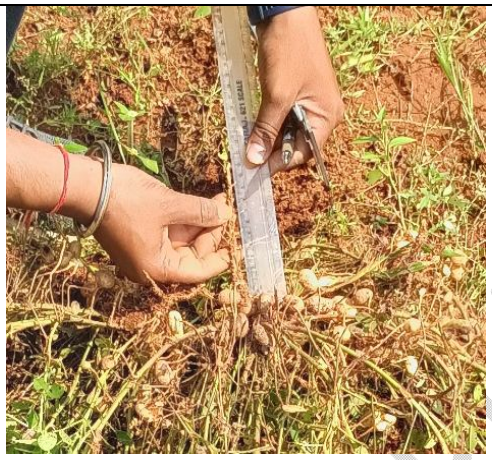
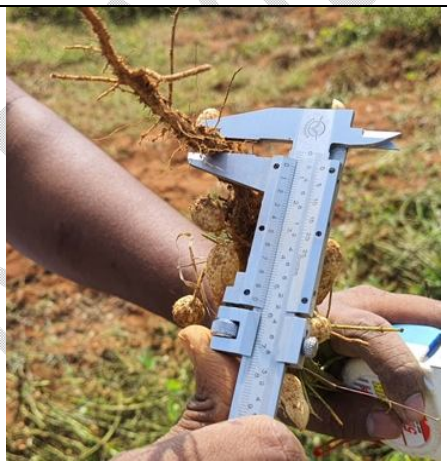
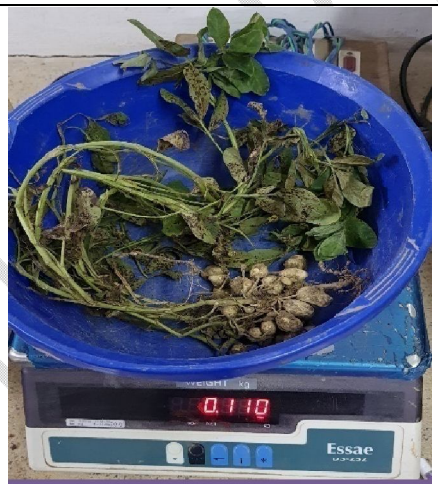
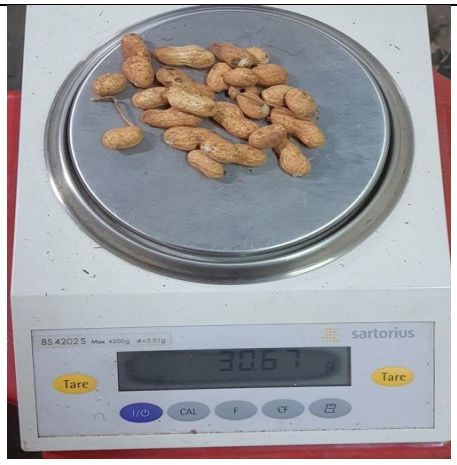
<tr><td>  </td><td>  </td></tr>
<tr><td>(g) Taproot length</td><td>(h)Taproot diameter</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>(i) Total weight of plant</td><td>(j) Wight of pod</td></tr>
<tr><td colspan="2">Fig. 2 Measurement of different crop parameters</td></tr>
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3. Results and discussion

3.1Effect of growing season on crop parameters

About 90% of the groundnut in India is sown in the Kharif season under rain fed conditions but the yield is low because of more vegetation growth, high weed infestation and more susceptibility to insects, pests and disease. Groundnut is raised in rabi season on a limited scale in areas where winter is not severe and night temperatures do not go below 15°C. This crop is usually raised in a rice fallow situation to utilize the residual moisture after the harvest of rice. Groundnut needs good sunshine and high temperature to produce more pods. Summer, is therefore the ideal season for groundnut cultivation wherever irrigation facilities are available and the soil is suitable. Some crop parameters of different varieties are given in Table-1 and Table-2.

Table-1 Crop parameters measured during the Kharif season

Sl. No.	Parameters	AK-12-24	Barapatria	Kalinga - 101	IVT-VG-1
1.	Plant height, cm	47.16	49.18	39.40	31.60
2.	Row to row spacing, cm	28.70	29.30	30.00	30.00
3.	Plant population/ m^2	28	27	29	27
4.	Pod zone, cm	6.70	6.86	6.7	6.58
5.	Number of pods/plants	11	16	15	19
6.	Pod spreading radius, cm	5.97	6.66	9.15	7.92
7.	Taproot length, cm	11.70	11.78	13.50	11.86
8.	Taproot diameter, mm	5.12	5.84	5.62	5.26
9.	Total weight of the plant, gm	113.54	70.40	91.38	88.84

Table-2 Crop parameters measured during the Rabi/Summer season

Sl. No.	Parameters	Devi	Dharni	Mallika
1.	Plant height, cm	47.60	36.40	31.40
2.	Row to row spacing, cm	27.00	25.00	25.00

3.	Plant population/ m^2	24	27	24
4.	Pod zone, cm	5.90	6.86	5.79
5.	Number of pods/plants	27	21	19
6.	Pod spreading radius, cm	5.87	6.36	7.15
7.	Taproot length, cm	12.30	13.78	13.50
8.	Taproot diameter, mm	4.89	4.64	5.17
9.	Total weight of the plant, gm	103.54	68.40	87.48

The study results indicated that Kharif season growing varieties have high vegetation growth compared to Summer/Rabi season growing varieties. The number of pods per plant was less and the yield was less in the Kharif season.

At the maturity stage of groundnut, the root development of different plants was observed and recorded. The study findings show that for all groundnut varieties the pod spread was 5.87 to 9.15 cm and the maximum pods were lies within the 7 cm depth.The taproot length and diameters varied from one stage to another stage during the process of pod formation and also varies by variety and the type of soil used to grow the groundnut. The results show that the taproot length and diameter at the time of harvest for both cropping seasons varied from 11.70 to 13.78 cm and 4.64 to 5.84 cm.

The plant population results indicated that the average number of plants was 30 at the starting stage up to 30 days and later on the count of plants per meter square area has decreased due to environmental conditions[3]and the number of plants during harvest varied from 24 to 29 for both growing seasons.

The study showed that the number of pods per plant varies among varieties. The experimental results revealed that an average number of pods per plant at the time of harvest for the Kharif season was recorded as 11, 16, 15 and 19 for AK-12-24, Barapataria, Kalinga-101 and IVT-VG-1, respectively. The average number of pods per plant at the time of harvest for the Summer/Rabi season was recorded as 27, 21and 19 for Devi, Dharni and Malika varieties, respectively. The number of pods includes filled pods. The differences in the number of pods among the varieties could be attributed to genotypic differences and their response to adverse environmental effects. **Virk*et al.*** [12]reported that groundnut varieties differ significantly in the number of pods per plant. The results of the study also

indicated that Kharif season growing varieties have a smaller number of pods per plant was and the yield was also less this was due to the Kharif season growing varieties having high vegetation growth compared to Summer/Rabi season crops and are more susceptible to insects, pests, and diseases.

3.2 Effect of soil type on soil parameters

Table 3 shows the values of soil parameters for two different soil types. From Table3 it is seen that the mean soil moisture of clay loam at the time of harvest was 16.47, 10.78 and 7.30 per cent respectively after irrigating the field 3, 6 and 12 days prior to harvest. In sandy loam.the corresponding soil moisture levels were 15.10, 9.18 and 6.35 per cent respectively, after irrigating the field 2. 5 and 10 days prior to harvest. It appears that there was an appreciable difference between the moisture content of the above two soils under identical situations. The corresponding soil bulk densities for clay loam are 1.40, 1.45 and 1.51 and for sandy loam 1.37, 1.43 and 1.47, respectively. It is also found that soil bulk density and cone index is influenced by soil moisture content and decreased as the soil moisture increases this was due to the decrease in soil moisture increases the soil strength. The maximum value of cone index was 5.68 kg/cm^2 for clay loam soil at 7.30 per cent soil moisture.

Table3 The measured soil parameters

Sl. No.	**Soil Parameters**	**Bargarh**			**AICRP on Groundnut, OUAT Farm**		
1.	Soil type	Clay loam			Sandy loam		
2.	Soil moisture content (%)	Irrigated three days prior to harvest	Irrigated six days prior to harvest	Irrigated twelve days prior to harvest	Irrigated three days prior to harvest	Irrigated six days prior to harvest	Irrigated twelve days prior to harvest
		13.81	10.84	7.43	13.12	9.18	7.31
3.	Bulk density(g/cm^3)	1.40	1.45	1.51	1.37	1.43	1.47

4.	Cone index (kg/cm^2)	3.47	6.35	10.06	2.77	5.38	7.47

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