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Analysis of Soil and Crop Parameters for the Development of Power Tiller-Operated Groundnut Digger

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 by tractor-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. The study was

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conducted to relate the soil and crop parameters for the digger 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 varieties were grown in sandy soils and harvested at 12-15 % soil moisture 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 depth, pod spreading radius, taproot length, taproot diameter and the number of pods per plant varies from 24-29/m^2, 31-49.18 cm, 5.79-6.86 cm, 5.87-9.15 cm, 11.70-13.78 cm, 4.64-5.84 cm and 11-27/plant, respectively.

*Keywords: Groundnut (*Arachis hypogea *L.); crop parameters; pod spreading.*

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 [1]. It is mainly grown because of its high protein (25–32%), oil (42–52%) and carbohydrate contents [2].

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 ^{0}C with optimum temperature between 30-33^{0}C for most rapid germination and seedling development [3]. Low temperature at sowing delays germination and increases seeds and seedling diseases [4].

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 [5]. Groundnut gives good yields in the soil with a pH between 6.0–6.5 [3]. Various studies have shown that the optimum depth of groundnut planting is 4-5 cm [4] and the pods penetrate an up-to-the depth of 4-7cm [3] 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 for 23% of the total cultivation cost [6]. 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/ha and 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

2.1 Soil Parameter

The soil parameters viz. soil type, soil moisture content, cone index and bulk density affected groundnut harvesting were identified and measured as shown in Fig. 1. The methods of measurement of these parameters are discussed below.

2.1.1 Soil type

The groundnut crop is grown in two different fields to study the performance of the power tiller operated groundnut digger. The experiments have been conducted in the experimental field of CAET and experimental field of AICRP on groundnut. The mechanical analysis of the soil from both the experimental field was conducted before sowing to determine its sand, silt and clay composition.

2.1.2 Soil moisture content

Soil moisture content plays a vital role in the growth and development of groundnut [7,4]. The soil moisture content tends to significantly affect the digging efficiency, pod losses, draft requirement of the implement [8,9]. Moisture content of the soil were measured at ten different locations in the experimental field using a digital soil moisture meter. Experiments were conducted at three different moisture levels viz. harvesting of groundnut crop after three, six & twelve and five, nine & fourteen days of irrigation in the experimental field of AICRP on groundnut and experimental field of CAET (Fig. 1(a)).

2.1.3 Bulk density of soil

Bulk density of the soil influences the tool parameters and draft requirement [10]. Prior to tilling both experimental fields, undisturbed soil samples were collected from ten random locations using a core cutter and their mass per unit volume were calculated using the core sampler method (Fig. 1 (b)).

2.1.4 Cone 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. The cone index of the soil was measured at twenty different locations up to the depth of 100 mm by using a Vicksburg cone penetrometer (Fig. 1(c)) for all soil moisture levels. The mean values in each level were calculated.

2.2 Crop Parameters

The crop parameters which influence groundnut harvesting were plant height, inter row spacing, plant population, pod zone depth, pod spreading diameter, number of pods per plant, taproot length, taproot diameter and pod-vine ratio. These crop parameters were discussed in the following sub-sections (Fig. 2).

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 Inter row spacing

The inter row spacing of groundnut was relevant to decide the working width of the groundnut digger (Fig. 2 (b**)**). It was measured using a measuring tape at twenty randomly selected rows.

2.2.3 Plant height

The plant height of the crop varies from variety to variety, the season of sowing and spacing between plant to plant. Twenty plants were selected randomly and their heights were measured with a measuring tape (Fig. 2(c)) and the mean height was determined.

2.2.4 Plant population

The plant population was determined by counting the number of plants available in a one-meter square area at different locations by using the 1 m^2 frame, as shown in Fig. 2(d). The plant population was used to determine the volume of the crop handled by the digger.

2.2.5 Pod zone depth

The pod zone depth was relevant to decide the depth of operation. The pod zone depth of twenty randomly selected plants were measured using a scale by digging the soil adjacent to the plant (Fig. 2(e)). The average value of pod zone depth was determined.

2.2.6 Pod spreading radius

The pod spreading was relevant for deciding the working width of the digging blade. The pod

spreading of twenty plants selected at random was measured using a scale by digging the soil adjacent to the plant on both sides as shown in Fig. 2(f). The mean pod spreading was determined.

2.2.7 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. The number of pods per plant were counted from twenty randomly selected plants. The average value for the number of pods per plant was calculated.

2.2.8 Taproot length and diameters

The digging of groundnut is coupled with either cutting or pulling by diggers and the conventional method of harvesting. The taproot length and diameter 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.

2.2.9 Pod-vine ratio

The pod-vine ratio was determined of twenty samples, each of with pod without soil. The pods were detached manually from the plant. The total weight of plant and total weight of pods were measured and pod-vine ratio was calculated for each sample (Fig. 2(i) and (j)). Average pod-vine ratio was calculated from twenty observations.

(a) Measurement of soil moisture content in the experimental field

(b) Bulk density using core cutter

(c) Cone index using cone penetrometer

Fig. 1. Measurement of soil parameters

(a) Variety

(b) Plant height

(c) Inter row spacing

(d) Plant population

(e) Pod zone depth

(f) Pod spreading diameter

(g) Taproot length

(h) Taproot diameter

(i) Total plant weight

(j) Total pod weight

Fig. 2. Measurement of different crop parameters

3. RESULTS AND DISCUSSION

3.1 Effect of Type Soil on Soil Parameters

The mean values of soil parameters for two different soil types were shown in Table 1. The mean values of sand, silt and clay of the experimental field of CAET was observed to be 41.48, 42.20 and 16.32% respectively. The type of soil was found to be clay loam. Similarly, mean values of sand, silt and clay of the experimental field of AICRP on groundnut was found to be 74.30, 15.10 and 10.60%, respectively and soil type of the field was observed to be sandy loam.

The soil moisture content of experimental field of AICRP on groundnut was found to be 13.12, 10.24 and 7.31% (wb) after 3, 6 and 12 days of irrigation, respectively. The soil moisture content of CAET experimental field was found to be 13.81, 10.84 and 7.43% (wb) after 5, 9 and 14 days of irrigation, respectively. The different stages of harvesting the groundnut crop after irrigation in case of sandy loam soil were 3, 6 and 12 days where as to achieve the similar ranges of moisture content the duration was increased to 5, 9 and 14 days in case of clay loam soil. The reason may be due to the fact that the rate of soil moisture depletion was faster in sandy loam soil than clay loam soil. The bulk density for sandy loam soil ranged from 1.40 to 1.47 g cm^{-3} while for clay loam soil it ranged from 1.59 to 1.65 g cm^{-3}. The average bulk density for sandy loam soil and clay loam soil was 1.45 and 1.62 g cm^{-3}, respectively.

The mean soil cone index for sandy loam soil was found to be 271.06, 527.04 and 731.96 kPa at 12.0-15.0, 9.0-12.0 and 6.0-9.0%, respectively. The mean soil cone index for clay loam soil was found to be 340.45, 622.10 and 986.17 kPa at 12.0-15.0, 9.0-12.0 and 6.0-9.0%, respectively. It was found that cone index is influenced by soil moisture content and increased with the decrease in soil moisture content. This may be due to the fact that decrease in soil moisture content results in increased soil strength.

3.2 Effect of Growing Season on Crop Parameters

About 90% of the groundnut in India is sown in the Kharif season under rainfed conditions but the yield is low because of more vegetative 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 2 and Table 3.

The study results indicated that Kharif season growing varieties have high vegetative growth compared to Summer/Rabi season growing varieties. The plant height of groundnut crop ranged from 31.60 to 49.18 cm and 31.40 to 47.60 in Kharif season and Rabi/Summer season, respectively.

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 [11] and the number of plants during harvest varied from 24 to 29 for both growing seasons.

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 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, 21 and 19 for Devi, Dharni and Malika varieties, respectively. The differences in the number of pods among the varieties could be attributed to genotypic differences and their response to adverse environmental effects. The results of the study also indicated that Kharif season growing varieties have a lesser number of pods per plant and the yield was also less. This may be due to the fact that the Kharif season growing varieties have high vegetative growth compared to Summer/Rabi season crops and are more susceptible to insects, pests, and diseases.

Table 1. The measured soil parameters

Sl. No.	Soil parameters	Experimental field of CAET			Experimental field of AICRP on groundnut		
1.	Soil type	Clay loam			Sandy loam		
2.	Soil moisture content (%)	Three days	Six days	Twelve days	Five days	Nine days	Fourteen days
		13.81	10.84	7.43	13.12	10.24	7.31
3.	Bulk density (g/cm^3)	1.59-1.65			1.40-1.47		
4.	Cone index (kg/cm^2)	340.45	622.10	986.17	271.06	527.04	731.96

Table 2. 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 3. 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 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.

4. CONCLUSION

The analysis of soil and crop parameters is crucial for the development of power tiller-operated groundnut digger. Through this analysis, various soil and crop factors that affect the performance and efficiency of groundnut digger have been identified. By considering the various soil and crop parameters, manufacturers can design groundnut diggers that are efficient, cost-effective, and environmentally sustainable, contributing to the overall growth and development of the agricultural industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Agricultural Statistics at a Glance. Directorate of Economics and Statistics. Ministry of Agriculture, Govt. of India; 2020.
2. Abdzad GA, Noorhosseini NSA. Effects of iron and nitrogen fertilizers on yield and yield components of peanut (*Arachis hypogaea* L.) in Astaneh Ashrafiyeh, Iran. American-Eurasian J. Agric. & Environ. Sci. 2010; 9(3):256-262.
3. Singh AL. Growth and physiology of groundnut. Groundnut Research in India. 2004;6:178–212.
4. Singh F, Oswalt DL. Groundnut production practices. Skill Development Series. 1995; (3).
5. Janila P, Mula MG. Cultural management practices of groundnut. Scaling-up of improved groundnut varieties through established seed system in various cropping systems of smallholder farmers in Odisha. Monograph. ICRISAT, Patancheru, Telangana, India; 2015.
6. Seshadri CR. Groundnut published by Dr. M.S. Patel, Secretary, Hydrabad. 1962:172-203.
7. Boote KJ. Growth stages of peanut (*Arachis hypogaea* L.). Peanut Science. 1982;9:35-40.
8. Duraisamy VM. Investigation on the effect of soil, crop, machine and operational parameters in relation to mechanical harvesting of groundnut, Ph.D. thesis, Tamil Nadu Agricultural University, Coimbatore, India; 1997.
9. Manuwa S, Ademosun O. Draught and soil disturbance of model tillage tines under varying soil parameters; 2007.
10. Mouazen AM, Ramon H. A numerical–statistical hybrid modelling scheme for evaluation of draught requirements of a sub soiler cutting a sandy loam soil, as affected by moisture content, bulk density and depth. Soil and Tillage Research. 2002;63:155–165.
11. Bolaji U, Olayinka Emmanuel, Etejere O. Growth analysis and yield of two varieties of groundnut (*Arachis hypogaea* L.) as influenced by different weed control methods. Indian Journal of Plant Physiology. 2015;20(2):130-136.

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