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Research Article

ANALYTICAL STUDY OF PHYSICAL AND CHEMICAL PROPERTIES OF SOIL IN THE AGRO-ECOSYSTM OF SESAME (SESAMUM INDICUM L.) IN THE NORTH-WESTERN ARID REGION OF RAJASTHAN (INDIA)

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Soil Profile, Physical characteristics, Chemical characteristics, Texture, WHC, Apparent Density, Absolute Specific Gravity, PH, Availability of N, P, K, Carbonates and micro nutrients (Zn, Cu, and Mn) Cation Exchange Capacity and Soluble Sodium ,Calcium and Magnesium.

A B S T R A C T

A field experiment was done to analyze the physical and chemical properties of soil in the agro-ecosystem of sesame (sesamum indicum L) at three different research sites which were located in the north-western arid region of district Bikaner, Rajasthan (India) in the kharif season of 2016. The physical and chemical properties that were analyzed were as follows: (A) Physical properties that were analyzed are 1. Mechanical analysis which includes (a) Texture (b) % of Sand, Silt, Clay and CaCo3 2. Apparent density and Absolute specific gravity 3. Maximum water holding capacity or Saturation percentage. (B) Chemical Properties that were analyzed are (a) Soil PH (b) Avaliabilty of N, P, K, Carbonates and micro nutrients (Zn, Cu, and Mn) (c) Cation exchange capacity and (d) Soluble sodium ,calcium and magnesium. The results of soil analysis indicates that soils were coarse textured (sandy to loamy sand), non-saline, non alkaline and slightly calcareous in nature. Available nitrogen, phosphorus and potassium content in soil profiles before sowing were 80.0, 25.02 and 540 kg/ha respectively and these content after harvesting were 129.0, 28.02 and 530 kg/ha respectively. The micronutrient data indicated that available Zn, Cu and Mn content in the experimental soils were sufficient. Higher values of calcium carbonate are responsible for greater fixation of available zinc. The pH of soils varied from 8.3 to 8.6.

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INTRODUCTION

Soils are our basic resource, out of the long list of nature gifts; none is perhaps so essential to human life as soils. Healthy soil is the foundation of the food system. It produces healthy crops that in turn nourish people. Soil is an independent dynamic body of nature. It is a living heterogeneous system with characteristics physical, chemical and biological properties. The plants growth is influenced by the type of soil and soils are influenced by the type of plant species grown. The soil is a tri-phasic system of solid, liquid and gaseous components, each of which has its own physical and chemical properties in equilibrium or transient-state, relationships with others. It is the medium where plants grow; plants depend on the soil for water and nutrients. The agro ecological significance of the soil medium cannot be under related because of the biological activities that are carried on in the soil and importance of the productivity of the underground plant parts. More important, however, the soil is the interface between living and the dead- where plants combine solar energy and carbon dioxide of the atmosphere with nutrients and water from the soil into tissue.

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Soil system is indeed very complex and dynamic, undergoing continuous change, and the rates of such changes being influenced by a number of other factors of the environment. The soil resource of Rajasthan, as a medium of growing crops, has furnished directly or indirectly, a significant share in the income of the state. Rajasthan, being geographically the second largest state in India, has proportionately a greater soil resource. The information and knowledge of soils of the state which could be gained through the study of their physical and chemical properties and their geographical distribution pattern, is an essential prerequisite for their proper utilization, management and conservation. It also helps in proper selection of crops and better land use. When seen in detail at the village level, the soils of Rajasthan are complex, and highly variable, reflecting a variety of differing plant materials, physiographic land features, range of distribution of rainfall and its effects, etc. The soils are generally evaluated for their production capacity through study of their ability to supply plant growth requirements in terms of water, nutrient and rooting media.

The major constraints on plant production in the western part of Rajasthan region are due to low and erratic rainfall with a mean value ranging from 100 to 450 mm, a high evaporative demand, atmospheric temperatures often rising as high as 52°C and sandy soils with low moisture retention and with storage capacity ranging from 100 to 150 mm^{-1} of soil profile (Gupta & Aggarwal, 1980a and 1980b). The deficiency of soil moisture and the wide variations in soil temperatures have been found to affect the availability and absorption of water and nutrients and thus the growth and yield of crops (Lahiri, 1964; Krishnan *et al.,* 1966; Parihar *et al.,* 1977; Lal, 1974; Gupta & Gupta, 1983; Gupta, 1983). Cloudsley-Thompson (1984) reported wide variability and extremes of temperature in the deserts. Kassas & Batanouny (1984) reported edaphic aridity in the Sahara due to limited water resources.

Desert surface soil remains dry all the year round except for a few days in the wet season. These variations in soil temperature and soil moisture deficits near the surface compel desert vegetation to develop deeper root systems in order to absorb water from the deep, permanently wet zone for their survival (Batanouny & Abdul Wahab, 1973). However, during the early period after planting, since the root system of the plants is shallow and the surface layers of the soil dry quickly, the rate of water absorption is lower than the water loss from the plants, and thus there is large scale mortality. Therefore, the study of water balance, water movement and soil moisture regimes as influenced by diurnal and seasonal variations in soil temperature is not only so important but also develop management technology which both moderates extremes of soil temperature so common in deserts and makes more water available for faster root growth.

During dry hot periods, however, heavy soils that get compacted resist wind erosion but under heavy rainfall, due to their low infiltration rates they generate high surface run off and thus cause extensive soil erosion through water. On the other hand, the sandy or light soils that are loose and single grained are more prone to wind erosion and are often subject to sand drift, but due to their coarse and open texture, coarse pores and resultant high infiltration capacity, they are not susceptible to water erosion, even during heavy cloud bursts. Medium textured soils have moderate condition between the above extremes. As such, these different soils create different types of habitats for plant growth, and therefore, the crop choice and cropping patterns on such kind of soils greatly vary. Soils are thus, variable in their soil-water-plant relationship, conservation needs and production potentials.

MATERIAL AND METHOD

To understand the soil profile of western Rajasthan three research sites was selected in the District Bikaner which lies in the arid region of north-western Rajasthan. The first research site (S_1) was in the village Kodemdesar lying 20 km. west to the town of Bikaner, on Bikaner Jaisalmer road. The area is only cultivated in Kharif season, lying fallow and grazed during the rest of the year, second research site (S_2) was in the village Khara lying 15 km north to the town of Bikaner. The third research site (S_3) was at Ridmalsar village lying 20 km. north-east to the town of Bikaner. The area is sandy plains with small sand dunes. At all the sites sesame was mainly cultivated during rainy season (Kharif). The layout of experiment was in randomized block design with six replications at each field. Each replication was separated with a path of 1.0 m. and each sub-plot was separated by 50 cm path.

For this study sesame agro-ecosystem was selected for following reason

1. Sesame is one of the most versatile crops that can be grown in dry arid regions. It has unique attributes that can fit most cropping systems.
2. Give profitable yield under non irrigated area.
3. Excellent soil builder-improves the soil texture and moisture retention, retains soil moisture better for planting the next crop. Its extensive root system enables the crop to thrive in low rainfall.

Soil samples were collected near each quadart during the crop season. Samples at 0-20 cm, 20-30 cm, and 30-40 cm depths were taken by auger and packed in polythene bags and brought to the laboratory for analysis. All the soil samples collected for the purpose of study were analyzed for various physico-chemical properties by following methods –

Physical Analysis

Mechanical analysis was done by the international pipette method of Piper (1957), with modification i.e. inclusive calcium carbonate fraction by using “calgon” as dispersing agent, Apparent density and absolute specific gravity- was determined as described by Piper (1957) using Keen’s boxes, Maximum water holding capacity or saturation percentage - was determined by preparing saturation paste of soil as suggested by Richards (1954).

Chemical Analysis

I. P^H (Soil reaction) - Soil P^H was determined by preparing 1:2 soil water suspension (20 gm of soil and 40 ml of distilled water). The suspension was stirred at regular interval for 30 minutes and the P^H was determined on systronic digital P^H meter by standardizing with buffer solution of P^H 4.0, 7.0 and 9.2,
II. Electrical conductivity - of 1:2 soil, water ratio was measured by ‘Box type’ Conductivity Bridge at 25^0c and results were reported in mm hos/cm at 25^0c,
III. Available Nitrogen - was estimated in the soil samples by using alkaline potassium as reported by Subbiah and Asija (1956). 20 gm of soil was taken in a Kjedhal flask. In it 20 ml of water was added followed by 100 ml each of 0.32% $KMno_4$ and 2.5% of NaOH solutions. The contents were distilled and liberated ammonia was collected in a flask containing 20 ml of the standard boric acid solution (with mixed indicator). About 100 ml of distillate was collected which was then titrated with 0.02 NH_2SO_4 to the original shade (pinkish).
IV. Available Nitrogen = R x 0.02 x ½ x 0.014 x 100
Where R = Volume of 0.02 NH_2SO_4 used in titration.
Available Phoshporus- Available phosphorus content was determined by Olsen’s *et al.,* (1954) method using 0.5 molar sodium bicarbonate solution of P^H 0.5 as extractant, colorimetrically, soil extract was prepared by taking 2.5 gm of soil in a 100 ml plastic

bottle, a little of Darco G 60 was added followed by 50 ml of Olsen's reagent. The flasks were shaken for 30 minute and contents were filtered immediately through dry filter paper and 5ml of soil extract was taken into a flask and 5ml of chloro molebedic acid was added. The contents of the flask were diluted to about 22 ml, to this 1 ml of diluted stannous chloride solution was added, shaken and made up to mark. The intensity of the colour was noted at 660 mμ. Standard curve was calibrated with the help of standard phosphorus solution and reading of unknown solution was plotted.

V. Available potassium- Available potassium was determined by using normal neutral ammonium acetate as an extractant with help of Flame Photometer (Jackson, 1973). 5 gm soil was shaken with 25 ml of neutral normal ammonium acetate for 5 minutes and the contents filtered immediately through a dry filter paper. First few ml of the filtrate was rejected. Potassium was estimated in the extract with the help of EEI Flame photometer, calibrating it by standard solution.

VI. Carbonates - were estimated by treating the soil with 1 N HCl and titrating against 1N NaOH as described by Piper (1957) and reported as percent $CaCO_3$.

VII. Zinc - was estimated by using Dithizone as described by Black *et al* (1965).

VIII. Copper–was estimated by using diethyldithiocarbonate method as described by Black *et al* (1965).

IX. (ix) Magnese – was determined by using per iodate method as given in Black *et al* (1965).

X. (x) Cation exchange capacity– was determined by saturating the soil with NaOAC and then extracting Na^+ with NH_4OAC after removing excess of soluble sodium by ethanol as described by Richards (1954). Soluble sodium and calcium plus magnesium – The soil saturation extract was used for Na^+ or Ca^{++} and Mg^{++} analysis as described by Richards (1954).

XI. The experiments were conducted on the same sites in year 2016. The soil samples were taken up to 40 cm depth because the root zone was not found beyond this.

RESULT AND DISCUSSION

***Physical Analysis*:** The mechanical composition of soil is the relative proportion of sand, silt and clay. It can be observed from the table no.1, that the texture of all the three sites varied from sand to loamy sand. There has been an increase in silt fraction in case of site I and II at depths of 0 to 20 cm and 30 to 40 cm respectively, resulting the loamy sand texture. The soils of site III have nearly the same composition up to the 40 cm soil depth. The content of calcium carbonate varied from 1.25 to 3.15 indicating the calcareous nature of soils. The surface (0-20 cm) and sub–surface (20-30 cm) soil samples contained less $CaCo_3$ as compared to the substrates (30-40 cm). Thus the content of $CaCo_3$ invariably increases with soil depth in all the sites (Table no.1) Mathur *et al.,* (1975) have classified these soils under aridosol on the basis of texture and calcium carbonate content. The maximum water holding capacity, absolute density and specific gravity of the soils mainly depends upon the composition of different particle such as sand, silt and clay. It has been observed that maximum water holding capacity of sand varies from 19.16 to 26.10% with an average of 22.00 % while in sandy loam texture it varies from 25.00 to 26.85 % with an average of 26.10 % (Table no.1). Frangmier *et al.,* (1960) reported the relationship of particle size composition and water holding capacity of Michigan soils and classified soils into different texture groups. It can therefore, be concluded that finer fractions such as silt and clay hold more water than sand fractions.

***Chemical Analysis*:** The chemical analysis of soil has been presented in table no.2. It can be observed that the soils of all the experimental sites are alkaline in nature. The P^H values vary from 8.2 to 8.6 (Table no.2). There has been increase in P^H as the depth of soil increases. The increase in P^H in sub-strata of these may be due to presence of higher amount of calcium carbonate and exchangeable sodium percentage.

The electrical conductivity data of soil profiles indicate that these soils are free from salinity problem. Seth (1967) also pointed out that electrical conductivity of soils in 1:2 soil-water ratio below 1 mm hos/cm should be placed under normal soils. It can be observed from the data that there is a tendency of accumulation of salts as the soil depth increases.

The available nitrogen content in soil profiles of experimental sites varied from 40.2 to 80.0 kg /ha (Table no 2). The content of available nitrogen was observed maximum in top soil and it decreased with soil depth. It may be due to presence of organic matter at surface soil. The site-I has highest nitrogen content as compared to site II and site III. Perur *et al.,* (1973) pointed out that available nitrogen content of such soils can be categorized under low category. The more nitrogen content at site I might be due to its inherent fertility.

The available phosphorus content in soils of the experimental sites varied from 8.75 g/m^2 to 25.02 g/m^2. The sites I & II were medium in available phosphorus contents where as at site III available phosphorus content was low.

The soil was rich in available potash contents and it varied from 280 to as high as 540 kg/ha (Table no. 2). The soils of site I and II as per Muhr (1965) can be categorized under medium potash content while site III fall under poor potash content.

The zinc, copper and manganese content in soils varied from 0.29 to 0.62, 0.12 to 0.32 and 1.50 to 4.90 ppm respectively (Table no.2). Their content were found to be maximum in site-I followed by II and III. The amount of these micronutrients present was more than the critical limit for the crop under study. It can therefore be concluded that the soils of the experimental areas were alkaline, calcareous, coarse textured, highly permeable and poor in water holding capacity. The soils are not deficient in micronutrients (Table no.2 & 3). It appears that site – I have more soil fertility, followed by sites II and III. There was no change in physical properties of soil during the course of study. After the crop harvest at each site, available nitrogen and phosphorus content showed increasing trend. Available nitrogen content increased from 80 to 129.0, 62.2 to 90.5 and 60.5 to 89.2 kg / ha in the surface layer at S_1, S_2 and S_3 sites respectively. Similarly available phosphorus content also increased from 25.02 to 28.92, 16.50 to 20.50 and 9.25 to 14.62 kg per ha in surface layer at S_1, S_2 and S_3 sites

Table 1 Physical characteristics of soil profile of different sites

S.NO	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	$CaCo_3$ (%)	Maximum WHC (%)	Apparent density (G/CC)	Absolute specific Gravity	Available moisture (%)
SITE – I (KODEMDESAR)										
1.	0- 20	96.0	0.80	3.40	Sand	1.25	25.00	1.61	2.59	10.5
2.	20-30	97.5	4.80	3.60	LoamySand	1.25	26.10	1.54	2.07	11.5
3.	30-40	86.5	4.80	3.90	LoamySand	3.15	26.85	1.52	2.12	11.3
SITE- II KHARA										
1.	0-20	94.7	2.92	2.79	Sand	2.05	22.00	1.64	2.58	10.3
2.	20-30	92.1	3.02	1.42	Loamy	1.95	26.10	1.54	2.06	11.2
3.	30-40	92.4	3.92	3.32	Loamy Sand	3.02	25.60	1.54	2.12	11.5
SITE-III (RIDMALSAR)										
1.	0-20	96.7	1.92	1.39	Sand	2.60	20.20	1.64	2.57	10.1
2.	20-30	97. 0	1.60	1.48	Sand	2.02	19.16	1.65	2.50	10.1
3.	30-40	97.0	1.60	1.49	Sand	3.03	19.26	1.63	2.55	10.2

Table 2 Physical characteristics of soil profile of different sites

S.No.	Depth (cm)	pH 1:2	ECX 10^3m mhos/ cm l:2	AV* Nitrogen kg/ha	AV* P_2O_5 kg/ha	AV* K_2O kg/ha	Zn in (ppm)	Cu in (ppm)	Mn In (ppm)	CEC me/100 g of soil	Soluble Na	Cations me/litre Ca+Mg
SITE – I												
1.	0-20	8.2	0.23	80.0	25.02	540	0.62	0.32	4.90	3.80	0.60	1.15
2.	20-30	8.4	0.46	71.2	16.01	500	0.40	0.30	4.20	3.95	1.02	3.65
3.	30-40	8.5	0.40	60.5	14.95	395	0.33	0.31	3.65	4.02	0.92	2.98
SITE- II												
1.	0-20	8.4	0.26	62.2	16.50	360	0.35	0.18	3.80	2.60	0.50	2.1
2.	20-30	8.4	0.26	52.5	10.81	400	0.33	0.26	2.75	2.60	0.4	2.20
3.	30-40	8.3	0.31	40.5	9.77	280	0.40	0.26	2.70	3.30	0.60	2.50
SITE – III												
1.	0-20	8.5	0.31	60.5	9.25	290	0.32	0.12	2.00	2.00	0.20	2.84
2.	20-30	8.6	0.29	50.6	8.75	300	0.30	0.12	1.50	2.60	0.10	2.80
3.	30-40	8.6	0.43	40.2	10.20	290	0.29	1.12	1.90	3.10	0.20	4.12

AV* = Available, P_2O_5 = Phoshporus, K_2O = Potash, CEC = Cation exchange capacity.

Table 3 Chemical properties of soil profile at different sites after harvesting

S.No.	Depth (cm)	pH1:2	ECX 10^3m mhos/ cm l:2	AV* Nitrogen kg/ha	AV* P_2O_5 kg/ha	AV* K_2O kg/ha	Zn in (ppm)	Cu in (ppm)	Mn in (ppm)
Site I									
1.	0-20	8.20	0.23	129.00	28.02	530	0.62	0.32	4.90
2.	20-30	8.40	0.46	105.50	20.04	500	0.40	0.29	4.20
3.	30-40	8.40	0.42	81.00	15.02	390	0.33	0.31	3.60
Site II									
1.	0-20	8.40	0.26	90.50	20.50	360	0.34	0.18	3.70
2.	20-30	8.30	0.26	72.60	15.81	390	0.32	0.25	2.70
3.	30-40	8.40	0.31	55.20	5.77	280	0.40	0.25	2.70
Site III									
1.	0-20	8.50	0.31	89.20	14.62	290	0.30	0.10	1.99
2.	20-30	8.60	0.29	68.50	10.98	310	0.30	0.11	1.42
3.	30-40	8.50	0.42	45.50	8.20	290	0.29	1.11	1.90

AV* = Available, P_2O_5 = Phosphorus, K_2O = Potash, CEC = Cation exchange capacity.

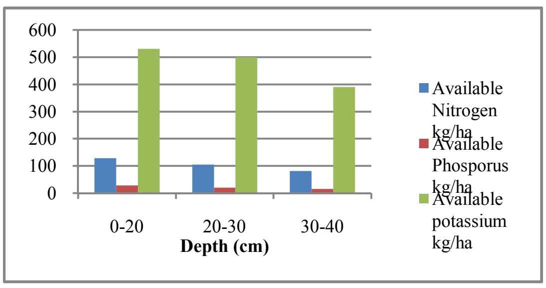

Fig 1 Available Nitrogen, Phospours and Potassium Before sowing at site 1

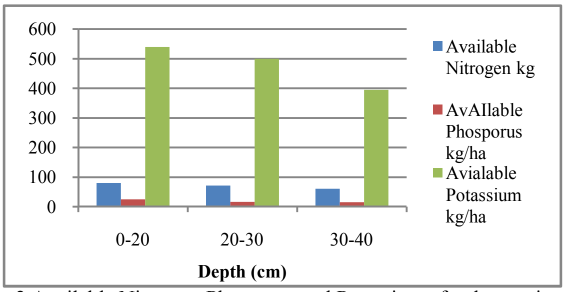

Fig 2 Available Nitrogen, Phospours and Potassium after harvesting at site 1

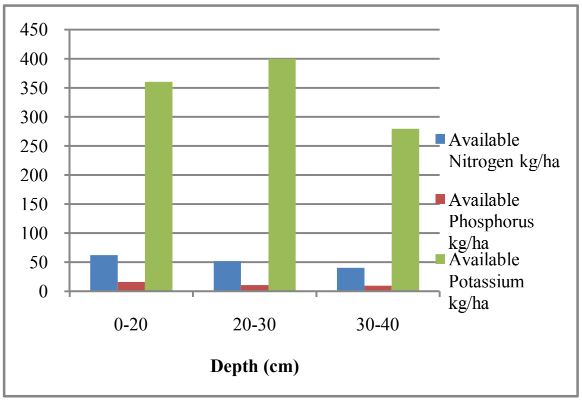

Fig 3 Available Nitrogen, Phospours and Potassium before sowing at site 2

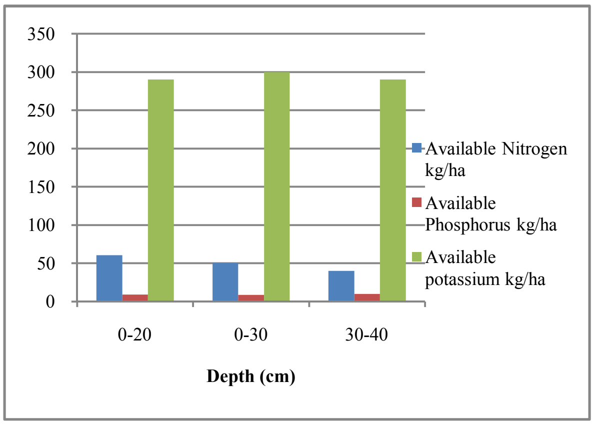

Fig 4 Available Nitrogen, Phospours and Potassium after harvesting at site 2

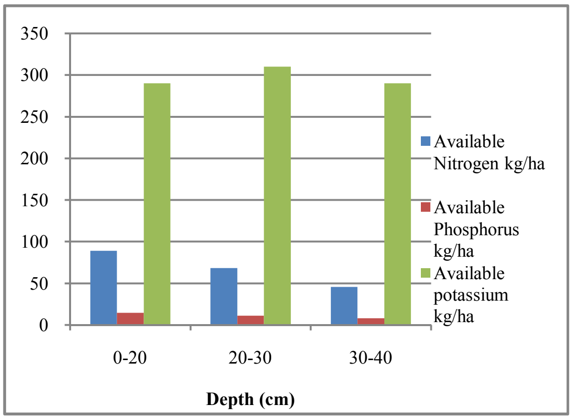

Fig 5 Available Nitrogen, Phospours and Potassium before sowing at site 3

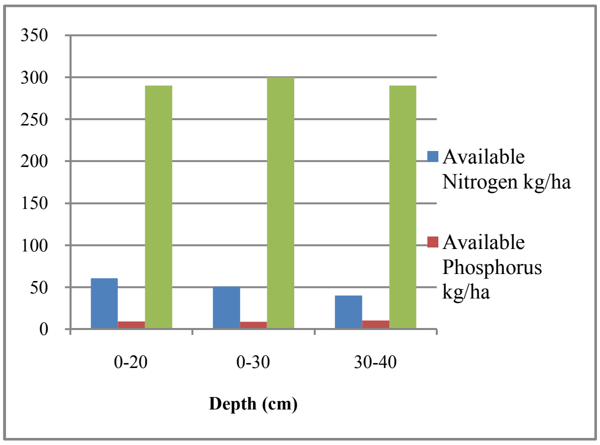

Fig 6 Available Nitrogen, Phospours and Potassium after harvesting at site 3

respectively. However, there was no significant change in available potassium and micronutrient contents.

CONCLUSION

Rational use and efficient management of land and water resources are very much essential to meet the growing needs of increased population and save the degradation of national natural assets. Hot arid regions of India need specific attention in this regard since the natural resources of this fragile ecosystem are not yet been fully identified and assessed on the developmental scale. So to make a broad picture of soil profile of western Rajasthan which comes under hot arid region the above study was done. The study of soil profile of sesame agro-ecosystem will no doubt help farmers and researcher of agro ecology for better understanding of pattern of rain fed cropping for the betterment of arid zone farming. The present study reveals that the physiochemical properties of the soils of experimental areas were sand to loamy sand, alkaline, calcareous and coarse textured. The maximum water holding capacity of sand varied from 19.16 to 25.0%. In loamy sand it was 25.60 to 26.96%. The p^{H} of soil varied from 8.2 to 8.6. The electrical conductivity data indicates that these soils were free from salinity problem which is good for cropping of sesame. The available nitrogen content varied from 39.2 to 80.0 kg/ha before taking crops *Sesamum indicum* (L.). At each site, available nitrogen and phosphorus contents increased from 80.0 to 129.0 and 25.02 to 28.92 kg/ha respectively after harvesting of the crop.

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