International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 15, Issue 8, 2023, pp.-12558-12560.
Available online at https://bioinfopublication.org/pages/jouarchive.php?id=BPJ0000217

Research Article

CHARACTERISTICS OF SISAL GROWING SOILS OF ODISHA AND SUGGESTIVE MEASURES TO ENHANCE FIBRE PRODUCTIVITY

MAJUMDAR B., SARKAR S.*, BARAI S. AND PASWAN A.
Crop Production Division, ICAR-Central Research Institute for Jute and Allied Fibres, Nilganj, Barrackpore, Kolkata, 700121, West Bengal, India
*Corresponding Author: Email - sarkaragro@gmail.com

Received: July 29, 2023; Revised: August 25, 2023; Accepted: August 28, 2023; Published: August 30, 2023

Abstract: Sisal is one of the important fibre crops in the marginal soils of Odisha. The Sambalpur and Jharsuguda districts are known for sisal cultivation. The information on sisal soils of Odisha and of the two districts (Sambalpur and Jharsuguda) were not available. In this study, we have characterized the sisal growing soils for their physico-chemical, chemical and biological properties. The sisal growing soils are acidic in nature, with low organic carbon and available nitrogen content and available P & K status was medium. The micronutrients in sisal growing areas were sufficient. The biological properties indicated that the microbial activity is very low because of very low organic carbon status. Use of organic manure like FYM, sisal compost, green manure and use of lime can improve the soil condition and improve the fertility status of the sisal growing soils of Odisha. Further, addition of P either as SSP or rock phosphate (RP) or in a combination of SSP + RP (1:1) will increase the available P status in acid soils of Odisha. In addition to this, growing pulse crop in between the sisal rows during kharif season may improve the organic matter, available N status of soil and will also help to earn additional income from sisal + pulse intercropping.

Keywords: *Sisal, Agave sisalana, Soil nutrient and biological status, Remedial measures, Odisha*

Citation: Majumdar B., *et al*., (2023) Characteristics of Sisal Growing Soils of Odisha and Suggestive Measures to Enhance Fibre Productivity. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 15, Issue 8, pp.- 12558-12560.

Academic Editor / Reviewer: Soma Biswas, Dr Kamal Kant

Introduction

Sisal is a xerophytic, monocarp, semi-perennial leaf fibre producing plant. The leaves are thick, fleshy and covered with waxy layer, generally observed in xerophytic plants. A sisal plant produces about 200-250 leaves during its 10-12 years life span, after which it produces a long flowering axis containing small plantlets and eventually dies after completing its life cycle. Different species of Agave (Aaparagaceae family) namely *A. sisalana, A. cantala, A. vera-cruz, A. amaniensis, A. angustifolia* and *A. fourcryodes* can produce hard fibre from its leaf. However, among the different species, A. sisalana contributes nearly 85% of the total sisal fibre production of the World. Quite a lot of sisal species are native to India and which often found growing wildly at places. It is primarily cultivated by the tribes/ villagers to get fibres from the leaf through extraction.

The main use of sisal fibre is for manufacturing of ropes and twines and other forms of cordage; although, considerable amount of fibre is also utilized for padding and upholstery and mats as well as for bags and sacking. More uses include sausage casings, reinforced plastics and building boards, carpets, crafts and speciality papers, different types of nets and brushes, straps of different use, ladies fancy purses and belts. In India, sisal fibre productivity is not more than 600-750 kg/ha due to selection of marginal land for the crop as well as no input use often by the cultivators. It was established that by following proper crop management practices, the sisal fibre productivity can be increased to 2000 to 2500 kg/ha [1].

Sisal thrives best on dry, permeable, sandy-loam soils with good quantity of liming materials (Ca and Mg) but can also grow on various other types of soils. In India it is grown in light calcareous and gravelly soils with good drainage. Sisal requires enough calcium for proper development of the roots of sisal. Low calcium in acidic soil is not apt for sisal plantation. In moderate waste land, sisal can be grown with suitable care by applying recommended doses of fertilizers and implementing proper agronomic practices [1]. Earlier Sahu and Mishra (1994) [2] reported characteristics of sisal cultivating soils of another region.

As the selection of land for sisal crop in Jharsuguda and Sambalpur are such that they are having comparatively poor soil characteristics resulting lower yield, the fibre productivity can be increased by manipulating and managing the soil with some efforts, which have been discussed in this article.

Materials and Method

The study was conducted in the Eastern Plateau and Hills Zone of the 15 Indian Agro-climatic zones. This zone consists of inland Odisha (and eastern part of Madhya Pradesh). The soils are shallow to medium in depth and the topography is undulating with a slope of 1-10%. In the present study, two important sisal growing districts of western Odisha namely Sambalpur and Jharsuguda were considered. In each district ten villages where sisal is grown by the farmers are selected. From each village five sisal growing farmers were randomly selected. From each farmer's field three soil samples were collected in zig-zag fashion. So, for the study, in a district a total of 50 farmers' fields were considered and thereby for the sisal growing part of the state, a total of 100 farmers' fields were identified for the two districts. The total number of soil samples for each district were 150 in number [10 (villages) x 5 (farmers) x 3 (soil samples)]. For the two districts, total soil samples collected from the sisal growing soils were 300 (150 x 2). The soil samples were collected from the farmers' fields in the month of September, 2022 and brought to the Central Laboratory of ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, West Bengal. The soil samples were processed and measured soil physico-chemical properties such as (i) pH, (ii) organic carbon, (iii) available nitrogen, (iv) available phosphate, (v) available potassium, micronutrients like (vi) iron, (vii) manganese, (viii) zinc, and (ix) copper by following standard procedures [3, 4]. The collected soil also studied for soil enzymes such as (i) DHA, (ii) FDHA, (iii) glucosidase, (iv) acid phosphatase, (v) alkaline phosphatase, and (vi) urease by using standard methods for each parameter [5].

Result and Discussion

Soil pH

The soil pH of Sambalpur villages ranged between 5.43 and 6.36 with a mean of 5.75. Whereas, Jharsuguda soil pH range were 5.72 to 6.17 and the mean soil pH was 5.93. On the basis of 300 soil samples, the mean soil pH of the sisal growing soils of Odisha state was 5.84. All the soil pH of sisal growing soils are in the acidic range. Such lower pH hampers availability of phosphate and sulphur. The main difficulty of lower pH is in availability of liming materials such as Ca and Mg, which are essentially required in large quantity for optimum growth of sisal, as one tonne of sisal fibre removes 81 kg of Ca and 30 kg of Mg taken from the soil [6]. The acidic pH of sisal growing soil fix applied phosphate immediately and therefore are not available to the sisal plant for optimum growth. In the acidic sisal growing soil of Odisha, application of dolomite [$CaMg(CO_3)_2$] of ≤60 mesh particle size @ 2-3 t/ha will increase the soil pH as well as enhances availability and uptake of elements such as P, Ca, Mg and Mo. Besides that, it reduces the concentration of Fe and Mn which often under strong acidic condition remain in toxic level for sisal and other crops grown in these areas.

Soil organic carbon

In general, the organic carbon content of the sisal growing soil were quite low. In Jharsuguda district, the range of organic carbon was quite good 6.15 g/kg to low of 3.15 g/kg, with a mean of 3.93 g/kg for the district. Similarly, for Sambalpur district, the organic carbon range was between 5.10 and 1.50 g/kg and the mean were 3.60 g/kg which can be considered as low. The mean organic carbon content of the sisal growing soil of Odisha was 3.77 g/kg, which is also quite low for optimum growth of sisal and many other crops [Table-1]. To increase the organic carbon level of sisal growing soil, application of sisal waste manure @ 5 t/ha once in a year for consecutive 4-5 years is suggested. In case of virgin field of sisal crop, i.e., before starting of sisal plantation, application of FYM @ 5 t/ha, if locally available may result positively. Growing of dhaincha (Sesbania) for consecutive years in high density during the monsoon months for 30-42 days and ploughing down & incorporating it in the soil have beneficial effect in enhancing organic carbon content in such soil.

Table-1 Soil reaction and important major soil nutrient status of sisal growing soils of Odisha

District/ State	Range and mean	pH	OC (g/kg)	N	P	K
				(kg/ha)		
Jharsuguda	Minimum	5.72	3.15	154.6	10.1	174.4
	Maximum	6.17	6.15	293.7	34.3	292.3
	Mean	5.93	3.93	197.9	18.8	230.6
Sambalpur	Minimum	5.43	1.50	170.1	12.9	230.7
	Maximum	6.36	5.10	247.4	28.3	331.8
	Mean	5.75	3.60	193.2	20.3	281.0
Odisha	Mean	5.84	3.77	195.6	19.5	255.8

Available nitrogen

The available nitrogen of Jharsuguda soils were between 154.6 and 293.7 kg/ha with a mean of 197.9 kg/ha. Whereas, the same parameter for Sambalpur soil was between 170.1 and 247.4 kg/ha. The mean available nitrogen of Sambalpur soil was 193.2 kg/ha [Table-1]. The mean soil available nitrogen of the sisal growing soil of Odisha was 195.6 kg/ha, which is classified as low (<280 kg/ha). It was reported that sisal in general is a nutrient demanding crop as one t of sisal leaves removes 23.5 kg N, 3.5 kg P, 35 kg K, 81 kg Ca and 30 kg Mg from the soil [1]. For improving available N content in sisal growing soil, application of 60-80 kg of nitrogen is recommended for Agave sisalana and for hybrid sisal the dose should be increased to 80-120 kg/ha. Nitrogenous fertilizer should be applied to each sisal plants in ring method around each plant to avoid nutrient loss and increase nitrogen use efficiency. It was observed that growing of legume intercrops such as cowpea, moth bean etc enhance the available N content of the sisal growing soil [7]. Application of N fertilizer increases individual leaf length and number of harvestable leaves, which has direct bearing on the fibre yield of sisal [8].

Available phosphorus

The available phosphate of Sambalpur soils was ranged between 12.9 and 28.3 kg/ha with a mean of 20.3 kg/ha. The range of available phosphate in Jharsuguda soils was 10.1 to 34.3 kg/ha, and the mean value of phosphate was 18.8 kg/ha. The mean phosphate level in the sisal growing soil of Odisha was 19.5 kg/ha, which is considered as medium as per standard soil nutrient chart [Table-1]. Use of dolomite @ 2-3 t/ha corrects soil acidity and thereby increase availability of phosphorus to the sisal plantation. It may be noted here that application of P in the form of single super phosphate is recommended for sisal as it contains 12.5% S and 19.5% Ca besides P (16%). The S and Ca are required by the sisal plantation for better growth and increased fibre yield. Further, as the soils of both the districts are acidic, in addition to lime, PSB may be used which can solubilize the fixed P in the soil and make it available to the sisal plants.

Available potassium

The range of available potassium in Sambalpur soil was between 230.7 and 331.8 kg/ha, with a mean of 281 kg/ha. Similarly, the range of available potassium in Jharsuguda district was between 174.4 and 292.3 kg/ha with a mean of 230.6 kg/ha. The mean available potassium status of sisal growing soil of Odisha was 255.8 kg/ha, which is considered as medium for potassium [Table-1]. In improved method of cultivation of sisal, application of K @ 40-60 kg in the form of muriate of potash is recommended. Recommended dose of N, P, K fertilizer not only increase the fibre productivity, but also increase sucker (planting material) production potential in sisal, which facilitates newer sisal plantation from the initial plantation within 3-4 years [9].

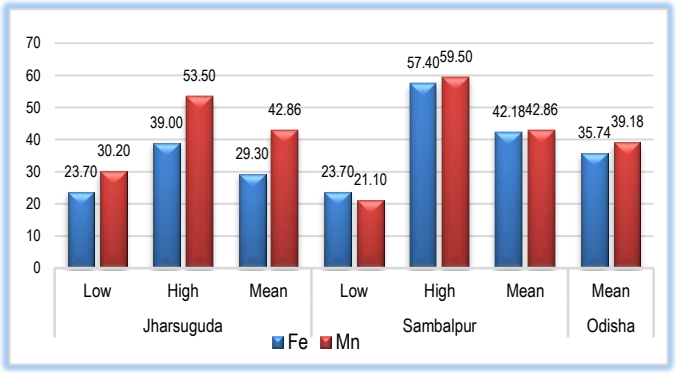

Fig-1 Available Fe and Mn content (in ppm) in sisal growing soils of Odisha

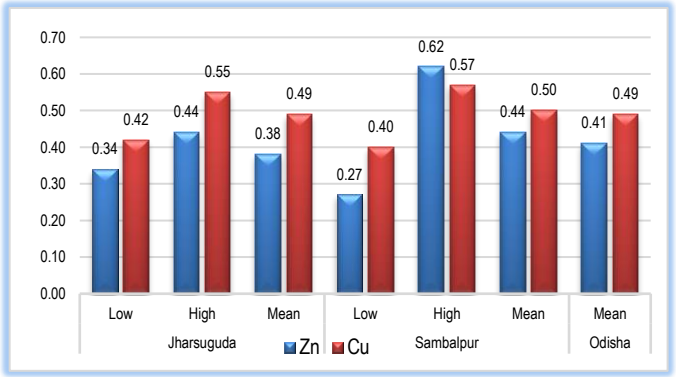

Fig-2 Available Zn and Cu content (in ppm) in sisal growing soils of Odisha

Available micronutrients

Being acid soil, the iron (Fe), manganese (Mn) and copper (Cu) content of the sisal growing soils of Odisha were in higher side. The available iron (Fe) content of Jharsuguda soil varied widely and the range of variation was 23.7 to 39.0 ppm, with a mean value of 29.3 ppm. Whereas, the available iron content of Sambalpur soil varied more widely and the range was between 23.7 and 57.4 ppm. The mean Fe content of Sambalpur soil was 42.2 ppm, which was about 44% more as compared to the Fe content of Jharsuguda soil. State, the Fe content of sisal growing soil of Odisha was 35.7 ppm [Fig-1]. Manganese (Mn) content of Jharsuguda soil varied between 30.2 and 53.5 ppm, with a mean of 42.9 ppm. In case of Sambalpur soil, the Mn content varied between 21.1 and 59.5 ppm and the mean value was 35.5 ppm [Fig-1]. The mean available Mn content of sisal growing soil of Odisha was 39.2 ppm, which is considered as high for most of the crops [10].

Table-2 Soil enzyme status of sisal growing soils of Odisha

District/ State	Range and Mean	DHA (µg TPF/g/h)	FDHA (µg fluorescein/g/h)	Glucosidase (µg pNP/g/h)	Acid Phosphatase (µg pNP/g/h)	Alkaline Phosphatase (µg pNP/g/h)	Urease (mg/ml)
Jharsuguda	Min.	0.62	1.45	5.60	22.80	2.30	54.20
	Max.	1.60	2.60	21.10	88.90	17.30	112.00
	Mean	1.12	1.99	10.62	39.32	8.22	75.22
Sambalpur	Min.	0.59	1.20	3.80	12.10	2.60	77.00
	Max.	2.32	5.40	15.20	87.90	7.50	112.0
	Mean	1.13	2.58	8.40	42.05	4.98	92.04
Odisha	Mean	1.13	2.28	9.51	40.68	6.60	83.63

The available zinc (Zn) status of Jharsuguda soil varied narrowly between 0.34 and 0.44 ppm, with a mean status of 0.38 ppm. However, the available Zn status of Sambalpur soil varied widely from 0.27 ppm to 0.62 ppm and the mean value was 0.44 ppm [Fig-2]. The mean available Zn status of sisal growing soils of Odisha was 0.41 ppm, which may be considered as sufficient for most of the field crops [10]. In Jharsuguda soil, the range of available copper (Cu) was between 0.42 and 0.55 ppm, with a mean of 0.49 ppm. The range of available Cu content of Sambalpur soil was between 0.40 and 0.57 ppm, and the mean was 0.50 ppm [Fig-2]. The same parameter value was 0.49 ppm (mean) for the sisal growing soils of Odisha state. So, it can be said that, all the sisal growing soils of Odisha was sufficient in Cu content [10].

Soil enzymes

The dehydrogenase (DHA), fluorescein diacetate hydrolyzing activity (FDHA) and glucosidase activity in soil indicates the intensity of microbial metabolism and thus the microbial activity in soil. The mean DHA activity in the soil of Sambalpur and Jharsuguda were 1.13 and 1.12 µg TPF/g/h and the FDHA activity was slightly higher in Sambalpur soil (2.58 µg fluorescein/g/h) than the Jharsuguda soil (1.99 µg fluorescein/g/h) [Table-2]. On the other hand, the glucosidase activity was higher in Jharsuguda soil (10.62 µg pNP/g/h) than the Sambalpur soil (8.40 µg pNP/g/h) and the state of Odisha it was 9.51 µg pNP/g/h. The lower dehydrogenase, FDHA and glucosidase activity in the Sambalpur and Jharsuguda districts as well in the sisal growing soils of Odisha is mainly because of lower organic carbon content in soil [Table-1]. The organic carbon and organic matter present in the soil, is the primary site of all microbial activities, so to increase the microbial activities in the soil, the organic carbon content in the soil must be improved. The organic carbon content in the western Odisha soil may be increased by addition of organic manures like FYM, vermicompost or sisal leaf manure and by adding green manuring which not only improve the organic carbon content, but also improve the nutrient status of the soil.

Acid and alkaline phosphatase play a crucial role in p-cycle of ecosystem and indicates about soil fertility. The soils of Sambalpur and Jharsuguda recorded higher acid phosphatase activity of 42.05 and 39.32 µg pNP/g/h compared to their corresponding alkaline phosphatase activity of 8.22 and 4.98 µg pNP/g/h. As the soils of both the districts are acidic in nature (pH 5.75 and 5.93), the acid phosphatase activity is high compared to the alkaline phosphatase activity. The acid and alkaline phosphatase activity in the soils of Sambalpur and Jharsuguda as well as in the sisal growing soils of western Odisha can be increased by using SSP or rock phosphate as a source of phosphorus, along with PSB as bio-fertilizer. This will not only increase the available P content in the soil, but also improve the phosphatase activity in the soil.

Conclusion

Urease activity in the soil plays a great role in the regulation of N supply to the plant system after urea fertilization. The Sambalpur soil had recorded urease activity of 92.04 mg/ml which is higher than the urease activity of Jharsuguda soil (75.22 mg/ml). The urease activity in the sisal growing soils can be increased by utilizing the space between two rows of sisal by growing pulse crop in the kharif season. This will not only help in the available nitrogen content in the soil, will also improve the organic carbon status as well as the urease activity of the soil.

Application of research: The application of this research output can be used for initiation of new sisal plantation and management of existing sisal plantation in Odisha for profitability and economic progress of the sisal planters of those regions

Research Category: Agronomy of sisal, Soil requirement for sisal cultivation

Abbreviations: FYM- Farm Yard Manure, SSP- Single super phosphate, PSB- Phosphate solubilizing bacteria, DHA- dehydrogenase, FDHA- fluorescein diacetate hydrolyzing activity, OC- Organic carbon, RP- Rock phosphate

Acknowledgement / Funding: Authors are thankful to Crop Production Division, ICAR-Central Research Institute for Jute and Allied Fibres, Nilganj, Barrackpore, Kolkata, 700121, West Bengal, India and Authors are also thankful to ICAR-CRIJAF-Sisal Research Station, Bamra, Sambalpur, Odisha for assisting in soil collection from different villages of Sambalpur and Jharsuguda.

****Principal Investigator or Chairperson of research: Dr Bijan Majumdar**
Institute: ICAR-Central Research Institute for Jute and Allied Fibres, Nilganj, Barrackpore, Kolkata, 700121, West Bengal, India
Research project name or number: Research station study

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Western Odisha

Cultivar / Variety / Breed name: Agave sisalana

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Sarkar S., Kar C.S., Sinha M.K. and Mahapatra B.S. (2010) *Indian Farming*, 59(12), 17-21.
[2] Sahu G.C. and Mishra A. (1994) *Journal of the Indian Society of Soil Science*, 42(1), 111-114.
[3] Jackson M.L. (1958) *Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi* (1973).
[4] Black C.A. (1965) *Methods of soil analysis. Part 2. American Society of Agronomy, Madison, Wisconsin, USA*.
[5] Tabatabai M.A. (1994) *Soil enzymes. (In) Methods of soil analysis, Part 2, Microbial and biochemical properties, 198-250. Weaver, R.W; Angel, J.S. and Bottomley, P.S. (Eds). Soil science Society of America, Madison, WI, USA*.
[6] Sarkar S. and Jha A.K. (2017) *International Journal of Current Research*, 9(11), 61136-61146.
[7] Sarkar S., Kundu D.K., Saha A.R., Majumdar B. and Jha A.K. (2015) *Indian Journal of Natural Fibres*, 1(2), 221-224.
[8] Sarkar S., Saha A.R. and Majumdar B. (2017a) *International Journal of Current Research*, 9(3), 47853-55.
[9] Sarkar S., Saha A.R. and Majumdar B. (2017b) *International Journal of Current Agricultural Research*, 5(6), 221-223.
[10] Pillai K.M. (1966) *Fertilizer News*, 11(2), 26-28.