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Soil Analysis GIS-Based Fertility Assessment and Soil Mapping of Cardamom Growing Area, Pandam, Ilam, Nepal

Ritik Pokharel[1], Rejina Adhikari[2], Nishant Nepal[3], Rajan Budhathoki[4]
Tribhuvan University, Kathmandu, Nepal

Abstract: ***The objective of this research was to map the status of soil nutrients in the farmlands of cardamom development centre, Pandam, Fikkal, Ilam. The research was carried out in January 2021, and soil laboratory analysis was performed in February 2021, after soil sample collection. n the soil lab of the Agriculture Knowledge Center, Ilam, soil samples were examined for texture, PH, N, P2O5, K2O, and organic matter using a conventional analytics procedure. The ARC-GIS version 10 was used to prepare the soil-fertility maps. The data revealed two predominant textural classes; sandy loam (70%) and loam (30%).The soil PH (5.19±0.08) was slightly acidic in majority of the study site i.e. 83.3% of the research location was found to be acidic and 16.6% of the location was found to be neutral soil. While the organic matter(5.3%±0.0096) and total nitrogen content (0.263%±0.0038) of the study area was found to be high in about two-third of sampling location, phosphorous (49.61kg/ha±0.89) was found to be medium in majority of the site i.e. 90% medium, 6.67% high and 3.33% was low. Available potassium (82.78kg/ha±7.71) was found to be low i.e. 60% of the research location was found to be low in Total potassium, 39.9% was medium and 0.01% was high in potassium. The research was carried out in January 2021, and soil laboratory analysis was performed in February 2021, after soil sample collection.***
Keywords: CDC Pandam, GIS, soil fertility maps.

I. INTRODUCTION

Cardamom Development Center is established in 2033 B.S, managed by National Center for Potato, Vegetable and Spices crop under the supervision of Department of Agriculture. It covers 18.6 ha (373.5 ropani) area of land (Adhikari, 2019). According to the statistic Agricultural book 2016; overall 80% of the national production of Nepal cardamom is concentrated to these four major districts. As per the recent data, 18,273 ha area is occupied by cardamom, 15,055 ha area is productive area whose production and productivity are 7954 MT and 0.53MT\ha respectively (Krishi Diary, 2077).The main objectives of CDC are to produce qualitative cardamom seedlings by maintaining the quality standards. It also focuses on the production of quality foundation seeds of vegetable, varietal registration of Cardamom, Good agricultural practices of cardamom, etc. It supplies healthy cardamom seedlings to the farmers focusing on the upliftment of living standard of farmers. At present, CDC is also involved in the production of foundation seed of potato (sowing PBS); Green Pea in order to provide foundation seeds to the farmers.

The process of building geographically referenced soil databases from spatially explicit environmental variables and field surveys is known as digital soil mapping (DSM), and it uses geographic information systems (GIS) for soil mapping. The foundation for many aspects of land use planning and management decision-making is having high-quality soil maps. Grassland enhancement, crop yield estimations, erosion control, and flood mitigation planning are just a few of the numerous uses for soil maps.The ARC-GIS Version 10 is used.

Fertilizer amount is generally recommended based on the initial/inherent fertility status of soil and the type of crop grown (Islam, 2008).Soil fertility evaluation is therefore crucial (Khadka et. al., 2019) for proper fertilizer recommendationthat ensures better development of orchard and better productivity. Similarly, for the commercialization purpose of a cardamom, healthy seedling is the most and for the production of healthy seedling, healthy soil is the most. So, for growing healthy seedlings, it is necessary to know the physic-chemical properties of soil.

Studies related to the soil fertility status of Cardamom Development Centre are not done yet. Therefore, it is important to investigate the soil fertility status and provide valuable information relating agriculture research. Keeping these in view, the present study was initiated with the objective to assess the soil fertility status of Cardamom Development Centre, Fikkal, Nepal.

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II. MATERIALS AND METHODS

A. *Study Area*

The study was carried out at Cardamom development Centre, Pandam, Fikkal, Ilam (Fig1). The study area is situated in the latitude N26º55'11.5" and longitude E088º04'27.9"and elevation of 1439masl. For the study purpose, nurseries, vegetable farm, cardamom orchard forest and barren land of CDC were stratified into five sections for soil sampling techniques.

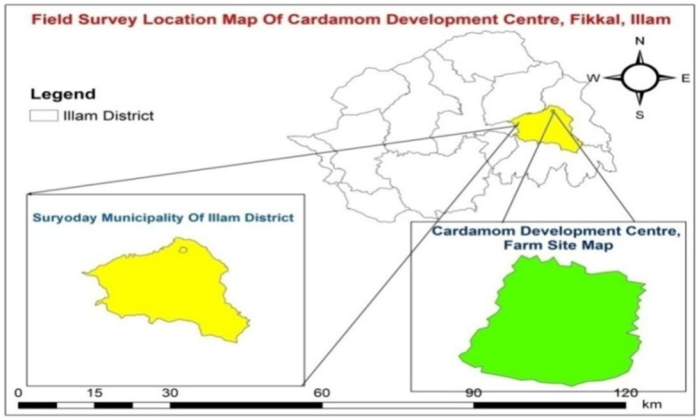


Figure 1: Map of Cardamom development Centre, Fikkal, Ilam

B. *Soil Sampling*

Altogether 60 samples were taken by simple random techniques with the help of auger. The exact locations of the samples were recorded using a handheld GPS device (Figure 2). The soil samples (0-20 cm) were analyzed in the soil laboratory of Agriculture knowledge centre, Ilam to determine its physic-chemical properties.

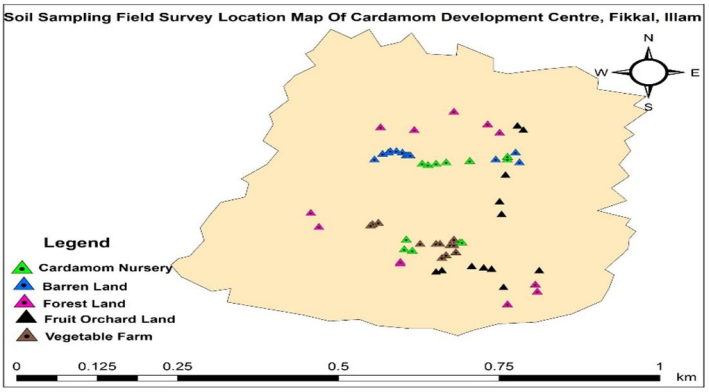


Figure 2: Distribution of sampling point

Table 1: Methods followed in soil laboratory analysis

Parameters	Analysis Methods
Soil texture	Hydrometer method (Gee and Bauder, 1986).
Soil Ph	Beckman electrode pH meter (Cottenie*et al.*, 1982)
Organic matter	Graham's colorimetric method (Graham, 1948)
Nitrogen	Pedo transfer function (MOALD, 2018)
Phosphorous	Modified Olsen's (Olsen *et al.*, 1954)
Potassium	Ammonium acetate extraction method (Pratt, 1965)using flame photometry

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C. Statistical Analysis

Microsoft Excel 2010 was used to calculate the descriptive statistics (mean, standard deviation, root mean square error, and coefficient of variation) for the soil parameters. Based on the findings from the Agriculture Knowledge Center, Ilam, the determined values were rated (very low, low, medium, high, and very high).Arc Map 10.1 with geo-statistical analyst extension of Arc GIS software was used to prepare soil fertility maps while interpolation method employed was IDW (Inverse Distant Weight).

III. RESULT AND DISCUSSION

A. Soil Texture

Majority of samples (70% of total soil samples) were identified as sandy loam textured whie 30% of soil samples were identified as Loam textured and no soil samples were identified as Clay loam texture.The microbiological processes, water infiltration and retention, soil aeration, tillage, and irrigation techniques are all influenced by the texture of the soil. (Shrestha *et al.*,2018).Most studies on the relationship between texture and cardamom production show loam soils as less productive than drained sandy loam soils (Khatiwada *et al.*, 2019). Highest yields are from soils with drained sandy loam in the surface soil and a similar or somewhat higher percentage in the subsoil (FAO, 2008).

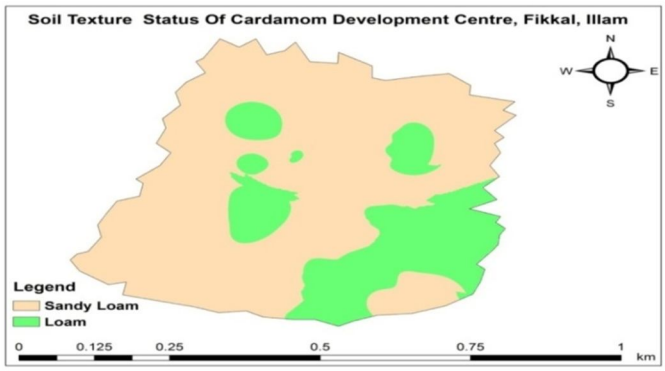


Figure 3: Soil texture map of CDC, Ilam

Table 2: Standard rating of soil texture

Variable	Soil textural class	Area (ha)
Soil texture	Sandy loam	12.11 (70%)
	Loam	5.19 (30%)

B. Soil PH

Variability of soil with reference to pH is shown in (Figure 4).The majority (83.3%) of soil of research area was found acidic and 16.6% of soil samples were found neutral. No samples were found to be alkaline in nature. This indicates moderately acidic soil pH. For normal growth, a pH range 5.5-7.5 is suitable for cardamom growth (Shrestha *et al.*, 2018). Acidic fields found in these places may not require liming to address soil acidity, therefore simple floods or field submergence may be used to those soils if their pH is below 5.1, however liming is required in fields with pH below 3.(Khadka *et al.*, 2019).

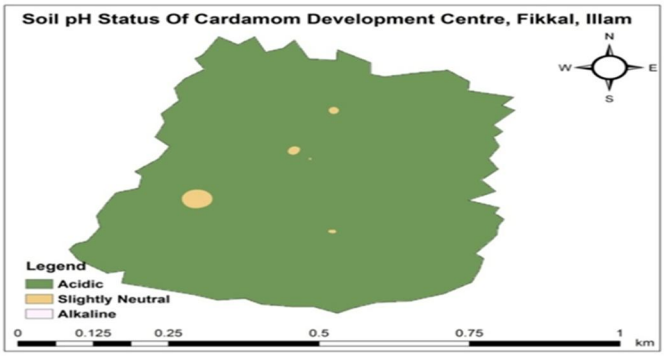


Figure 4: Soil pH status of CDC, Ilam

Table 3: Standard rating of soil pH.

Variable	Rating	Area (ha)	Area (%)
Soil pH	Acidic	14.42	83.3
	Neutral	2.88	16.6
	Alkaline	0	0

C. Organic Matter

Majority (75%) of the soil samples of the research area were found to be high in soil organic matter content (SOM). Similarly, 1.67% of the field was found to be low in SOM and 23.33% of the field was found to be in medium state. Organic matter is important source of plant essential nutrients after their decomposition by microorganisms (Fageria, 2012). It supplies plant nutrient, improve the soil structure, water infiltration and retention, feeds soil micro-flora and fauna, and the retention and cycling of applied fertilizer (FAO, 2014).

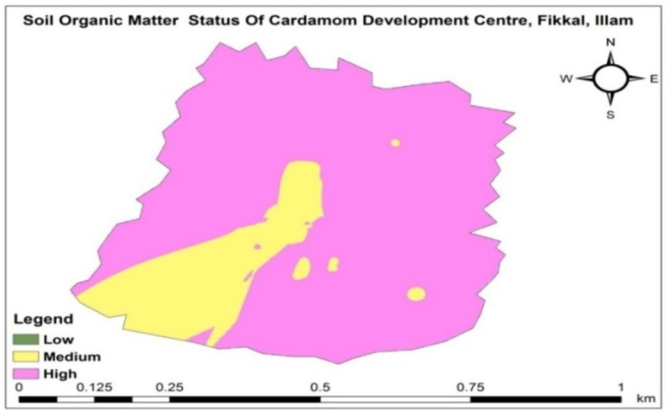


Figure5: soil Organic matter status of CDC, Fikkal

Table 4: Standard rating of soil Organic Matter.

Variable	Rating	Area (ha)	Area (%)
Total soil organic matter .	Low	0.29	1.67
	Medium	4.04	23.3
	High	12.98	75

D. Total Nitrogen

In the sample area,73.3% of the area was observed to be high in Nitrogen,25% of the area was observed to bein medium range and 1.67% of the area was observed to be low in nitrogen content. One of the most critical and usually inadequate nutrients for plants is nitrogen (N). (Tisdale et al., 1993).

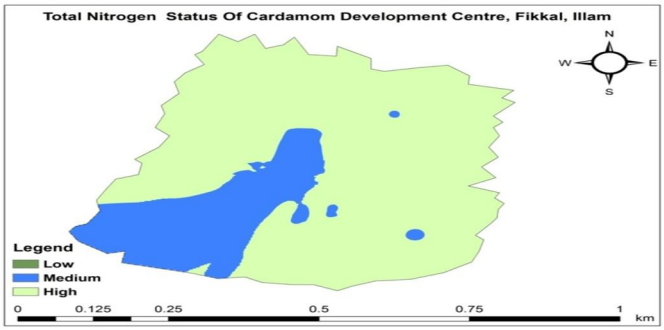


Figure 6: Soil nitrogen map of CDC, Ilam

Table5: Standard rating of soil nitrogen.

Variable	Rating	Area (ha)	Area (%)
Total soil Nitrogen .	Low	0.29	1.67
	Medium	4.33	25
	High	12.69	73.3

Majority of the sampled soils had high nitrogen content (73.3% of total sample) and high organic matter content (75% of total sample).

E. Total Phosphorous

Majority (90%) of the soil samples were found to be medium in phosphorus content. About 3.33% and 6.67% of the soil samples were found low and high in Soil phosphorus content respectively in the study area (Table 6). The availability of P in the soils restricts the growth of both cultivated and uncultivated plants(Foth & Ellis, 1997). Like other spice crops, cardamom needs a significant amount of phosphorus for brisk growth and great grain output. (Shrestha *et al.*, 2018).

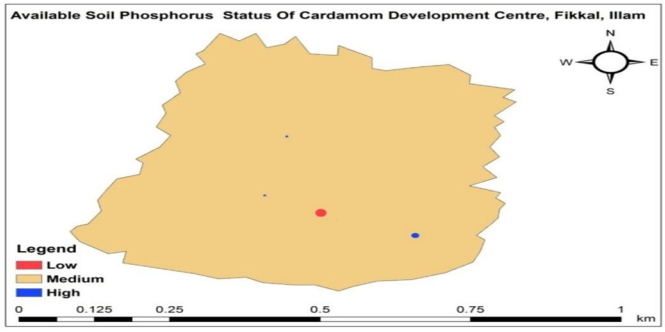


Figure 7: Soil phosphorous map of CDC, Ilam

Table 6: Standard rating of soil Phosphorous

Variable	Rating	Area (ha)	Area (%)
Total soil Phosphorous .	Low	0.58	3.33
	Medium	15.57	90
	High	1.15	6.67

Department of Soil Science, NARC rated P ranges of 0 – 31kg/ha as low, 31-55 kg/ha as moderate and >55 kh/ha as high. This shows that P levels in most of the location in the study area was medium. For the energy transmission system, phosphorus is necessary. It is a part of the RNA and DNA that control genetic information. (Khadka *et al.*, 2019)

F. Extractable Potassium

Available potassium status of the research area shows that majority (60%) of the soil samples were found to be low in potassium content. About 39.9% and 0.01% of the total samples were found to be medium and high in potassium content respectively (Table 7).After nitrogen and phosphorus, potassium (K) is the third-most crucial necessary element that limits plant productivity. (Sadanandan *et al.*, 2000).

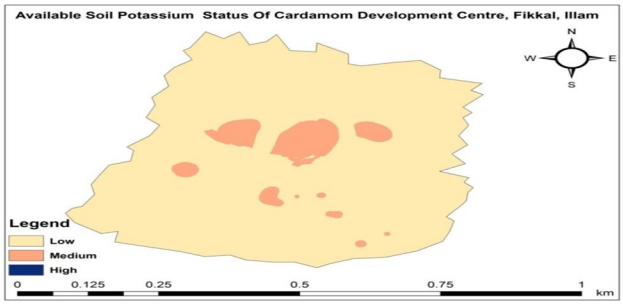


Table7: Standard rating of soil Potassium

Variable	Rating	Area (ha)	Area (%)
Total soil Phosphorous .	Low	10.38	60
	Medium	6.92	39.9
	High	0.001	0.01

Department of Soil Science, NARC rated K ranges of <110 kg/ha as low, 110-280 kg/ha as moderate and >280 as high. Majority of soil samples (60% of total soil samples) was found to be deficient in potassium content and the average value was also found to be moderate. Potassium is necessary in young growing tissues for cell elongation and possibly for cell division. It also helps in several physiological processes and uptake of other nutrient elements (Sadanandan *et al.*, 2000).

G. Overall Soil Fertility Status of CDC, ILAM

Table 8 shows general soil fertility status averaged over cardamom development center, Ilam. The pH of soil varied from 3.9 to 6.05 with a mean value of (5.19±0.08) which indicates slightly acidic nature in majority of the research location. The soil pH showed low variability (12.64%) among the soil samples. Therefore, observed pH is suitable for cardamom cultivation in the majority of the area. In context to Organic matter, it was found to be high (5.3%±0.0096) with majority of the research location and showed moderate variability (11.024%) among the soil samples. Total soil nitrogen (0.263kg/ha±0.0038) was found to be high with majority of the research location with the low variability of 11.35%.The total nitrogen content was ranged from 0.17 to 0.31 with a mean value of 0.263. This indicates high content of total nitrogen. The nitrogen content is satisfactory. Therefore, there is no necessity of regularly supply of nitrogen either in organic or inorganic form. Available phosphorous (49.61±0.89) was found to be medium in nature and showed low variability (14.045%) among the tested soil samples. The organic matter content was varied from 3.5 to 6.23% with a mean value of 5.3 %(Table 8). It indicates that the organic matter content was high. The plants have tolerance capacity against any kinds of stressed conditions. Therefore, incorporation of organic matter adding materials is not important as per the conditions of the field. However, Available potassium (82.78±7.71) was found to be low and High variability (67.13%) in extractable potassium was determined among the soil samples.

Table 8: Overall soil fertility status of CDC, Ilam

	Ph	Organic Matter (%)	Nitrogen (%)	Phosphorus (kg/ha)	Potassium (kg/ha)
Mean	5.19(0.08)	5.30(0.08)	0.26(0.003)	49.61(0.89)	82.78(7.17)
CV	12.6	11.04	11.35	14.04	67.13
Minimum	3.90	3.50	0.17	9.47	16.00
Maximum	6.80	6.23	0.31	55.52	160.00
Root mean square error	0.08	0.01	0.004	0.89	7.71
Median	5.05	5.30	0.27	51.39	48.00

IV. CONCLUSION

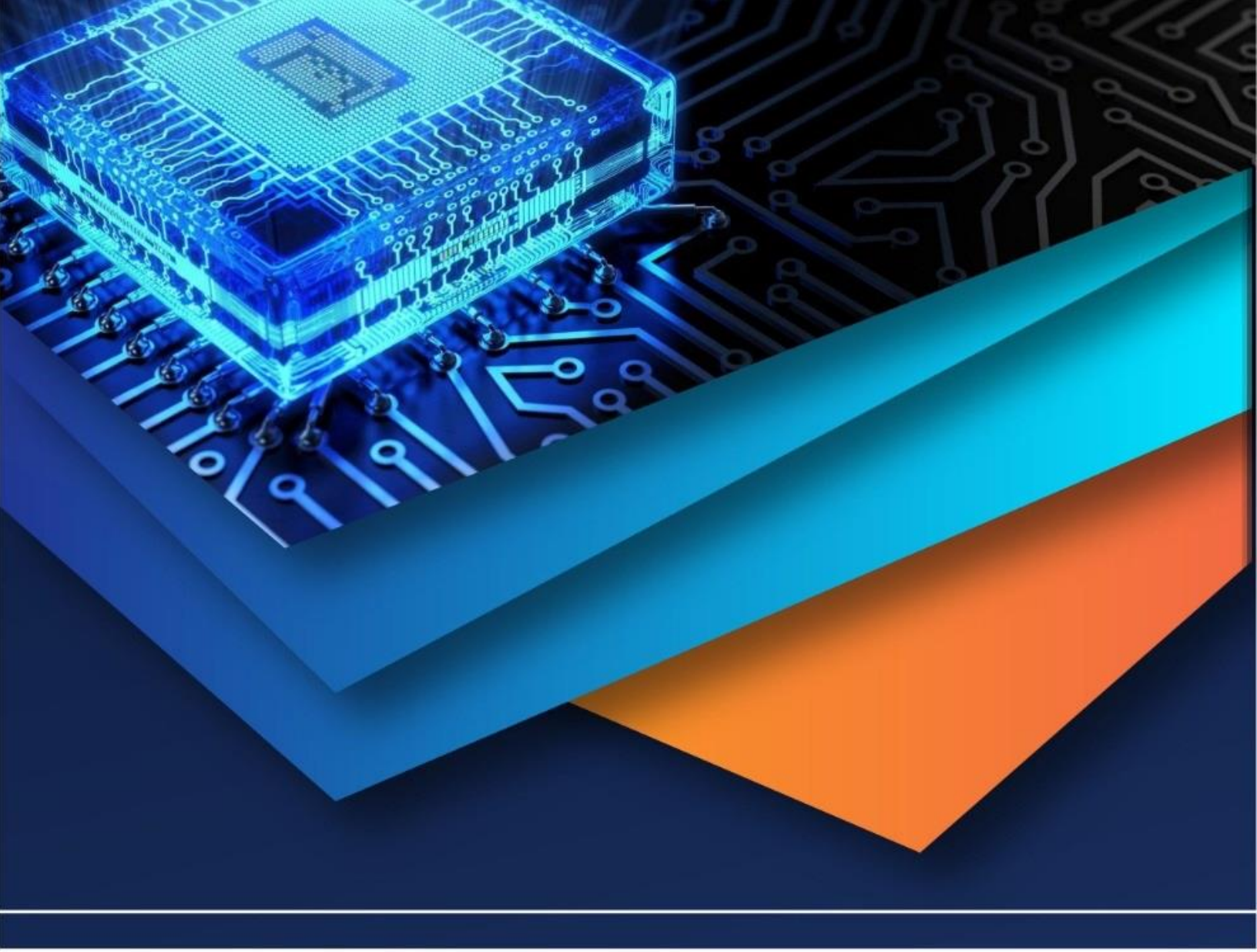
In general, soils had a sandy loam texture. They were highly acidic in reaction and it is advisable to apply agricultural lime periodically for its amelioration as per the level of the level of acidity. The nitrogen, phosphorus and potassium status were high, medium and low. Soil pH was found in optimum conditions for cardamom growing soils. Cardamom may suffer from deficiency of potassium and high toxicity of Nitrogen; hence, for these nutrients specifically, a proper nutrient management plan should be used. The integration of manure or compost, crop residue retention, green manuring, etc. are not essential due to the high level of soil organic matter. This study has led to the conclusion that future research strategies for improving the efficacy of cardamom production should be developed based on the soil fertility status of farmland in the cardamom development center region in Pandam, Fikkal.

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