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YIELD ESTIMATION OF PADDY CROP BASED ON SOIL ORGANIC CARBON LEVELS IN COMMAND AREA OF HANJIHALLI VILLAGE TANK USING REMOTE SENSING (RS) AND GIS

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ABSTRACT

Field research was conducted during 2019 in command area of Hanjihalli village tank to access the yield of paddy crop using remote sensing (RS) and geographical information system (GIS). The experimental study area was divided into 63 grids and soil samples were collected from the precise location using Garmin 72H GPS device. The organic carbon (OC) content was analyzed by employing wet oxidation method and the samples were sorted into low, medium and high OC status. The samples of low, medium and high OC status grids were marked using Garmin 72H GPS device, the paddy samples were analyzed for yield and were arrived at conclusions. Grain yield of paddy was recorded significantly higher (8942 kg ha^{-1}) in high organic carbon level compared to other organic carbon levels. The higher paddy grain yield was a result of higher yield attributes.
Keywords **:** GIS, Paddy, Remote sensing, Soil OC, Yield estimation

Introduction

Soil mainly is the incredible gift of nature to all the earthlings. It is an important innate resource base to perform basic functions for gain of mankind and environment. On count of this kindness, we treat soil as ‘mother’. Contribution of India is 10 per cent to the global degraded soil area, which was largely driven by anthropogenic mistreat of soil via indiscriminate, non-scientific and non-sustainable intensive agricultural practices. It has turn out to be more crucial now than before to protect and safeguard worth of soil resource to sustainably put-up productivity. Since assault on soil quality, more than nature, is the act of all builders, stakeholder-farmers and common folks. They have to be fraction of protection and preservation programs also.

In the year 2018, the global population has crossed 7.5 billion and it may reach 9.6 billion by 2050. Hence to convene the demand, the agriculture production has to be increased to 3 billion tonnes from current 2.1 billion tonnes. The growing population pressure demand for food, fibre and fuel, appropriate management of this indispensable natural resource is of vital significance for sustenance.

One of the difficulties frequently met for making decisions are lack of the scientific data pertaining to our natural resources. Food production have to be increased by at least 40 per cent by 2025 to meet the desires of 33 per cent raise in human population and to gratify trends for enhanced nutrition (Bos *et al.*, 2005). To come across these targets of food production for a healthy population, increase in the food grain and therefore development in agriculture segment is unavoidable. As land availability is restricted, increasing food production from finite land wealth is one of the challenging tasks for upcoming decades.

Remote sensing has developed as a potent tool for studying soil resources as it aids to study soils in the spatial sphere in time and lucrative way (Saxena, 2003). RS is the proficient tool in the basket of geo-scientists for geomorphological, geological and soil resource mapping with regard to their degree, nature, spatial allocation and limits for best possible utilization of natural resources on a sustainable root. Several studies conducted in India as well as overseas have proved this (Govardhan, 1991).

Geographical Information System (GIS) analyzes as well as display manifold data layers resulting from diverse sources and gives valuable information to figure out huge data generated by usual and RS expertise both in spatial and non-spatial set-up predominantly in soil surveys.

Organic carbon is one of the important parameters for crop production. Higher the organic matter level in soil adds up to the higher soil organic carbon (SOC) pool and increased microbial activity in soil. Organic matter also adds an advantage of increased physical properties of soil.

Reliable nutrient recommendations depend on precise soil tests and crop nutrient standardizations based on widespread field research. The real fertility status of soils has to be evaluated before setting up for any crop production, which will aid in overseeing the nutrient/fertilizer application to crops. At Hanjihalli village tank, system of farming has transformed gradually during the past years. It is vital to measure the fertility and ways for improving their productivity. Active information on these soils is meagre. Hence thorough soil assessment was undertaken to discern the soil fertility status.

Rice (*Oryza sativa* L.) is the staple food crop of the world. It is grown in over six continents and in more than 100 countries. In Asia alone, more than 2 billions of people are getting nearly 60-70 per cent of their energy need from rice and its derived products (Geethalakshmi *et al.*, 2011). Human consumption accounts for nearly 85 per cent of total rice production and hence deserves a unique status among food grain crops as world's most important wetland crop. Area under paddy in the world is 163.2 million hectares with a production of 758.9 million tonnes and an average productivity of 4.45 t ha^{-1}. In India, rice is grown in an area of 43.44 million hectares with an annual production of 112.40 million tonnes and a productivity of 2.70 t ha^{-1} (Anonymous, 2021). In Karnataka, it is grown in 2.52 million hectares with a total production of 3.92 million tonnes and the average productivity of 2.72 t ha^{-1} (Anonymous, 2021).

Hanjihalli lies in Hassan district, Karnataka state, India. Its contribution to agricultural production is very phenomenal, where in Paddy is the only crop grown in this command area in the *kharif* season. Hence an effort was made to delineate the organic carbon status of the soils and paddy yield assessment using remote sensing and geographical information system technique for sustainable crop production in the study area.

Material and Methods

A field experiment was planned during *kharif* 2019 (June-September) in command area of Hanjihalli village tank to access the yield of paddy crop using RS and GIS. The command area of Hanjihalli village tank is positioned in Alur Taluk of Hassan district with a coverage of 63 hectares (Fig. 1). The command area of Hanjihalli village tank is located at 12^{o} 55' 28.647" to 12^{o} 56' 1.221" North latitude and 75^{o} 58' 38.419" to 75^{o} 59' 14.882" East longitude. The Hanjihalli village tank comes under Southern Transition Zone (Zone VII) of Karnataka and is about 6.9 km from Alur town. The altitude of command area is 914 m above MSL.

The soils in the command area are majorly belong to order *Alfisols*, which represent chief soil order for food and fiber production. The soil texture varies from loamy sand to clay. It is characterized by a clay enriched subsoil and relatively medium to high native fertility.

The climate is moist, hot, sub-humid and the annual precipitation ranges from 612-1054 mm. The average minimum and maximum temperature being 18.20^{o}C and 29.12^{o}C, respectively.

Space borne multi spectral digital data

The satellite data utilized for the study was obtained by Karnataka State Remote Sensing Applications Centre (KSRSAC), Bangalore. The amalgamated data of Cartosat-1 (PAN) and Resourcesat-2 (LISS IV) MX in the type of digital and geo-coded were analyzed in GIS setting besides cadastral map.

Topographic map

The necessary topographic map (C43E13) at 1:5000 scale covering the study area was unruffled from the Survey of India (SoI) and used for the study.

Database creation and organization

For study purpose, digital cadastral map of command area provided by the KSRSAC, Bangalore was used. For database conception and union of various thematic maps the GIS with Arc GIS 10.4 software was used.

Field implements

Field implements used throughout study and grid sampling were soil digging tools like spade, markers, polythene cover and GPS (Model- Garmin72H) was used to determine the accurate location of study area.

Collection of samples

Sixty-three composite soil samples from the surface (0-15 cm) soil were collected transversely across the command area of Hanjihalli village tank covering an agricultural area of 63 hectares at 100 m grid intervals. The GPS data was recorded at each sample site.

Soil chemical analysis

The soil samples were dried in air beneath shade, powdered with pestle and mortar and were passed through 0.2 mm sieve. Later were analyzed for SOC by using wet oxidation method as described by Walkley and Black (Subbiah and Asija, 1956). In this method, samples were digested with concentrated H_2SO_4 in 10 ml of 1N $K_2Cr_2O_7$ making use of heat of dilution of H_2SO_4. Excess of $K_2Cr_2O_7$ was back titrated with standard FAS in the presence of Diphenylamine indicator. To hasten the reaction 10 ml of orthophosphoric acid was used and the results were expressed in %.

Grain yield of paddy at different organic carbon levels

Based on the organic carbon status, the soil samples depicting low, medium and high organic carbon status were marked using Garmin 72H GPS device and sample harvest was done from one m^2 area at different organic carbon level of the study area and yield parameters were recorded. The samples were analyzed using the CRD.

Statistical analysis

The observation obtained on yield attributes and yield of paddy in study area were underwent to statistical analysis using Fisher's method of ANOVA as outlined by Gomez and Gomez (1984). The 5 per cent level of significance used in 'F' test. Critical difference (CD) values are given in the table at 5 per cent level of significance, wherever the "F" test was found significant at 5 per cent level.

Results and Discussion

Soil organic carbon

The OC (%) in command area of Hanjihalli village tank ranged from 0.21-1.56% (Table 1). 31 ha (50%) of the command area recorded high organic carbon content (>0.75%) owing to application of organic manures in the previous years. While 16 ha (25%) of paddy fields reported low OC content (<0.5%). In remaining 16 ha (25%) area, the OC content varied from medium to high OC content (0.5-0.75%). Majority of soils in command area are high in OC content. The intricate relations among SOC, soil pH, allophane, aluminium (Al) phosphate showed that at lower pH values, liberation of aluminium from allophane promoted the formation of Al–humus complexes which increased the OC (Huygens *et al.*, 2005). Allophane was known to physically shield SOC against biodegradation in its mesoporic structures, where the O_2 diffusion and SOC accessibility to microorganisms will be low (Chevallier *et al.*, 2010).

Sixteen ha (25%) was under low organic carbon range, this was due to continuous cultivation of paddy and farmers had not applied recommended FYM or organic matter to the fields. Medium organic carbon area 16 ha (25%) was mainly due to application of recommended FYM to the field, 31 ha (50%) was having high organic carbon %, this was due to crop residue of pulses and paddy, and FYM application which led to more OM and the results were in evidence with the findings of Haribhushan *et al.* (2013).

Table 1: Soil organic carbon (OC) content of command area of Hanjihalli village tank

OC Class	Command area of Hanjihalli village tank	
	Area (ha)	Area (%)
Low (<0.5%)	16	25
Medium (0.5-0.75%)	16	25
High (>0.75%)	31	50

Grain yield of paddy at different organic carbon levels

Grain yield of paddy was recorded significantly higher (8942 kg ha^{-1}) in high organic carbon level compared to other organic carbon levels (Table 2). The higher paddy grain yield was contributed by higher number of productive tillers per hill & higher number of seeds per panicle (Laxminarayana, 2000).

Fig. 1: Landscape view of command area of Hanjihalli village tank

Table 2: Yield analysis of paddy at command area of Hanjihalli village tank at different organic carbon levels

Treatments	Number of hills m^{-2}	No. of productive tillers $hill^{-1}$	No. of seeds $panicle^{-1}$	Test weight (g)	Yield (kg ha^{-1})
Low OC level	17.6	9.4	113.66	0.024	4095
Medium OC level	18.2	13.4	138.01	0.021	6150
High OC level	17.6	21.6	182.33	0.015	8942
S.Em±	0.673	0.812	22.47	0.004	307.22
CD (P=0.05)	NS	2.531	NS	NS	957.13

Conclusion

Remote sensing and GIS is a most powerful tool in analysing the nutrient status and yield estimation. The OC content of the study area ranged from 0.21-1.56%. 50% of study area was high in organic carbon status, 25% in medium organic carbon status and 25% area in low organic carbon content. The grain yield of paddy based on OC status was higher in high OC soils (8942 kg ha^{-1}) followed by medium and low OC soils (4095 kg ha^{-1}).

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