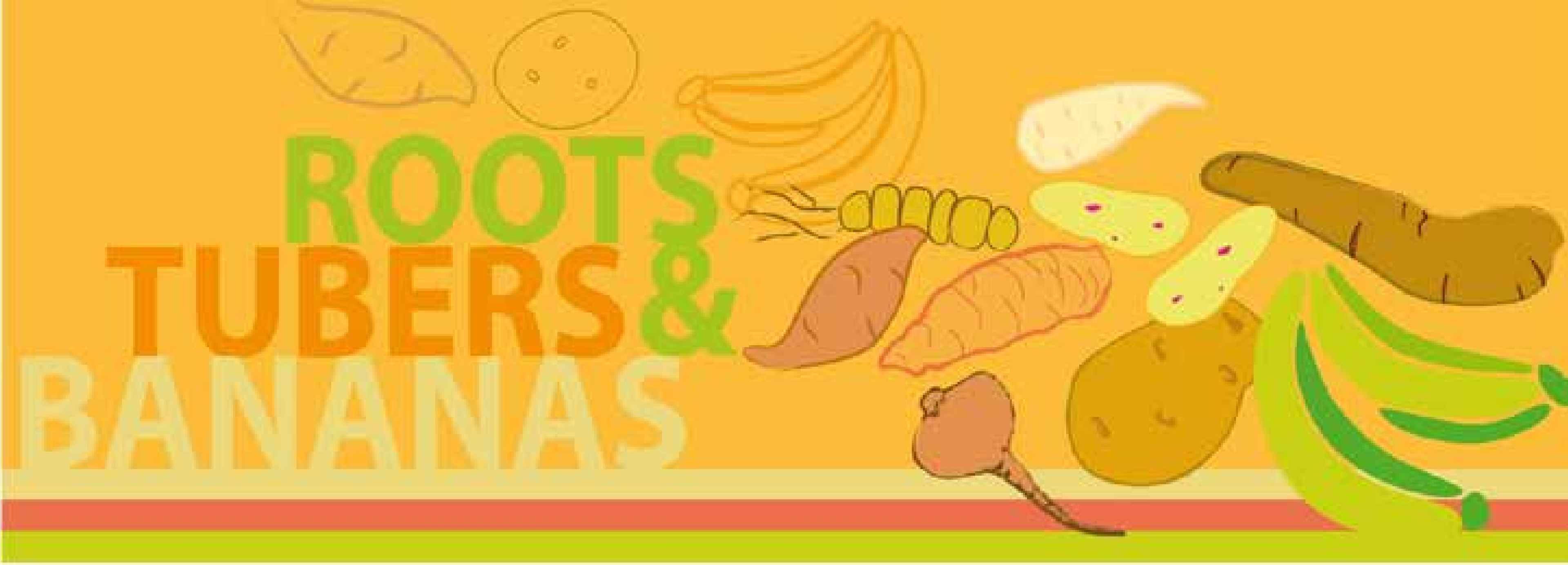


Spatial variability of soil organic carbon in a cassava farm, Nigeria

Tunrayo Alabi & Jayeoba James

ESRI International User conference/San Diego, USA
July 12-15 , 2014

CGIAR
Research Program on Roots, Tubers and Bananas

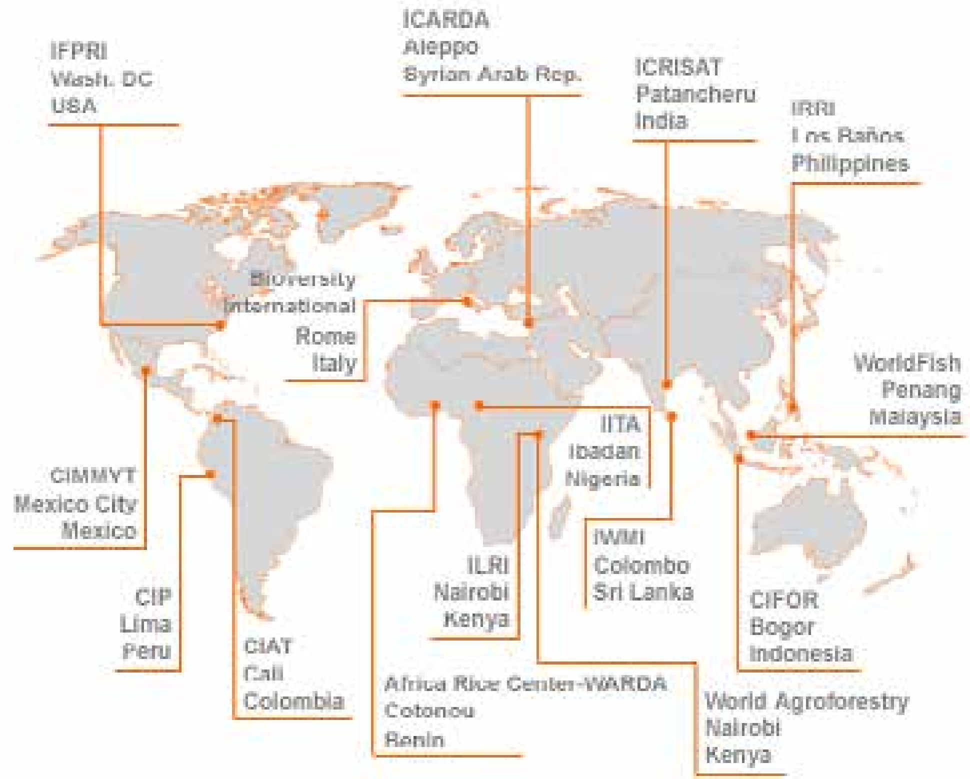
Outline of presentation

- Introduction of IITA
- Cassava : a new industrial crop in Nigeria
- Cassava production and yields in Nigeria
- Ekha Agro Farms
- Organic Carbon importance
- Soil Organic Carbon (SOC) data collection
- Data exploration techniques
- Kriging modes and results
- Conclusion

Introduction of IITA

CGIAR Research Program on Roots, Tubers and Bananas

- **IITA is one of the Consultative Group of International Agriculture Research Center (CGIAR)**
- **Our *mission is to work with partners to help* resource-poor farmers raise agricultural production, improve food security, and increase incomes in Sub-Saharan Africa**
- **Research mandate on cassava, maize, yam, soybean, banana/plantain, and cowpea**
- **Headquarter in Ibadan, Nigeria, with research hubs in West, Southern, East, and Central Africa.**

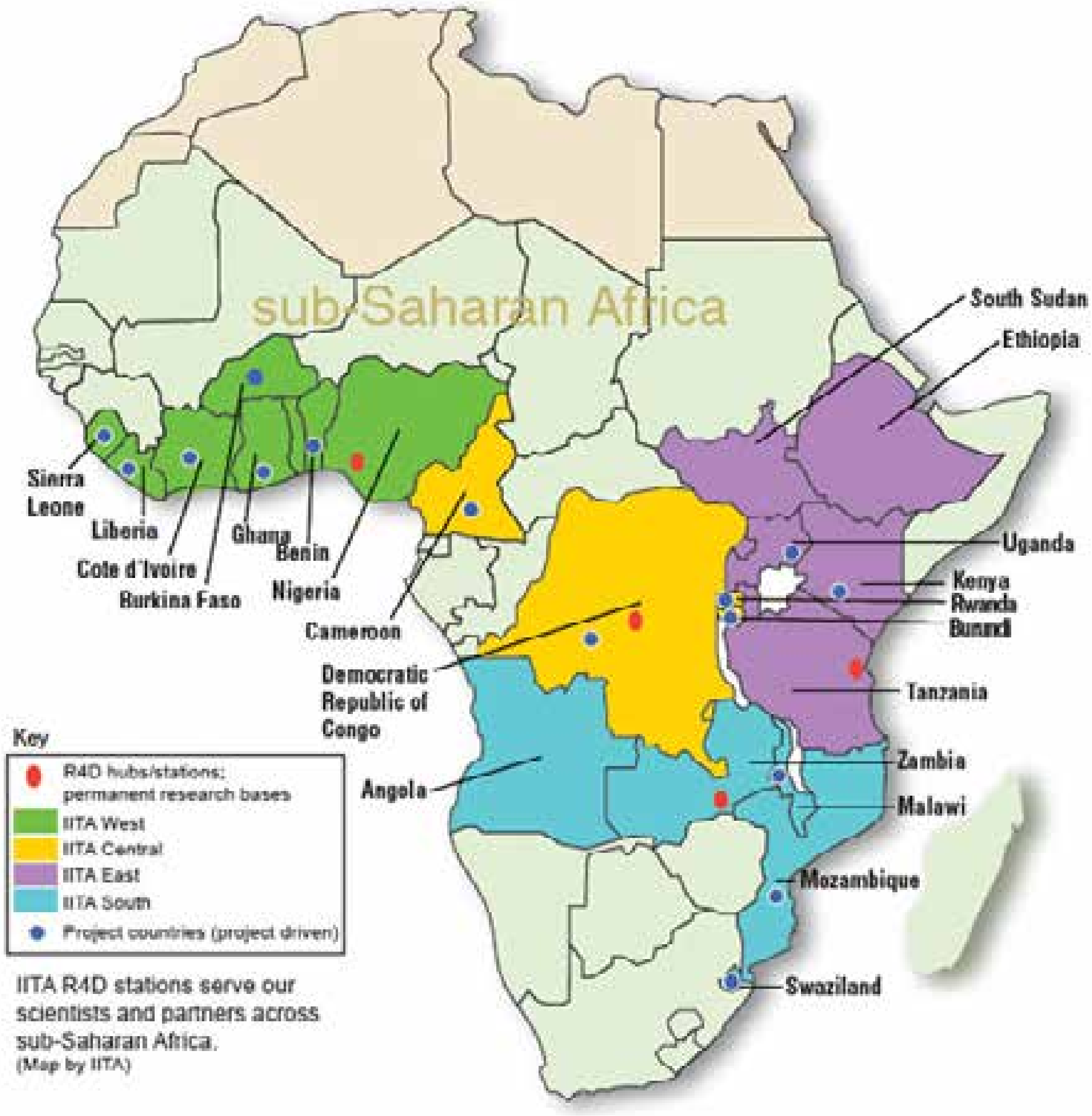


What we work on:

IITA’s Mandate crops

- **Cassava** (Manihot esculenta)
- **Maize** (Zea mais)
- **Cowpea** (Vigna unguiculata)
- **Soybean** (Glycine max)
- **Yam** (Dioscorea sp.)
- **Banana, Plantain** (Musa sp.)

Where we work



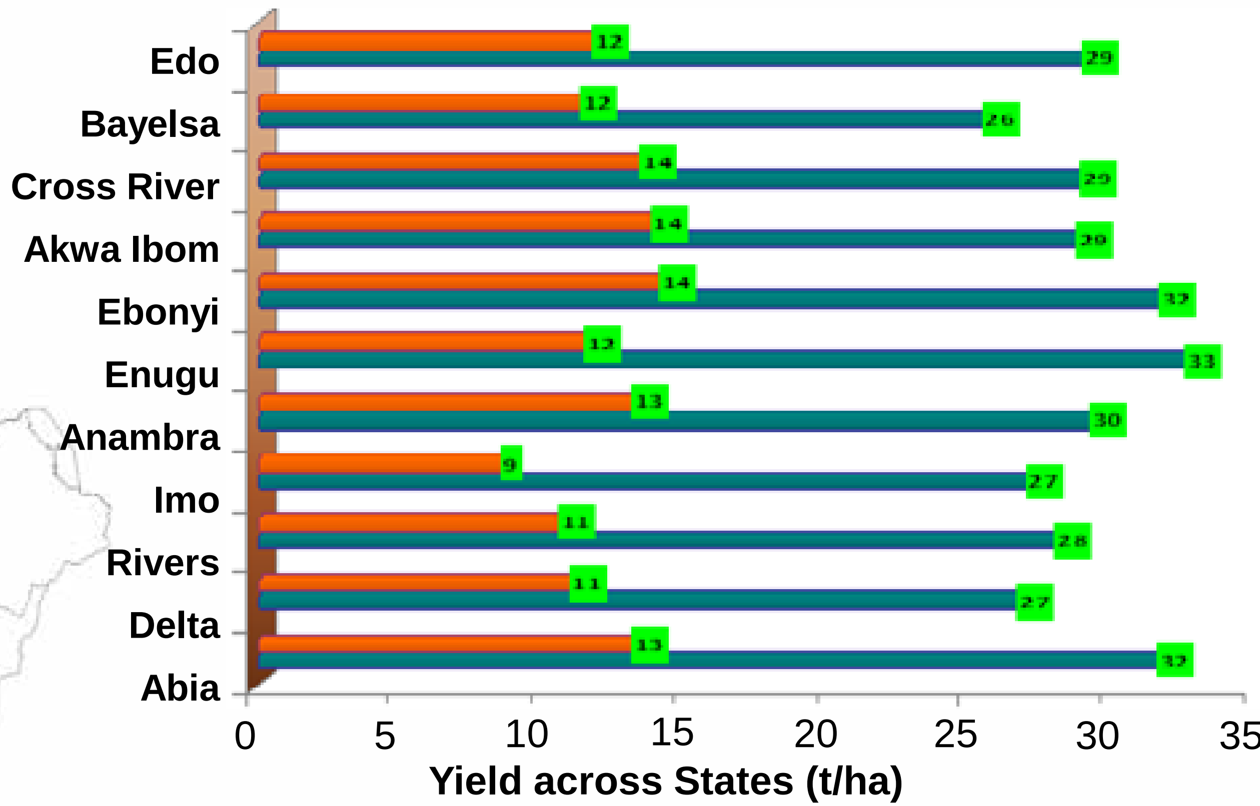
IITA R4D stations serve our scientists and partners across sub-Saharan Africa.
(Map by IITA)

Cassava: A new industrial crop in Nigeria

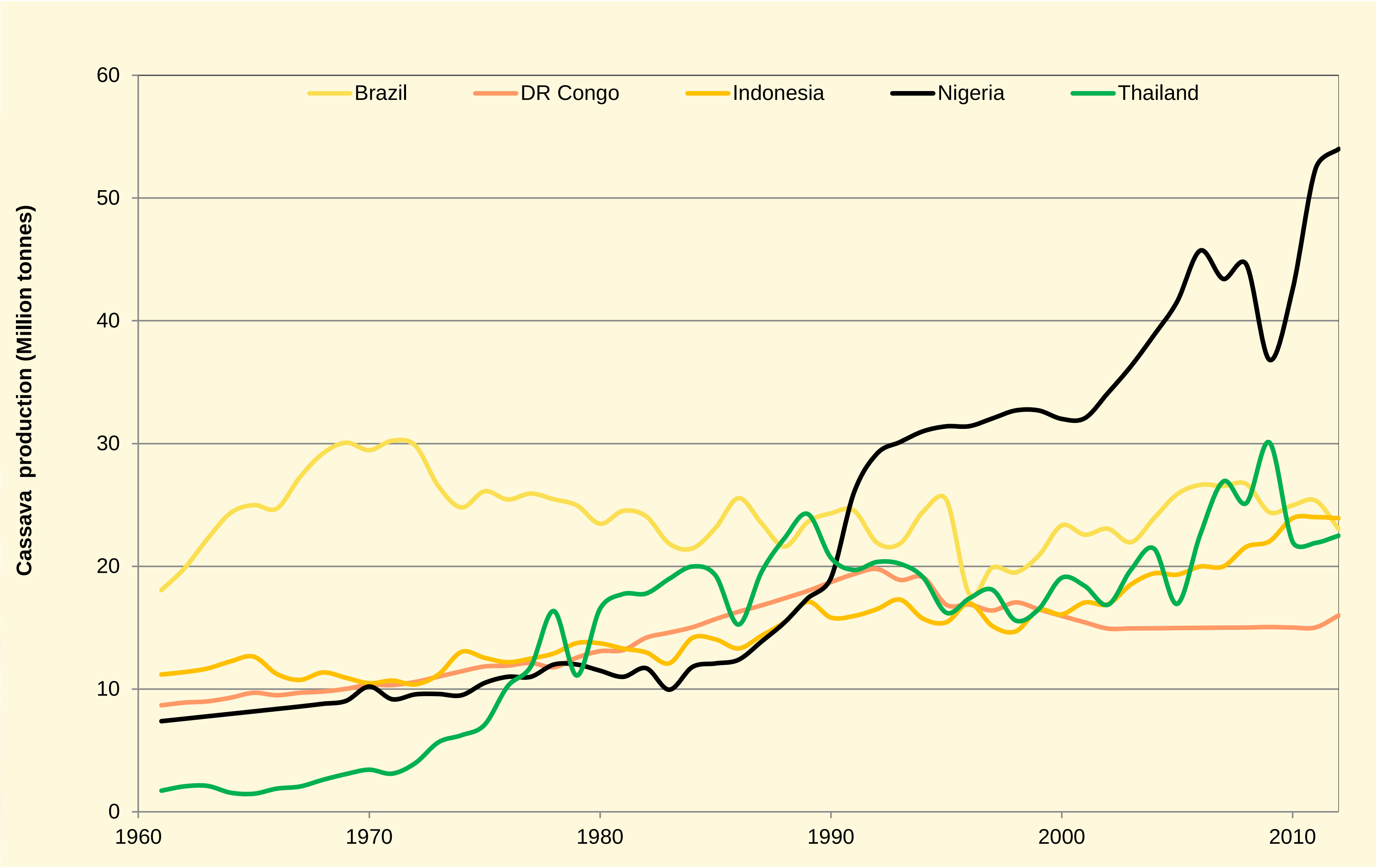
- Cassava has enjoyed over 400 years of cultivation in Nigeria
- Mainly used as food crops (only 10% for industrial uses)
- Brazil and Thailand employs 62% and 95% for industrial uses
- Nigeria targets to earn $5 billion annually from cassava exports

Yield gap of improved vs local cassava varieties

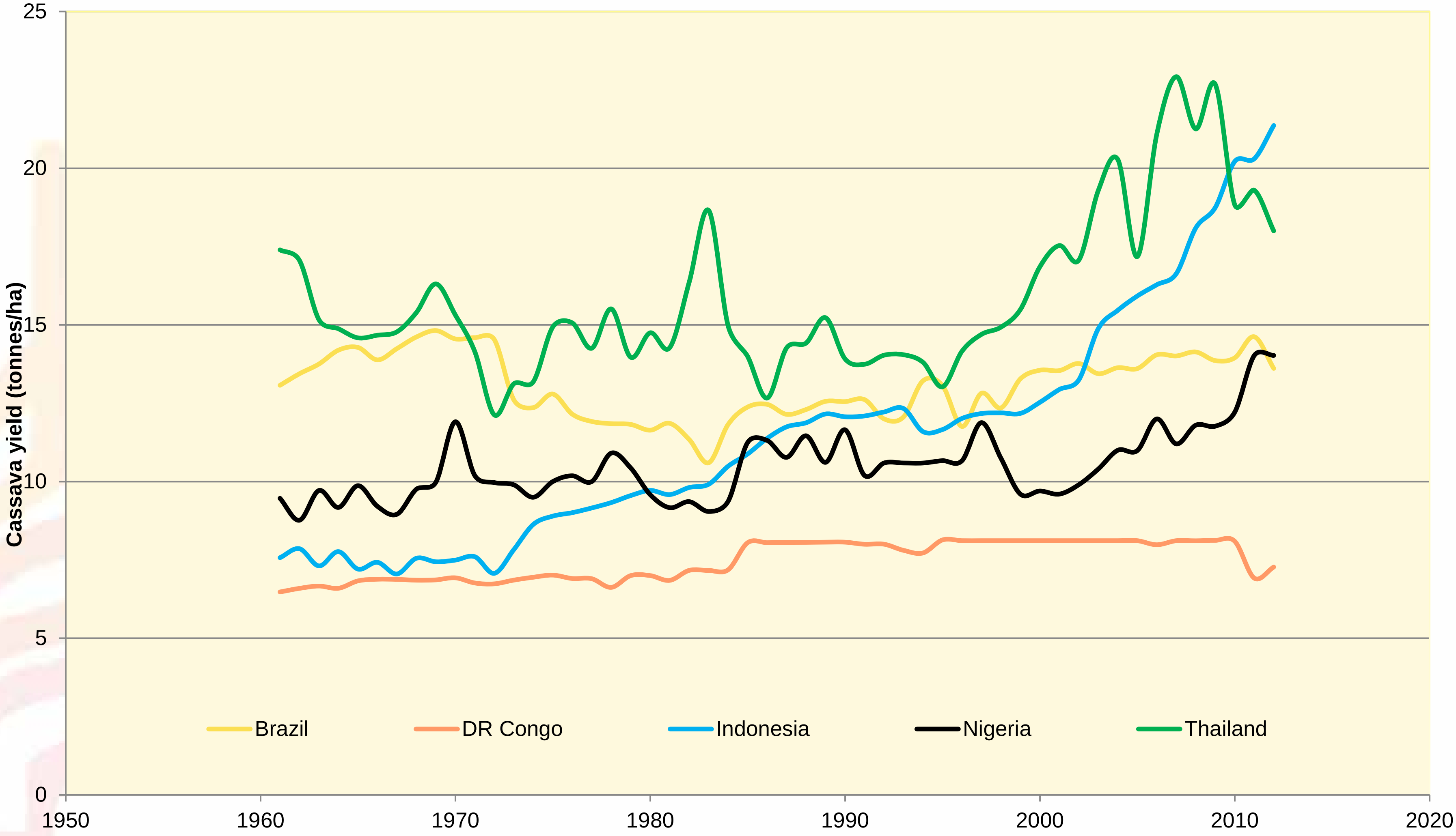
Trials in the Niger Delta region of Nigeria shows high yield gap between well managed Cassava farm and farmer's farm



Cassava production by major producer



Cassava yield of major producer



Cassava industrial Products

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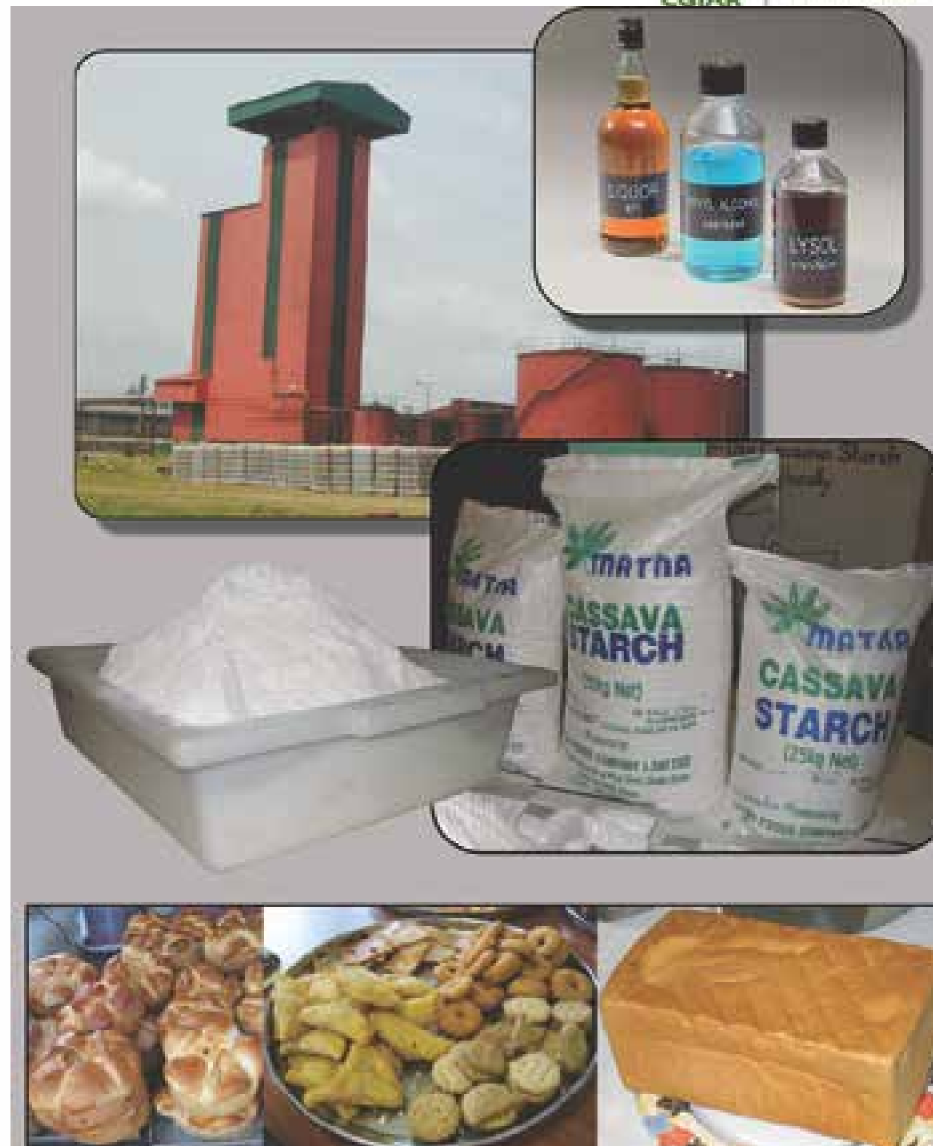
- Textile industries
- Ethanol
- Bakery & Flour industries
- Animal feeds
- Chips/pellets

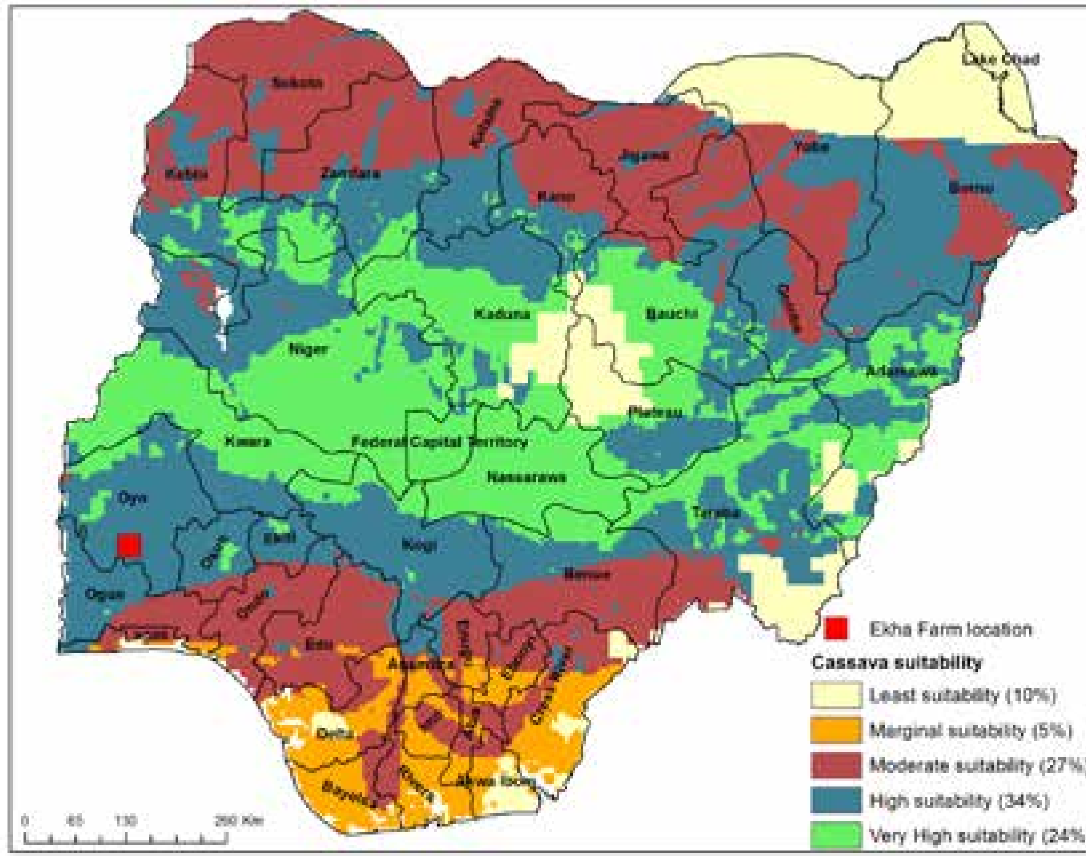


Ekha Agro Cassava Farm

- Ekha Agro Farms Limited was incorporated in 1986 and started operations in 1990 with importation and sale of food and feed additives such as amino acids, vitamins, and sweeteners including glucose syrup
- In 2004, the company made the strategic decision to diversify its operations into the production of cassava-based glucose syrup.
- IITA supported the establishment of the farm with improved cassava varieties and carried out soil survey of the 467 ha farm

Cassava suitability map of the farm

- Farm located in a high suitability zone for cassava production in Nigeria
- Ekha Agro farms is located in the south western part of Nigeria.
- Within derived savanna ecology
- The FAO dominant soil Ferric Luvisols
- Mean annual rainfall 1200-1300 mm



Source: Akoroda and Alabi, 2005

Soil Organic carbon importance

- Soil carbon improves the physical properties of soil.
- Increases the cation exchange capacity (CEC) and water-holding capacity of sandy soil
- Soil organic matter, of which carbon is a major part, holds a great proportion of nutrients, cations and trace elements that are of importance to plant growth.
- It prevents nutrient leaching and is integral to the organic acids that make minerals available to plants.
- It also buffers soil from strong changes in pH (Leu, 2007).
- It is widely accepted that the carbon content of soil is a major factor in its overall health.

Soil data collection

- **Soil sampling was carried out on a 250 m grid system with the aid of a GPS.**
- **Sampling points were pre determined and loaded into the GPS and located on the field with the GPS Go to' function**

Soil Sampling at Ekha Farms

Exploring soil organic carbon data

- Testing for Normality
  - Histogram
  - Normal QQPlot
- Testing for Stationarity
  - Voronoi map
  - StDev
  - Entropy
- Detecting Trends in the data

Exploring soil organic carbon data

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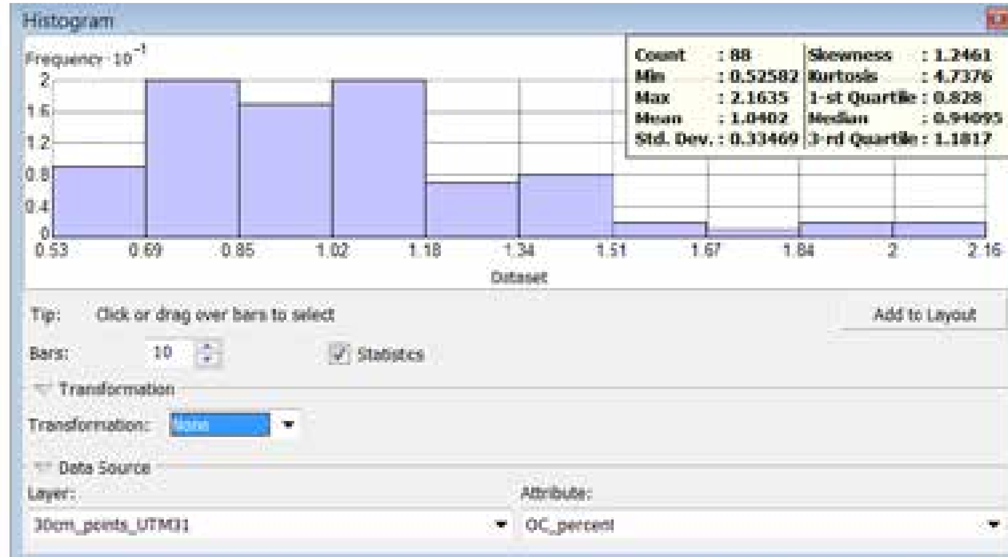
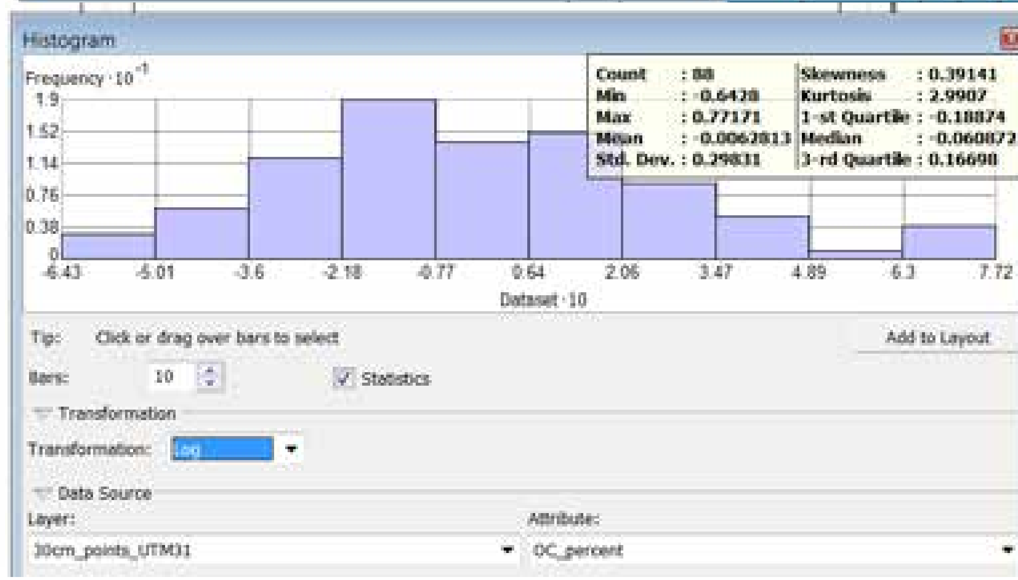
Histogram

- Normality tests conducted and log transformation applied on both topsoil and subsoil organic Carbon

- Skewness =1.246
- Kurtosis = 4.7376

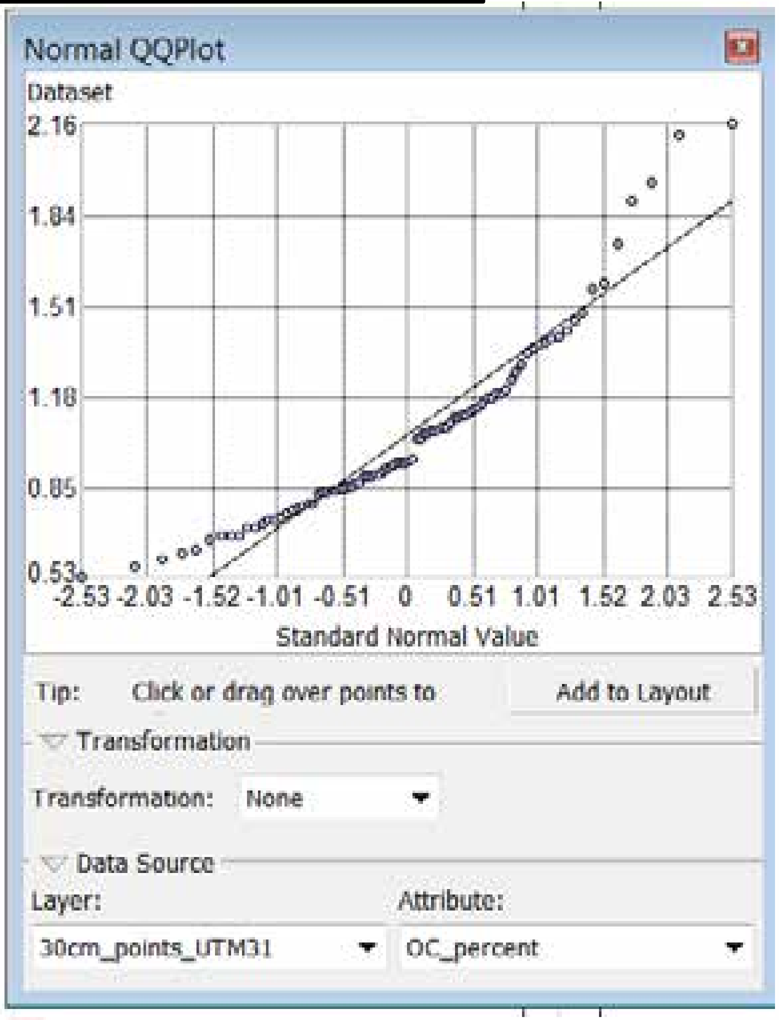
- After log transformation
- Skewness =0.3914 (≈ 0)
- Kurtosis = 2.9907 (≈ 3)



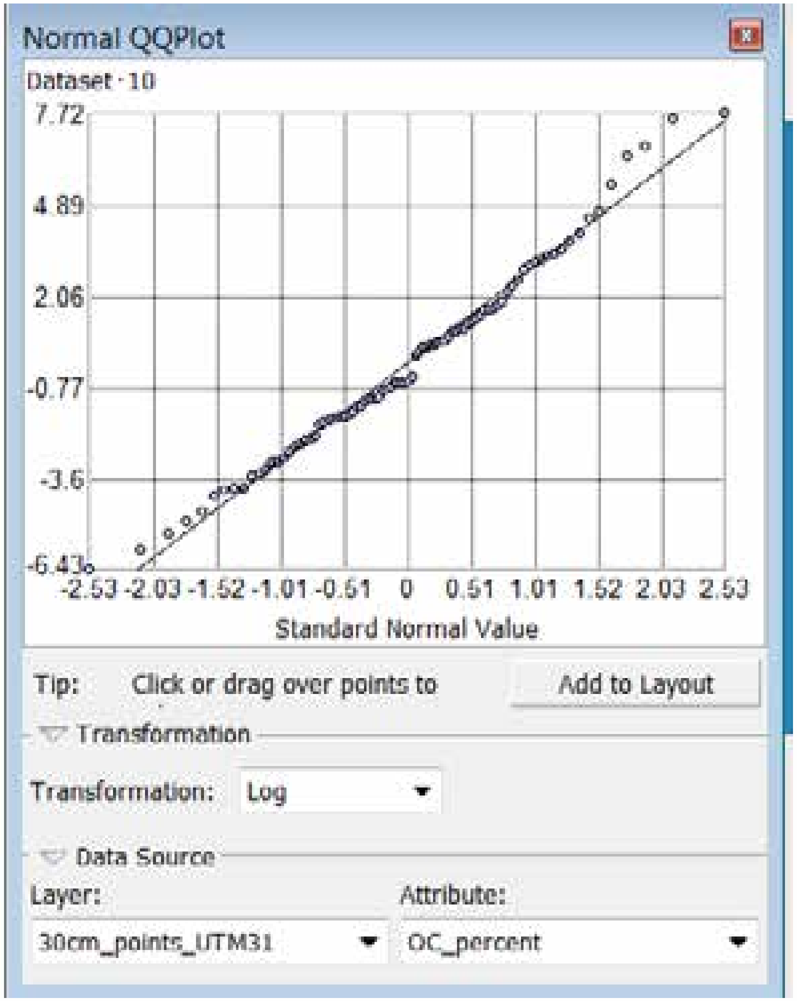


Exploring soil organic carbon data

Normal QQplot



Before transformation



After log transformation

Detecting trends in the data

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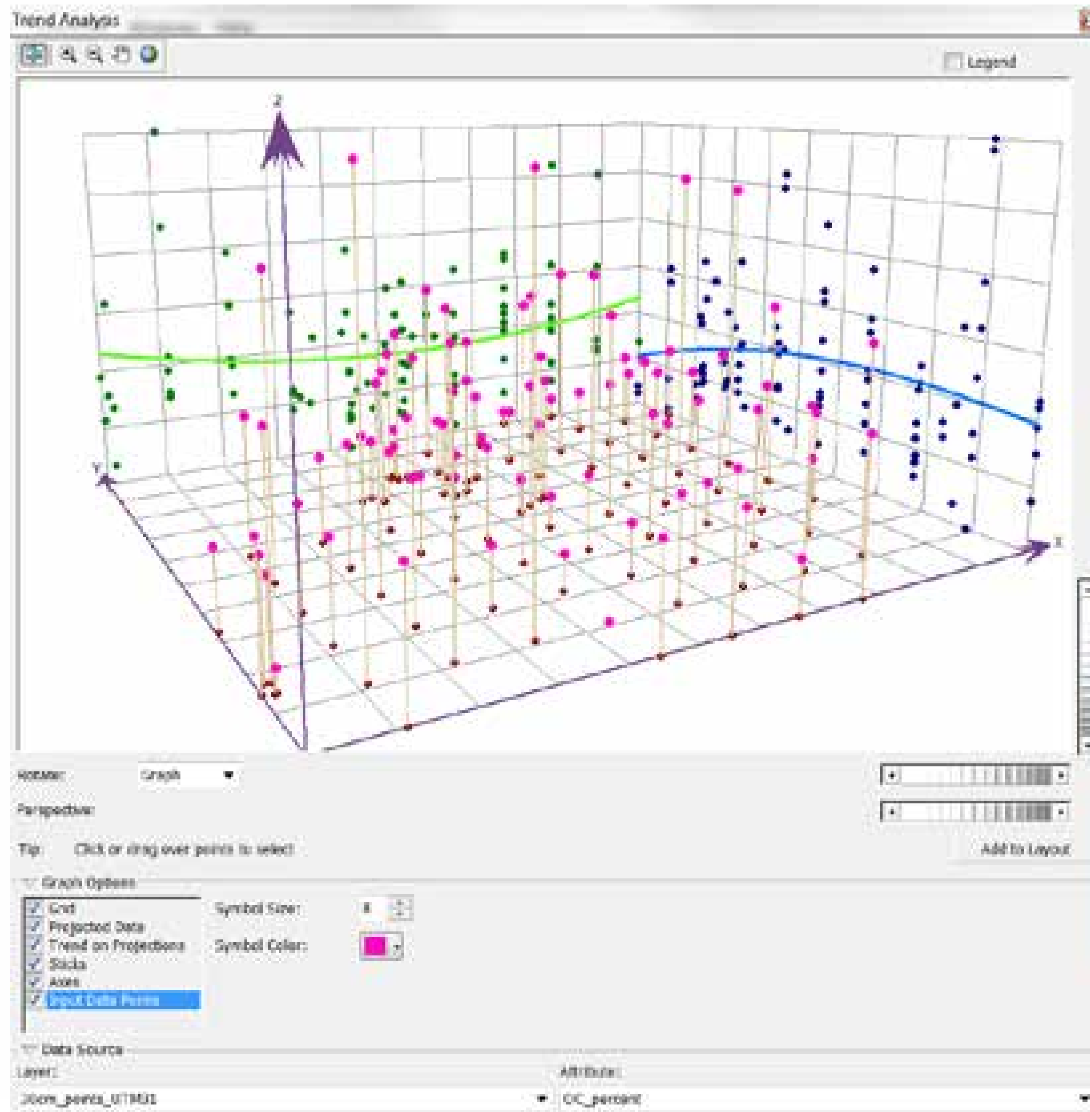
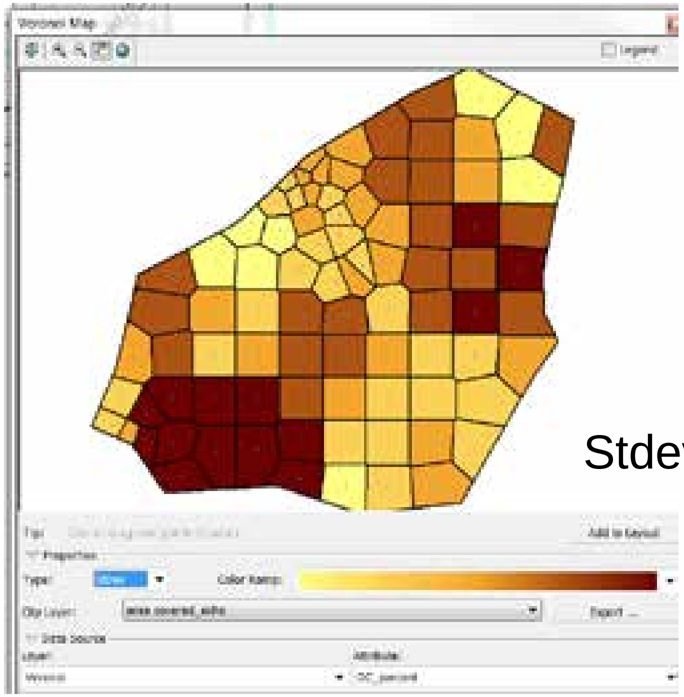
- Little trend exists along both axis
- Hence trend was not removed
- In the kriging procedure

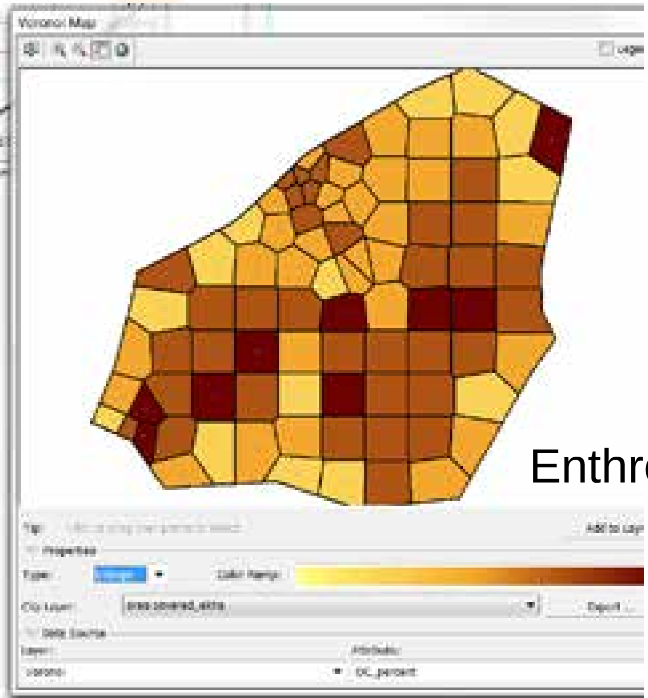


Stationarity in the data

- Voronoi map



Stdev

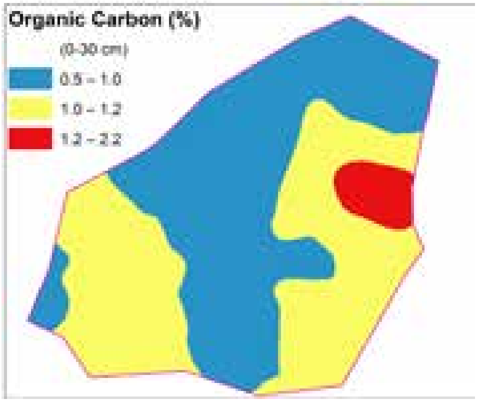


Enthropy

Randomness seen on both as evidence of stationarity in the data

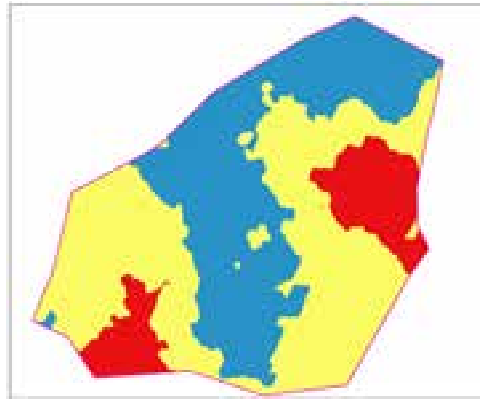
Prediction maps at topsoil (0-30cm)

Empirical Bayesian Kriging



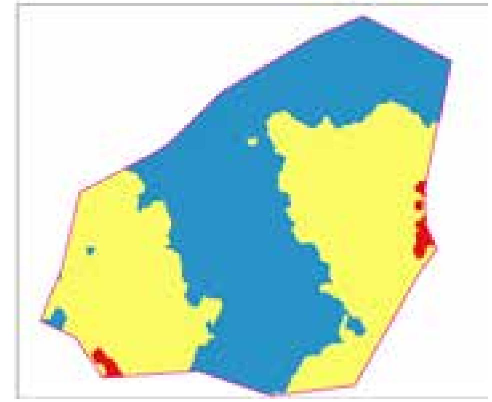
Mean Error (ME): -0.01139
Root Mean Square (RMS): 0.322138
Mean standard Error (AVS): 0.312
Root Mean Square Standardized (RMSS):1.017)

Ordinary Cokriging (K-Bessel)



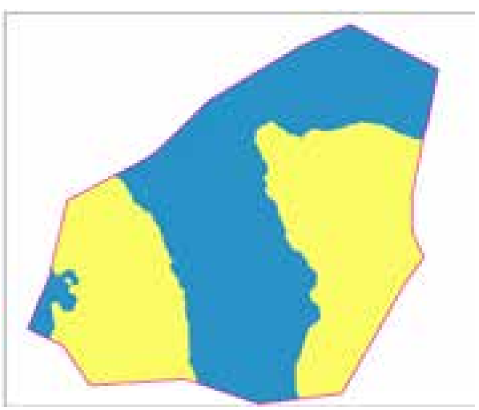
ME: -0.005294
RMS: 0.2382817
AVS: 0.235118
RMSS: 0.9989

Universal Kriging (Hole effect)



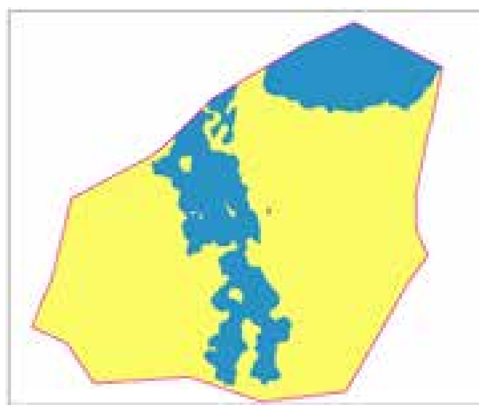
ME: -0.0004453
RMS: 0.3298
AVS: 0.31963
RMSS: 1.0321

Simple Normal score Kriging



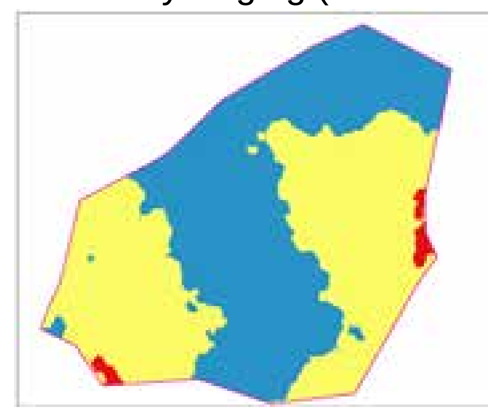
ME: -0.004323
RMS: 0.329815
AVS: 0.30996
RMSS: 1.05777 (Hole effect)

Simple Normal Score Cokriging



ME: -0.0034075
RMS: 0.2311
AVS: 0.2069
RMSS: 1.0706 (K-Bessel)

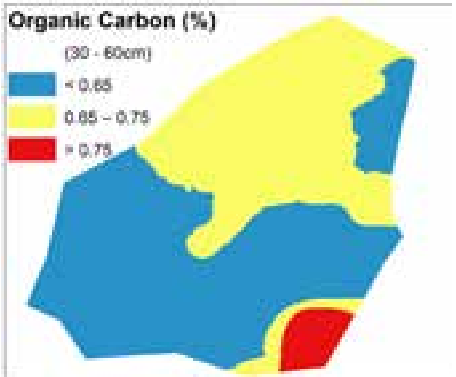
Ordinary Kriging (Hole effect)



ME: -0.0004453
RMS: 0.3298
AVS: 0.322685
RMSS: 1.0101

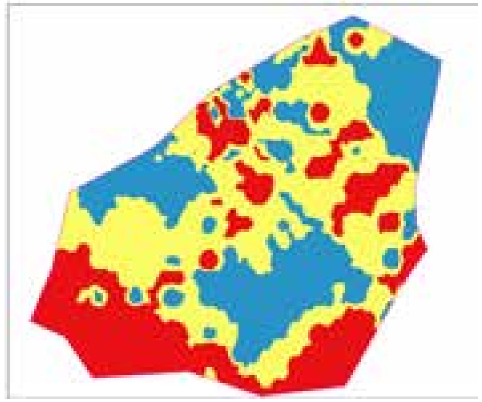
Prediction maps at subsoil (30-60cm)

Empirical Bayesian Kriging



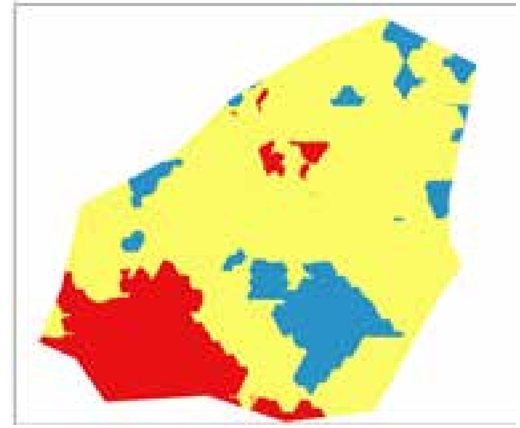
ME: 0.000597
RMS: 0.305104
AVS: 0.304083
RMSS: 0.9796

Ordinary Cokriging (J-Bessel)



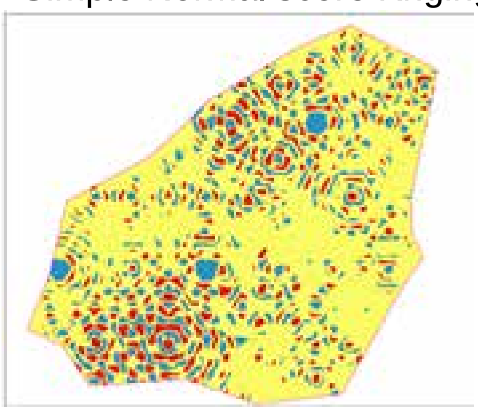
ME: -0.006204
RMS: 0.215256
AVS: 0.25804
RMSS: 0.97732

Universal Kriging (Hole effect)



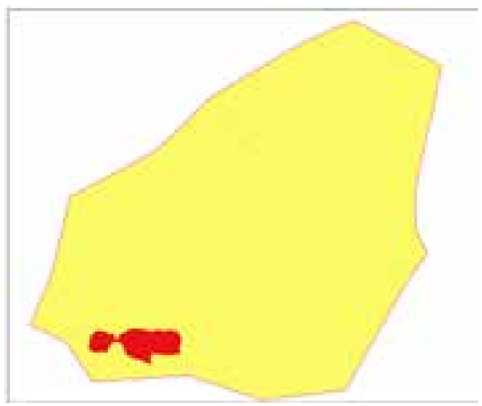
ME: -0.00142
RMS: 0.3183
AVS: 0.3128
RMSS: 1.0167

Simple Normal score Kriging



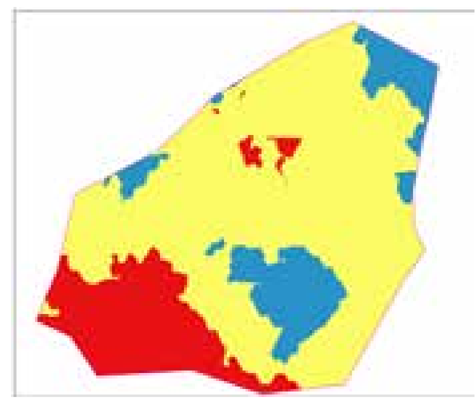
ME: 0.01151
RMS: 0.29118
AVS: 0.28044
RMSS: 1.0067 (J-Bessel)

Simple Normal Score Cokriging



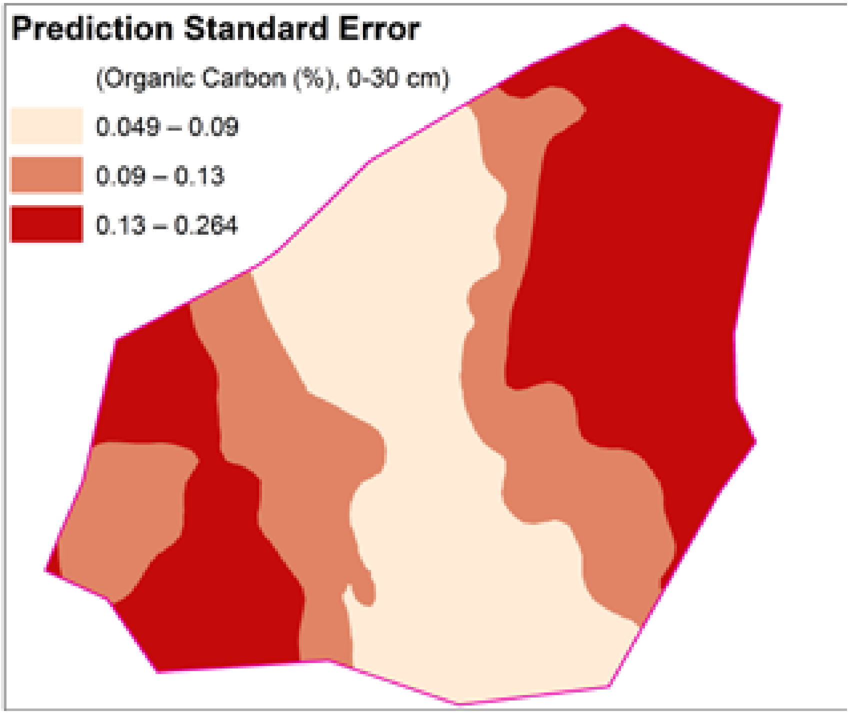
ME: -0.006978
RMS: 0.1999
AVS: 0.19075
RMSS: 1.0912(Stable)

Ordinary Kriging (J-Bessel)

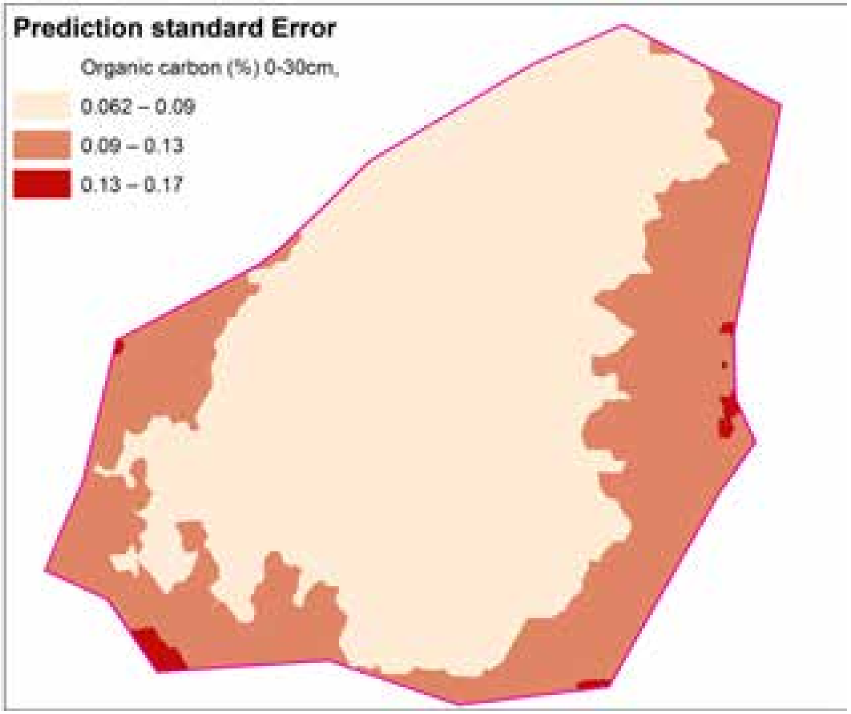


ME: 0.000143
RMS: 0.320146
AVS: 0.29978
RMSS: 1.066

Prediction standard error maps



Empirical Bayesian Kriging



Ordinary Kriging method

Kriging model parameters

Parameters of the best model semivariogram for SOC cokriging (Covariate: Nitrogen)

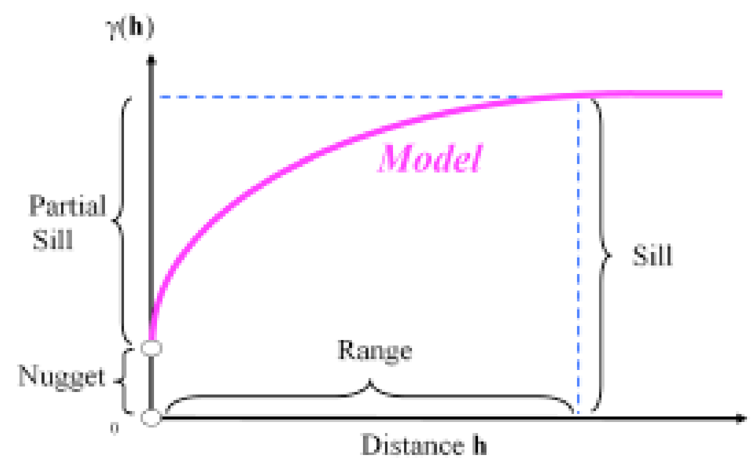
Properties	Model	No of Lag	Lag size (m)	Nugget (Co)	Partial sill (C)	Range (m)	Sill (Co + C)	Ratio Co/ (Co + C)
Soil Organic Carbon (0-30cm)	K-Bessel	12	71.88	0.092807	0.81007	575.11	0.90287	0.103
Soil Organic Carbon (30 – 60cm)	J-Bessel	12	192	0.0114	0.16576	141.214	0.17687	0.062

Spatial dependency defined by nugget to sill ratio Co/(Co+C)

Strong spatial dependence Co/(Co +C) < 0.25

Moderate spatial dependence Co/(Co +C) ~ 0.25 – 0.75

Weak spatial dependence when Co/(Co +C) > 0.75



Conclusion

- Organic carbon is generally low on the farm (0.3 – 1.5%)
  - Higher in the topsoil (0-30cm) than the subsoil (30-60cm)
- Different kriging methods identify variations of SOC within the farm
- Cokriging produced the best surface with minimum error (RMS 0.23) and reliability of RMSS 0.999
- Empirical Bayesian Kriging (EBK) gave the smoothest surface and gave the 2nd best RMS (0.322)

Conclusion contd

- Cokriging was performed with many covariates (Nitrogen, Calcium, Phosphorus, CEC, Magnesium, Potassium, Iron, Sodium, elevation, EVI and NDVI)
- Nitrogen performed best as covariate (RMS 0.23 improved by 29% over EBK RMS 0.322)
- CEC and Calcium proved 2nd best covariates(RMS 0.26)
- Magnesium is the 3rd best covariate (RMS 0.28)
- NDVI, EVI and elevation did not improve predictions as covariates with SOC
- Combining covariates did not improve performance of Cokriging for SOC
- Two SOC nutrient management zone were suggested by the results

Thanks for listening

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