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Research Article

Correlation of pH on Soil Physicochemical Properties using Linear Regression Model for Spectral Data Analysis

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Abstract Soil properties may be varied by spatially and temporally with different agricultural practices. An accurate and reliable soil properties assessment is challenging issue in soil analysis. The soil properties assessment is very important for understanding the soil properties, nutrient management, influence of fertilizers and relation between soil properties which are affecting the plant growth. Conventional laboratory methods used to analyses soil properties are generally impractical because they are time-consuming, expensive and sometimes imprecise. On other hand, Visible and infrared spectroscopy can effectively characterize soil. Spectroscopic measurements are rapid, precise and inexpensive. Soil spectroscopy has shown to be a fast, cost-effective, environmentally friendly, non-destructive, reproducible and repeatable analytical technique. In the present research, we use spectroscopy techniques for soil properties analysis. The spectra of agglomerated farming soils were acquired by the ASD Field spec 4 spectroradiometer. Different fertilizers treatment applied soil samples are collected in pre monsoon and post monsoon season for 2 year (4 season) for banana and cotton crops in the form of DS-I and DS-II respectively. The soil spectra of VNIR region were preprocessed to get pure spectra. Then process the acquired spectral data by statistical methods for quantitative analysis of soil properties. The detected soil properties were carbon, Nitrogen, soil organic matter, pH, phosphorus, potassium, moisture sand, silt and clay. Soil pH is most important chemical properties that describe the relative acidity or alkalinity of the soil. It directly effect on plant growth and other soil properties. The relationship between pH properties on soil physical and chemical parameters and their influence were analyses by using linear regression model and show the performance of regression model with R^2 and RMSE.
Keywords *soil; physicochemical properties; spectroscopy; pH*

1. Introduction

Soil quality and identification of key soil indicators are essential for maintaining sustainability of agricultural soils (Viscarra Rossel et al., 2016). Nutrient management strategies are imperative for improving soil functions, maintenance of soil fertility and higher productivity. We sought to identify the indicators for such assessment of soil quality; and assess the fate of organic, mixed and chemical amendments on quality of soils under different cropping systems in farmers' fields. Organics, mixed, and chemical fertilizers play a crucial role for improving crop yield and soil properties (Rajeev Srivastava et al., 2004). In the literature, many researcher suggest application of FYM with inorganic fertilizer always, maintain higher soil quality index for soils under long-term cropping (Nirmalendu

Basak, 2016). The various environmental factors with crop residue inputs also have strong influence on soil properties and microbial activities in soils (Nirmalendu Basak et al., 2017).

The sampling plots were a part of the original experimental design maintained throughout the experimental period (4 seasons) for assessing the relative ability of different fertilizers treatments for their influence on soil quality.

In this experiment, to gain a better understanding of soil properties, relationship between different soil properties, processes and functions, we need to develop effective methods to soil assessment.

Conventional laboratory methods used to analyses soil properties are generally impractical because they are time-consuming, expensive and sometimes imprecise. Often, these methods need significant amounts of sample preparation; can use harmful reagents and complex apparatus that are inadequate when many measurements are needed. On other hand, Visible and infrared spectroscopy can effectively characterize soil. Spectroscopic measurements are rapid, precise and inexpensive. The spectra encode information on the inherent composition of soil (Tarik Mitran, 2017). Soil spectroscopy has shown to be a fast, cost-effective, environmentally friendly, non-destructive, reproducible and repeatable analytical technique. Soil reflectance analysis in the visible-near infrared-short wave infrared (VIS-NIR-SWIR) region has become a well-recognized, rapid and reproducible analytical method that has been used for non-destructive and low-cost soil analyses (Fikrat Feyziyev et al., 2016; Amol D. Vibhute et al., 2018; Todorova et al., 2014; Khadse, 2011). It differentiates materials based on their reflectance in the wavelength range from 350–2500 nm and can be used to encode information on the inherent composition of soil and determine a wide range of soil parameters. Although the technique is mainly used under controlled laboratory conditions, with the rise in available FieldSpec4 spectroradiometer (Viscarra Rossel et al., 2016).

The strength of the relationship between pH soil properties and their influence on sand, silt, clay, SOM, moisture, carbon, nitrogen, phosphorous, potash analyzed in an efficient way. Different fertilizers treatment applied soil samples are collected in pre monsoon and post monsoon season for 2 year (4 seasons) for banana and cotton crops. Then spectral data acquired in under control condition lab environment using FieldSpec4 spectroradiometer. The acquired spectral data processed by applying required statistical methods for quantitative analysis of physicochemical properties. The relationship between pH properties on soil physical and chemical parameters and their influence were analyses by using linear regression model. Soil pH is most important chemical properties that describe the relative acidity or alkalinity of the soil. The availability of some plant nutrients is greatly affected by soil pH. The ideal soil pH is close to neutral. It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range, plus this range of pH is generally very compatible to plant root growth (Trishna Mahanty et al., 2016; Hatari Labs). Reflectance spectroscopy is now used operationally in laboratories, allowing accurate and fast determination of most soil properties from prepared soil samples. In the laboratory, the soil reflectance measurements are made under controlled conditions which may enable researcher to understand the relationship between the physical and chemical properties of soil and soil reflectance (Asa Gholizadeh et al., 2017; Todorova et al., 2014).

2. Material and Methods

Soil samples are collected from Raver tehsil of Jalgaon district (Study area) where Organic, Chemical and Mixed fertilizers treatments used for banana and cotton crops sites in two different seasons in year 2018 with GPS locations and labeled DS-I to the collected dataset. The soil samples are collected as per the guideline of soil survey and soil testing, Agriculture department Maharashtra Government. In pre-monsoon (May) season 60 soil samples were collected. Each location containing 2 soil sample one from surface (5-20 cm) and other from subsurface (30 cm). As well as, in post monsoon (First week of November) season 50 soil samples were collected where different fertilizers treatment used for different crops. Each location containing 2 soil sample one from surface (5-20 cm) and other from subsurface (30 cm). Collected soil samples are classified according to season, fertilizers treatment and crop wise like Pre monsoon Organic Cotton (PROC), Post monsoon Organic Cotton (POOC), Pre monsoon Mixed Cotton (PRMC), Post monsoon Mixed Cotton (POMC), Pre monsoon Organic Banana (PROB), Pre monsoon Mixed banana (PRMB), Pre monsoon Chemical Banana (PRCB), Post monsoon Organic Banana (POOB), Post monsoon Mixed Banana (POMB), Post monsoon Chemical Banana (POCB). Also same soil samples are collected in the year 2019 pre monsoon 60 and post monsoon 50 respectively and labeled DS-II to the collected dataset. The appropriate soil sampling and preparation of soil samples methods are used for data collection (Takamitsu Kai et al., 2015; Vipin Y. Borole et al., 2020; Bhise Pratibha and Kulkarni Sonali; Bhise and Kulkarni, 2018; Vipin Y. Borole and Kulkarni, 2019; Pratibha R. Bhise and Sonali B. Kulkarni, 2019; Pratibha R. Bhise et al., 2019).

2.1. Data acquisition

Data acquisition perform using ASD FieldSpec4 Spectroradiometer (Analytical Spectral Devices Inc., Boulder, Colorado, USA) NIR reflectance spectroscopy performed in under controlled lab condition, it relatively simple, non-destructive, reliable, inexpensive, fast, and accurate method for characterizing soil sample. The required set up were used for data acquisition (Pratibha R. Bhise and Sonali B. Kulkarni, 2019; Pratibha R. Bhise et al., 2019; Vipin Y. Borole et al., 2019; Fikrat Feyziyev et al., 2016; Amol D. Vibhute et al., 2018) in Multispectral Research lab, Department of Computer Science & Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad with the ASD FieldSpec4 sensor. There are 10 spectral signature are acquired for each samples.

2.2. Data processing

The acquired 10 spectral signatures for each sample are processed by applying mean and generate one spectral signature for each sample. Then convert the spectral signature in numeric format using Viewspec pro software. Numeric data were opened in Microsoft Excel and process the by applying statistical mean methods for quantitative analysis of soil properties on the respective absorption wavelength range.

3. Results and Discussion

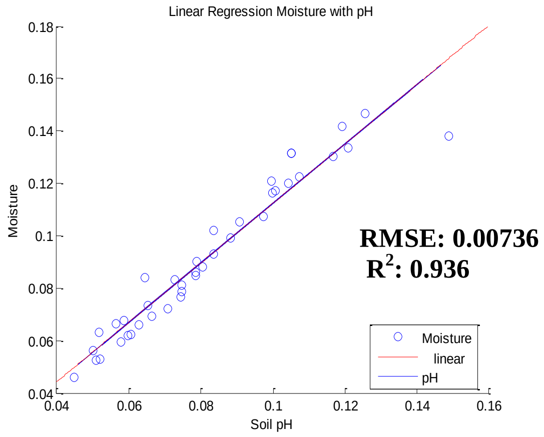
The spectral data acquisition performs using ASD FieldSpec4 Spectroradiometer and process the spectral data by applying statistical methods for quantitative analysis. The DS-I and DS-II datasets are represented in Table 1. Then perform the regression analysis for finding the correlation of pH with other physicochemical soil properties because maximum properties are depends on pH and pH is effecting to plant growth and soil properties.

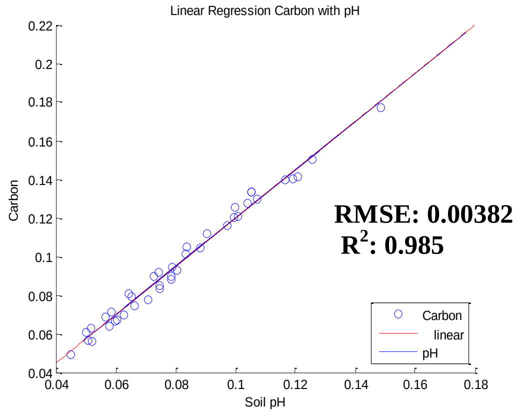
Table 1: *Quantitative representation of DS-I & DS-II*

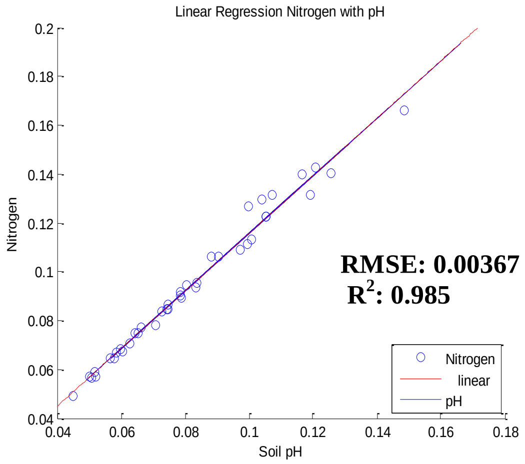
Database	DS-I & DS-II										
	Soil sample	**Sand**	**Silt**	**Clay**	**SOM**	**Moisture**	**pH**	**Carbon**	**Nitrogen**	**Phosphorus**	**Potash**
DS-I	**POOC**	0.061	0.061	0.063	0.038	0.062	0.061	0.067	0.067	0.066	0.065
	PROC	0.059	0.059	0.061	0.039	0.060	0.058	0.064	0.064	0.063	0.063
	POOB	0.060	0.057	0.059	0.057	0.056	0.050	0.061	0.057	0.058	0.053
	PROB	0.067	0.064	0.067	0.064	0.066	0.057	0.069	0.065	0.066	0.059
	POMC	0.068	0.068	0.070	0.039	0.069	0.066	0.074	0.077	0.072	0.074
	PRMC	0.070	0.066	0.069	0.067	0.068	0.059	0.071	0.067	0.068	0.062
	POMB	0.076	0.076	0.079	0.047	0.079	0.075	0.083	0.085	0.082	0.082
	PRMB	0.080	0.075	0.079	0.076	0.084	0.064	0.081	0.075	0.077	0.069
	POCB	0.086	0.087	0.088	0.086	0.085	0.079	0.088	0.090	0.087	0.080
	PRCB	0.090	0.085	0.090	0.086	0.077	0.074	0.092	0.085	0.088	0.079
	POOC	0.093	0.089	0.093	0.089	0.090	0.079	0.095	0.089	0.091	0.082
	PROC	0.105	0.101	0.105	0.102	0.099	0.088	0.105	0.106	0.104	0.093
	POOB	0.111	0.105	0.109	0.106	0.105	0.091	0.112	0.106	0.107	0.097
	PROB	0.114	0.109	0.115	0.109	0.107	0.097	0.116	0.109	0.113	0.101
	POMC	0.119	0.114	0.119	0.114	0.117	0.101	0.121	0.113	0.117	0.105
	PRMC	0.121	0.124	0.128	0.123	0.120	0.104	0.128	0.130	0.126	0.112
	POMB	0.124	0.127	0.131	0.126	0.123	0.107	0.130	0.131	0.129	0.114
	PRMB	0.131	0.123	0.131	0.124	0.131	0.105	0.133	0.122	0.129	0.113
	POCB	0.135	0.137	0.142	0.137	0.134	0.121	0.141	0.143	0.140	0.126
	PRCB	0.140	0.132	0.141	0.135	0.130	0.117	0.140	0.140	0.139	0.123
DS-II	**POOC**	0.046	0.046	0.047	0.034	0.046	0.045	0.049	0.049	0.048	0.048
	PROC	0.051	0.051	0.053	0.033	0.052	0.051	0.057	0.057	0.056	0.055
	POOB	0.052	0.052	0.054	0.038	0.053	0.052	0.056	0.057	0.055	0.055
	PROB	0.061	0.061	0.063	0.036	0.062	0.060	0.067	0.068	0.065	0.066
	POMC	0.062	0.059	0.062	0.059	0.063	0.052	0.063	0.059	0.061	0.055
	PRMC	0.064	0.064	0.066	0.042	0.066	0.063	0.070	0.071	0.068	0.068
	POMB	0.071	0.071	0.074	0.049	0.072	0.071	0.078	0.078	0.076	0.076
	PRMB	0.078	0.074	0.077	0.074	0.074	0.065	0.079	0.075	0.076	0.069
	POCB	0.083	0.084	0.086	0.082	0.081	0.075	0.085	0.087	0.084	0.077
	PRCB	0.089	0.084	0.088	0.084	0.083	0.073	0.090	0.084	0.086	0.078
	POOC	0.090	0.087	0.091	0.088	0.086	0.079	0.090	0.092	0.090	0.081
	PROC	0.093	0.090	0.094	0.090	0.088	0.081	0.093	0.094	0.092	0.083
	POOB	0.099	0.094	0.100	0.094	0.102	0.083	0.101	0.094	0.098	0.087
	PROB	0.102	0.096	0.103	0.098	0.093	0.084	0.105	0.095	0.101	0.089
	POMC	0.118	0.113	0.118	0.114	0.121	0.099	0.120	0.111	0.117	0.105
	PRMC	0.126	0.119	0.131	0.124	0.131	0.105	0.133	0.122	0.129	0.113
	POMB	0.131	0.123	0.138	0.133	0.142	0.119	0.140	0.131	0.136	0.123
	PRMB	0.137	0.133	0.147	0.143	0.147	0.126	0.150	0.140	0.146	0.131
	POCB	0.147	0.142	0.173	0.168	0.138	0.149	0.177	0.166	0.172	0.155
	PRCB	0.174	0.167	0.127	0.121	0.117	0.100	0.126	0.127	0.125	0.109

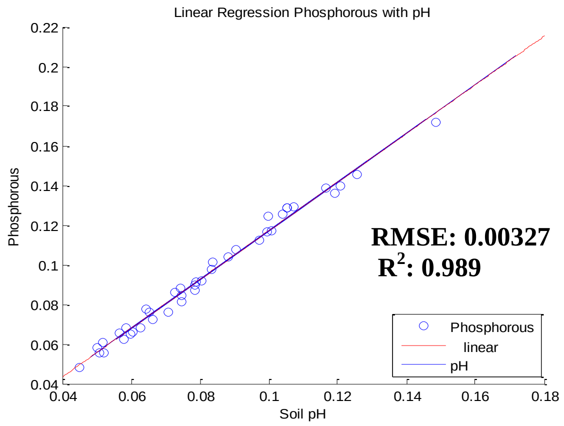
3.1. Correlation of pH with soil physicochemical properties using linear regression model

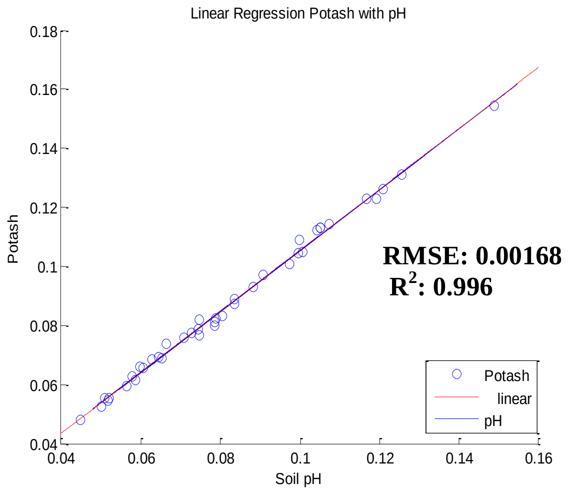
Linear regression model is used for finding the correlation of analyzed soil properties. In the performance of linear regression model the soil pH and carbon properties are good correlated with other soil properties but pH properties are highly correlated with other properties as compare to carbon. Therefor pH properties are considered as independent variable and other properties are considered as dependent variables. Soil pH can affect physical and chemical soil properties and plant growth (Takamitsu Kai et al., 2015; Vipin Y. Borole et al., 2020; Bhise Pratibha and Kulkarni Sonali). The nutrition, growth, and yields of most crops decrease where pH is low or high. Almost soil properties or content availability are depends on soil pH properties.











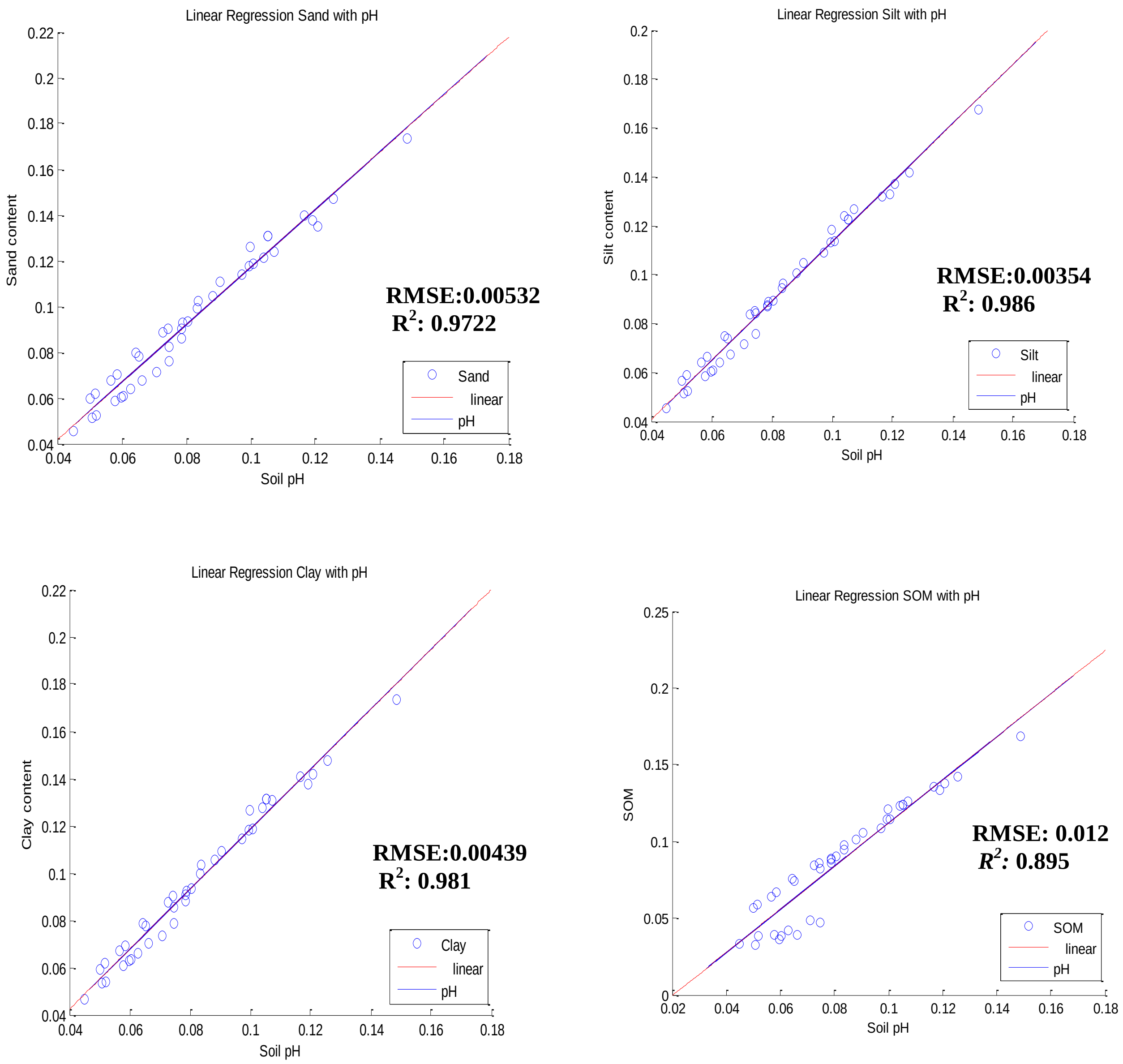


Figure 1: *Linear regression of pH and sand, silt, clay, SOM, moisture, carbon, nitrogen, phosphorous, potash*

In the linear regression analysis R^2 and RMSE are calculated for finding the correlation and it represent in Table 2. The RMSE is the square root of the variance of the residuals. It shows the absolute fit of the model to the data–how close the observed data. Whereas R-squared is a relative measure of fit, RMSE is an absolute measure of fit. Lower values of RMSE indicate better fit (National Soil Survey Center). In the linear regression for SOM (R^2 = 0.895) is found minimum value and for Potash (K) (R2 =0.996) maximum value.

Table 2: *Performance of linear regression model for soil properties*

Soil Properties	pH	
	R^2	RMSE
Sand	0.972	0.00532
Silt	0.986	0.00354
Clay	0.981	0.00439
SOM	0.895	0.012
Moisture	0.936	0.00736
Carbon	0.985	0.00382
Nitrogen	0.985	0.00367
Phosphorous	0.989	0.00327
Potash	0.996	0.00168

The performance of linear regression model for pH with other soil properties are represents in the Figure 1. On the basis of regression analysis pH is highly correlated with sand, silt, clay, moisture, SOM, carbon, nitrogen, phosphorous, potassium.

4. Conclusion

This study assessed the efficiency of spectroscopy and its techniques for rapid and inexpensive determination of soil properties parameters. The acquired spectral data represents large range of soil data which contain physicochemical properties. In this analysis, the spectral data converted in numeric format and find out the various soil properties by applying statistical methods for quantitative analysis of soil properties. On the basis of quantitative analysis, linear regression model are used for finding the correlation of pH with other physicochemical soil properties. The performance of linear regression model is calculated with R^2 and RMSE. The maximum (R^2 =0.996) and minimum (RMSE=0.00168) values are found for Potash properties. The performance of linear regression of pH with other soil properties are also highly correlated with sand, silt, clay, moisture, SOM, carbon, nitrogen, phosphorous and it represents the best fit of regression. To maintain the pH of soil is necessary because other soil properties and plant growth is depend on pH properties. This study is helpful to researcher for analysis of soil parameter using spectral data and process the data as well as to farmers for fertilizers management and it will help for reducing the fertilizers cost.

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