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# Spatial Variance of Soil Available Nutrients in Continuous Cropping of *Zea May L.* Plantation in Central China

**Haisheng Chen, Qiankun Hong*, Linsheng Cai, Zhenyu Li, Youcong Zhu**
Zhejiang Tongji Vocational College of Science and Technology, Hangzhou 311231, Zhejiang, China
*Corresponding Author.

***Abstract:***

Revealing the spatial variance characteristics of soil available nutrient properties is important in carrying out precise fertilization in *Zea may L.* plantation. The spatial variance characteristics of soil nutrients contents including total N, available P, and available K were examined on a 87 ha long -term *Zea may L.* plantation in Jia County of Henan province based on geostatistical techniques, which can help in precise fertilization of the fields. The results indicated that the structure of AP and AK showed moderate spatial dependence, indicating their spatial variance were controlled by intrinsic factors and extrinsic factors, while the structure of TN showed strong spatial dependence, indicating that its spatial variance was mostly determined by intrinsic factors. The contour maps for soil TN, AP, and AK obtained from this study exhibit a rather patchy distribution. Our results provided the basis for precise fertilization of *Zea may L.* plantation in central Henan province, China.

***Keywords****: Geostatistics, Spatial variance, Soil available nutrients, Zea may L.*

## I. INTRODUCTION

The revealing of the distribution of soil nutrients including TN, AP, and AK in soil of *Zea may L.* plantation are important for optimum cultivation technique and increasing the yields and enhancing the quality of *Zea may L.* crops. Geostatistics provides the means to determined spatial variance, apply the collected data for reasonal interpolation [1, 2]. Geostatistical can estimate spatial variance of soil physical characterics, soil biochemical properties, and soil microbiological process [3, 4].

The variance of soil nutrients is often studied by classical statistical technique, which assume that variation is randomly distributed within mapping units. Soil variance is the outcome of many processes acting and interacting on scales and is inherently scale dependent [2].

Few studies have been reported about the spatial variance characteristics of TN, AP and AK in continuous cropping *Zea may L.* plantation in central China. Nowadays, fertilization has been applied uniform inspite of inequality of soil nutrients distribution in the field, which leads to the high and under

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application of fertilization in the fields, which could reduced *Zea may L.* yields and quality. So, Measure must be taken to apply variable rate fertilization based on GIS and Geostatistics.

Jia County is situated in central Henan province, China. To a great degree, the yields of *Zea may L.* depend on the soil fertility in *Zea may L.* plantation. Our study deals with the spatial variance of soil nutrients in *Zea may L.* plantation in Jia County, central China. The objectives of this research were to: (i) quantity the spatial variability of TN, AP and AK in *Zea may L.* plantation of the study area; (ii) generate the contour map revealing the distribution of TN, AP and AK in this given regions, which can guide the farmer to conduct scientific site-specific fertilizer effectively.

## II. MATERIALS AND METHODS

The experiments was conducted in *Zea may L.* planting areas, located in southeast of Jia County in Henan Province, central China, at latitude 33°58′46″N and longitude 113°12′25″E. There are 40 thousands ha arable area there, of which there are 10 thousands ha *Zea may L.* planting area [5]. The study area is showed in Figure 1. The average temperature in this region is about 14.7 ℃ and the average precipitation in this region is about 681 mm. The soil is characterized by slightly alkaline.

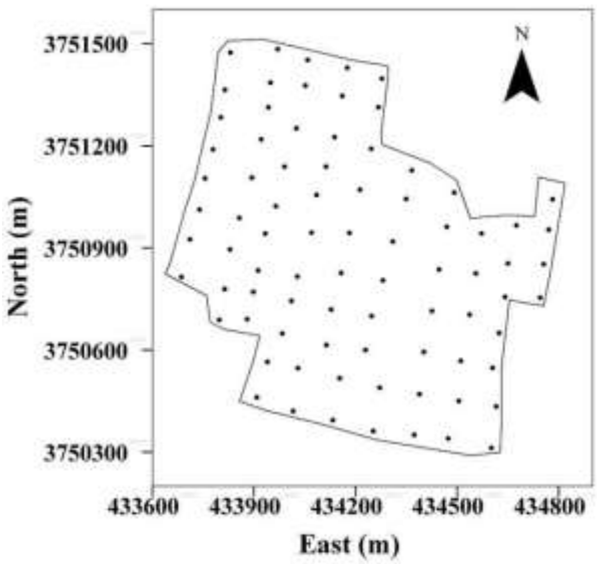


Fig 1: Rearch areas and sampling sites

Soil sampling were conducted in May 2020. Eighty-one samples points were taken from layer (0- 20 cm) on a 100-m grid based on the GPS unit, and then changed into the x and y coordinates as shown in Figure 1.

The soil samples were put into plastic papers, and soil samples were air-dried and ground to pass through a 2-mm sieve for analyzing TN, AP and AK. TN was measured by Kjeldahl approach [6]. AP was measured by Olsen extraction approach by use of alkaline sodium bicarbonate as the extractant in a 20:1

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ratio [7] and AK was determined by the neutral ammonium acetate extraction approach [8].

Geostatistical analysis of the data was conducted for determining the spatial structure of TN, AP and AK with GS+ 3.1 program [9] designed by Gamma Design Software. The GS+ has a number of models that can be suitable for evaluating semivariogram by using non-linear square procedure.

In this study, the spherical model was determined:

$$\gamma (h) = C0 + C[1.5(h/a) - 0.5(h/a)3] \text{ as } h \le a$$
$$\gamma (h) = C0 + C \quad \text{as } h > a \quad (1)$$

Where γ (h) is the semivariance and C0 is the nugget variance. The maximum semivariance was defined as the sill (C0 + C), and a is the range of spatial correlation [10]. To classify spatial dependence of the soil nutrient factors, nugget to sill ratios were adopted to determine spatial dependence values [11, 12]. The values less than 25% showed strong spatial dependence, the values between 25% and 75% showed moderate spatial dependence, and the values greater than 75% showed weak spatial dependence [13-15]. Contour maps of TN, AP and AK were made by the block kriging interpolation.

## III. RESULTS AND ANALYSE

### 3.1 Descriptive Statistics of Soil Nutrients in the Given Regions

Table I shows the statistical characteristics of soil TN, AP and AK in Zea may L. planting fields in the studied regions. There are a total of 81 samples collected from whole corn plantations. The abnormal date which influence interpolating results extremely were deleted for determining the spatial variation of each soil fertility factors exactly. The Kolmogorov-Smirnov test revealed that those three soil fertility factors were normally distributed (P > 0.05). It can be seen that the mean value of soil TN and AP contents are in the middle level, being 0.74g/mg and 15.81mg/kg respectively, while the mean contents of available K are in deficiency level, being 107.30mg/kg. The variation coefficient of TN,AK and AP are medium, being 13.40%, 36.60% and 13.50% respectively.

**TABLE I. Descriptive statistics of TN, AP and AK in soils of the investigated Zea may L. plantation**

| Variable | Mean | SD | Min | Median | Max | CV[a] | Skewness[b] | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| TN, g kg-1 | 0.73 | 0.1 | 0.45 | 0.74 | 0.93 | 13.40 | -0.34 | 0.14 |
| AP, mg kg-1 | 16.14 | 5.9 | 2.62 | 15.81 | 28.23 | 36.60 | 0.05 | -0.57 |
| AK, mg kg-1 | 105.9 | 14.3 | 70.3 | 107.3 | 137.02 | 13.50 | -0.18 | -0.23 |

[a] CV: coefficient of variation (%).

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[b] Kolmogorov-Smirnov test was conducted to test the significance level of normality, all nutrient factors were normally distributed ($P > 0.05$)

3.2 Isotropic Characteristics Analysis

3.2.1 Isotropic semivariogram

Semivariogram analysis was conducted to determined spatial variance of three soil nutrient factors in Zea may L. plantation (Table II). The contents of all those three variables could be expressed by spherical model. Soil TN showed a shorter range of spatial dependence of 274 m, while soil AP and AK showed longer range of spatial dependence of 337m and 345m respectively.

**TABLE II. Spatial variance of soil nutrients in this area**

| **Variable** | **Model** | **$C_0$[a]** | **$C_0$+C[a]** | **Nugget[b]%** | **Spatial class[c]** | **Range** | **$R^2$** | **RSS** |
|---|---|---|---|---|---|---|---|---|
| TN | Spherical | 0.002 | 0.011 | 20 | S | 274 | 0.94 | 8.46E-07 |
| AP | Spherical | 13.4 | 35.99 | 37 | M | 337 | 0.98 | 2.665 |
| AK | Spherical | 66.9 | 216.1 | 30 | M | 345 | 0.99 | 7.661 |

[a] $C_0$ = nugget variance; C = structural variance.
[b] Nugget % = $C_0/(C_0+C) \times 100$;
[c] S indicated strong spatial dependence ; M indicate moderate spatial dependence.

The results suggested that the soil AP, AK had moderate spatial dependence, mainly controlled by intrinsic factors such as climate, parent material, topography, soil type, and extrinsis factors such as cropping system or fertilization. The soil TN had strong spatial dependence, indicating that its spatial variance was mainly controlled by intrinsic factors.

3.2.2 Kriging interpolation

Block kriging was performed with a block size of 2 by 2 m2 to obtain interpolated values for all nutrient factors all over the sampled area of 87 ha (Figure 2). Kriged contour map for TN determined the spatial distribution of the contents of the TN along the region. Soils with high TN content were found in the southwest part of the field with small areas of low concentration TN at the middle and at the top corner. The spatial pattern maps for available P showed that AP with high value was found at southeast part of the region, also low value at top corner. The spatial pattern of AK is low in middle part of the region extending from NW to SE, moderate AK (90-120 mg kg-1) covering the larger parts of areas, higher at the right side of the region and bottom middle and left of the region.

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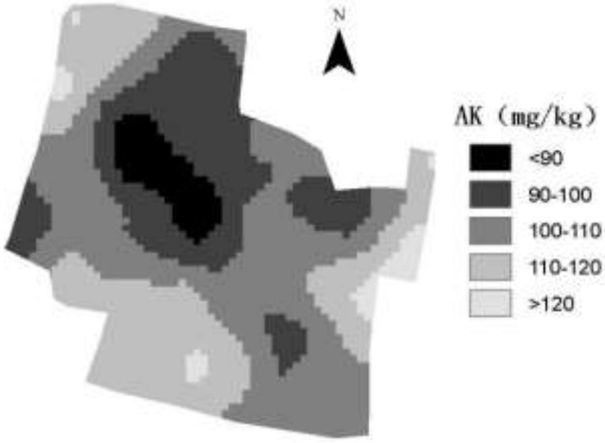


Fig 2: Spatial distribution maps of TN, AP and AK in soils of Zea may L. plantation in the given region

## IV. CONCLUSION AND DISCUSSION

(1) The classic statistical analysis revealed that the distributions of all the selected soil nutrient factors in *Zea may L.* plantation in Jia County, central China were normally distributed. The average contents of soil TN and AP are in the middle level, the value of which were 0.74g/mg and 15.81mg/kg respectively, while the average contents of AK are in deficiency, the value of which was 107.30mg/kg. The variation coefficient of TN, AK and AP are medium, the value of which were 13.40%, 36.60% and 13.50% respectively.

(2) The contents of all those three variables could be expressed by spherical model. Ranges of spatial dependence from the semivariogram models were highly variable among nutrient factors, range from 274 to 345 m. Soil TN had a shorter range of spatial dependence of 274 m, while soil AP and AK showed longer range of spatial dependence of 337m and 345m respectively.

(3) The structure of AP and AK showed moderate spatial dependence, indicating their spatial variance were determined by intrinsic factors and extrinsic factors, while the structure of TN showed strong spatial dependence, indicating its spatial variance was mostly determined by intrinsic factors.

(4) The contour maps for soil TN, AP, and AK obtained from this study exhibit a rather patchy distribution. Our results provided the basis for precise fertilization of Zea may L. plantation in central Henan province, China.

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