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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 3 (10): 1580-1582, 2000

Patterns in Gypsum Requirement Before and After Gypsum Application

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Abstract: Spatial patterns in gypsum requirement of a salt affected field at Shandau village in Dera Ismail Khan district ware determined before and after treatment with gypsum. Surface soil samples (0-25 cm) were collected from six parallel transacts at 15 m intervals. Gypsum requirement was determined for all these samples. Each transect was divided into two strips. One strip received a single uniform rate of gypsum while the adjacent strip was treated with variable rates of gypsum to match gypsum requirement of different locations. Wheat crop was planted in the whole field after gypsum application. At harvest, wheat yields were measured at 15 m intervals from an area of 1 m^2 in both the strips from all the six transacts. Surface soil samples (0-25 cm) were also collected from both the strips from all the six transacts. GR was determined for all these samples. The data on GR and wheat yields were subjected to classical statistical analysis and geostatistical technique of semivariogram analysis. Results showed that there was a considerable variation (CV = 63%) in GR before and after gypsum application (Cv = 75 and 106%). GR was significantly reduced with gypsum application. There were strong spatial patterns in GR before and after treatment in variable-rate strips. Similarly there was a considerable variation in grain yields (CV = 50 and 47%) with strong spatial patterns.

Key words: Spatial patterns gypsum requirement

Introduction

Identification of spatial patterns of various soil properties such as soil fertility status or salinity/sodicity problem is a pre-requisite to designing any management strategy for fertilization programme or reclamation of salt affected soils. Traditionally, salt affected soils especially sodic soils are reclaimed using a single uniform rate of gypsum irrespective of the presence of spatial patterns of gypsum requirement in a field. This practice causes under-application or over-application of gypsum in different areas of the field when spatial patterns of gypsum requirement are present. Considerable research work has been carried out by many scientists to identify the magnitude and extent of spatial variability of soil fertility status and crop productivity (Trangmar *et al*., 1987; Bhatti *et al*., 1991; Wollenhaupt *et al*., 1994) and variable-rate fertilizer management (Mulla *et al.,* 1992; Bhatti and Mulla, 1995). Some research work has also been carried out on spatial variability of salinity/sodicity (Wagenet and Jurinak, 1978; Hajrasuliha *et al*., 1980; Bhatti and Bakhsh, 1995).

Materials and Methods

Spatial patterns of gypsum requirement of a salt affected field were studied before and after gypsum application. For this purpose a salt affected field was selected in Shandau village of Dera Ismail Khan district. The field was divided into six parallel transacts 154 m long and 5 m wide. Each transect was sampled at 15 m intervals from 0-25 cm depth. Gypsum requirement of all the samples was determined. Each transect was divided into two strips. In one strip gypsum was applied at a single uniform rate based on the mean value of gypsum requirement. In the adjacent strip, variable rates of gypsum were applied to match the gypsum requirement of different locations. Wheat crop was planted in the whole field after gypsum application. All the recommended cultural practices were followed during the growth period of crop. Wheat crop was harvested at 15 m interval from an area of 1 m^2 from both the strips on all the six transacts. Wheat yields were converted to per hectare basis. Surface soil samples were collected after wheat harvest from both the strips in each transect at 15 m intervals. All soil samples thus collected were analyzed for gypsum requirement. Three dimensional plots of gypsum requirement before and after treatment and grain yields were made to visualize spatial patterns. Descriptive statistics (mean and coefficient of variation) for all the data on gypsum requirement and wheat yields were computed. Differences between gypsum requirements before and after treatment were compared using t-test of significance. Similarly, t-test was also applied to compare the differences in gypsum requirement and wheat yields between the two management strategies. Geostatistical technique of auto correlation analysis was used to identify the magnitude and extent of spatial dependence of observations on gypsum requirement. Auto correlation analysis provides a quantitative estimate of the degree to which sample points are correlated with one another by virtue of separation distance. Because samples taken from locations closer to one another are typically more closely related than are samples taken from locations farther apart. Auto correlation statistics of semivariance was calculated, which when graphed yields a sernivariogram. Semivariance is defined as:

$$G(h) = [1/2N(h)] \Sigma [z_I - z_{I+h}]^2$$

where, G(h) = semivariance for lag distance h
z_i = measured sample value at point I
z_{i+h}, = measured sample value at point h+I and
N(h) = total number of sample pairs for the lag interval h

The resulting graph of semivariance vs. different lag distances yields a semivariance in a data set. Different models are used to fit the semivariograrn of the data. The model is considered to be the best fit when the residual sums of squares (RSS) term is not further minimized by significant changes in model parameters. RSS is calculated for the

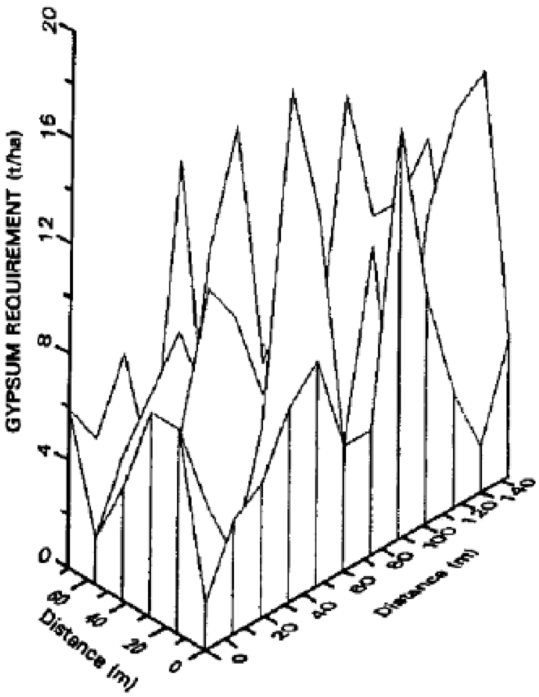

Fig. 1: Spatial patterns in gypsum requirement before gypsum application

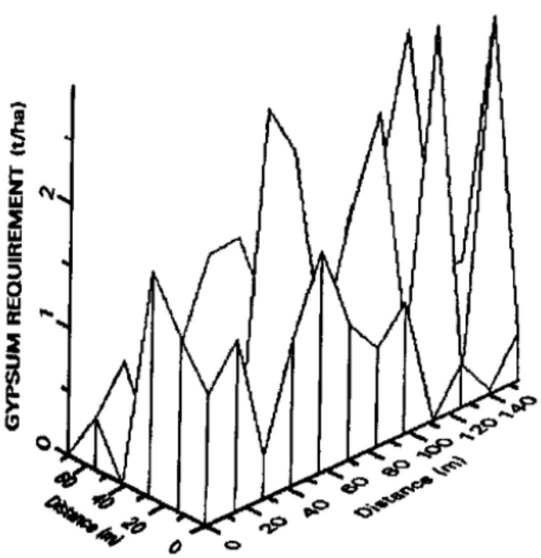

Fig. 2: Spatial patterns in gypsum requirement in variable strategy after gypsum application

regression of actual vs. model estimated servivariance at each lag distance. Different models used include linear, linear to till, spherical. exponential and gaussian model. Each model Is defined in terms of nugget variance (C_o), sill (structural variance C, +nugget variance C_0) and range (a) parameters. Spherical and exponential models were found to be the best fit for the present study. Spherical model is a modified quadratic function

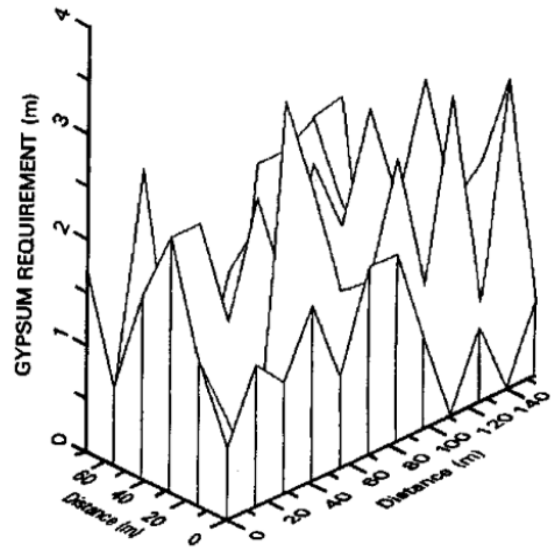

Fig. 3: Spatial patterns in gypsum requirement in uniform strategy after gypsum application

in which at some distance 'a', pairs of points no longer be auto correlated and the semivariogram asymptotes. The formula used for this model is:

$G(h) = C_0 + C_1$ $(1.5(h/a)\text{-}0.5(h/a)^3$ I for $h<a$
$G(h) = C_0 + C_1$ for $h>a$

Where h = lag interval
C_0 = nugget variance >0
C_1 = tructural variance >0 and a
a = range

Exponential model is similar to the spherical in that it approaches the sill gradually, but different from the spherical in the rate at which the sill is approached and in the fact that the model and the sill never actually converge. The formula used for this model is:

$G(h)$ = $C_o + C_1$ 11-exp(h/aH
Where h = lag interval
C_0 = nugget variance >0
C_1 = structural variance >0 and
a = range parameter (not range)

Range in the exponential model is usually assumed to be the point at which the model includes 95% of the sill (C_0+C_1), this can be estimated as 3* a.

Results and Discussion

Descriptive statistics of gypsum requirements before and after gypsum application (Table 1) showed that the mean value of OR reduced significantly both in uniform ($t = 11.82$, $p = 0.0000$) and variable-rate strategy ($t = 12.78$, $p = 0.0000$). However, the GR was significantly lower in variable-rate strategy than in the uniform-rate strategy after gypsum application. It = -5.24, p = 0.0000). Coefficient of variation for GR increased in both the strategies, Grain yield of wheat (Table 1) was lower in variable-rate strategy than in the uniform-rate strategy but the difference between the two

Table 1: Descriptive statistics of OR and grain yield

Gypsum requirement.(tjha)	Whiten	CV(%)
Before application	6.34	63
After application (Uniform)	3.06	75
After application (variable)	1.93	106
Grain yield Ckg.fhal		
Uniform strategy	1757.00	50
Variable strategy	1793.00	47

Table 2: Parameters of semmariogrem models for GR

	Nugget	Sill	Reno	Model	r^2
UR Before	14.55	24.830	294.7	Exponential	0.49
After Uniform	0.562	1.01a	243.2	Exponential	5.04
Variable	0.445	0.715	45.5	Spherical	9.72

Table 3: Parameters of sernivariograrn models for grain yields

Strategy	Nugget ($x10^5$)	Sill ($x10^5$)	Range	Model	r^2
Uniform-rate	2.64	7.75	39.2	Exponential	0.94
Variable-rate	3.46	9.80	9.7	Spherical	0.99

strategies was non-significant (t = 0.39, p = 0.6975). Moreover, the coefficient of variation for grain yield was higher in uniform-rate strategy then in the variable-rate strategy. Regarding the spatial patterns of GR, three dimensional plots of GA before and after treatment with gypsum showed that there were strong spatial patterns in GR before gypsum application (Fig. 1). After gypsum application, the spatial patterns were still present in both the management strategies (Fig. 2 and 3) and were more obvious in variable-rate strategy. Sernivariogram analysis of GR before gypsum application (Table 2) showed that there were strong spatial patterns. A summary of the best fitting semivariogram model parameters (Table 2) showed that the exponential model was the best fit for GR with a nugget of 14.55 and a range of influence of about 295 m. The r^2-value for this model was 0.49. Exponential model was also the best fit for GR after gypsum application in uniform-rate strategy but the -value was very small, showing poor spatial pattern. While spherical model was the best fit for the semivariogram of Gil in variable-rate strategy with a nugget of 0.445 and a range of influence of 48.5 m. The r^2 -value for this model was 0.72. Semivariogram analysis of grain yields in both the management strategies (Table 3) showed that there were strong spatial patterns in grain yields.

Exponential model was the best fit for grain yield semivariogram in uniform-rate strategy with a nugget of 2.64×10^5 and range of influence of 39 m. Spherical model was the best for the semivariogram of grain yield in variable-rate strategy with a nugget of 3.45×10^5 and a range of about 100 m.

Application of gypsum using a single uniform rate as well as variable rates reduced the GR significantly. Strong spatial patterns were also observed after treatment with gypsum in variable-rate strategy. These were due to the treatment with different rates. Similarly, strong spatial patterns of grain yields were observed in both the management strategies. Such fields should be divided into different management units and be managed differently to increase the efficiency of added inputs.

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