

*Full Length Research Paper*

# Analyses of spatial variations of kenaf in experimental field

Dauda, T. O.<sup>1\*</sup>, Asiribo, O. E.<sup>2</sup>, Adekeye, K. S.<sup>3</sup> and Agbaje, G. A.<sup>1</sup>

<sup>1</sup>Institute of Agricultural Research and Training, Obafemi Awolowo University, PMB 5029, Moor Plantation, Ibadan, Nigeria.

<sup>2</sup>Statistics Department, University of Agriculture, PMB 2240, Abeokuta, Nigeria.

<sup>3</sup>Statistics Department, Redeemers' University, Mowe, Ogun State, Nigeria.

Accepted 1 October, 2009

**Preliminary investigations of experimental field usually involve collection of soil samples at widely spaced locations which are patchily or globally at variant spatially. This study was carried out to evaluate spatial variations in experimental fields using a split plot experiment distributed in a completely randomized design at Ikenne and Ilora between June and September 2006 (test crop was kenaf). The preliminary descriptive statistics suggested the dependency of the stem girth and height on the spatial positions. The variance - covariance analyses matrices of the plots showed that stem girth and plant height were independently distributed and exhibited a non stationarity principle. The results also revealed that spatial autocorrelation exists in patches in the experimental fields while the entire plots showed random distributions because the autocorrelations were neither dominated by negative nor positive correlation and more than 50% of these values falls within the range of  $\pm 2/\sqrt{n}$ . From this study, a regionalized spatial variation is imminent in 625 m<sup>2</sup> experimental plot despite the difference in the treatments. Spatial variations study was found necessary in any plot not more than an acre (250 m<sup>2</sup>) of land otherwise such variations should be treated as block or environmental effect(s).**

**Key words:** Spatial variation, mean growth parameters, classical statistical analysis.

## INTRODUCTION

Preliminary investigations of soils of experimental fields are usually carried out on soil samples collected at widely spaced locations which are patchily or globally different spatially. This is usually due to the fact that the spatial scales of variations in the variables being measured are not often known before sampling is done. Consequently, the outcome of such experiment is prone to error due to such spatial variation. Although one of the essence of randomization as well as replication is to eliminate errors due to variations but, spatial variation in the number of species in plots have been found to be caused by differences with regards to the mean values in the blocks indicating differences in the site conditions (Presinger et al., 2000). It could also be due to differences in previous farming practices as well as land use, topography of the land and nutrient application inaccuracy, (Fulton et al.,

1996; Vieira and Gonzalez, 2003). These may be quite beyond mere randomization or replication because the variations may be large enough to cause error.

Kenaf, *Hibiscus cannabinus*, is a short day annual herbaceous plant cultivated for the soft baste fiber in its stem and recently due to search for commercial fibre for the woody core fiber as well (Fike, 1990). Spatial statistic is concerned with the study of spatially referenced data and associated statistical models and processes (Song and Kuldorf, 2008). The need for the investigation of the validity of the assumptions of classical statistical analysis (CSA) cannot be over emphasized because it may results into inflation of the probability of a type I error in hypothesis test (Vieira and Gonzalez, 2003). One of the assumptions of CSA is that observations as well as error are assumed independent. However, agricultural experiments often contain spatial layout and or temporal correlation due to repeated sampling of measurements at the the same experimental unit. Indeed, lack of spatial independence in ecological data have been viewed as a

\*Corresponding author. E-mail: [taofikdaud@yahoo.com](mailto:taofikdaud@yahoo.com)

problem that can obscure one's ability to understand the biology of the organism being studied, (Liebhold and Gurevitch, 2002). Also, spatial statistics analyses (SSA) have been described as inferential analysis which allows for more reliable inference to be made from data analysis results. Works on spatial statistics thus provide insight into field distribution of the data values to avoid unbridled generalization of the data behaviour. Similarly, the nature of the spatial distribution of the data (whether random or otherwise) can be obtained through spatial statistic study (SSS). This study would thus boost the outcome of the results of any experimentation because of the incorporation spatial variability pattern (SVP) in the arrangement of experimental treatment and its consideration in the analysis of the data of the experiment. This work is therefore justified from the need to boost experimental design and analysis through provision of information about SVP in experimental plots. Therefore, there is need to boost experimental design through the provision of information about spatial variation in experimental plots which is the focus of this paper. The objective of this study is thus to evaluate spatial variation in experimental fields.

**MATERIALS AND METHODS**

**Experimental settings**

Data sets for this project were from two experiments set up at Ikenne and Ilora out stations of the Institute of Agricultural Research and Training, Ibadan between June and September 2006. The two (2) sample experiments were both on evaluation of the effect of fertilizer and insecticides on Kenaf. Ikenne falls within the forest zone (27° 48'N and 3° 52') of the country while Ilora is located in the intermediate guinea savanna (126° 52'N and 3° 41'). Each of the experiment was carried out using split plot in a restricted completely randomized design. The main plot is the spraying regime (S<sub>1</sub> = 300 kg NPK + 100 kg Furadan + 2 pre flowering insecticide sprays and S<sub>2</sub> = 600 g NPK + 200 kg Furadan + 4 pre flowering insecticide sprays) while the sub plot was the varieties (V<sub>1</sub> = Cuba 108, V<sub>2</sub> = Ifeken 400 and V<sub>3</sub> = local cultivar). Data on stem girth and plant height were collected at interval of 2 weeks commencing at 4 weeks after planting and relative to their spatial positions. This was repeated five times (that is 4, 6, 8, 10 and 12 weeks after planting).

The data obtained from the experiment were evaluated for normal distribution using D<sup>2</sup> plots, (Richard and Dean, 1998) and as well subjected to descriptive statistics including the mean and the variance (for each of the plots and for each of the experiments). Removal of treatment effects was done using:

$$Z(x) = x_i - (\bar{x} - \bar{x}_i) \quad (1)$$

where  $\bar{x}$  is the mean of the original value regardless of the treatments and  $x_i$  is growth values at plot  $i$ .  $\bar{x}_i$  is the mean of the plots receiving the same treatment. Also, autocorrelations of the data from each plot over convenient time lag of 35 were computed. Autocorrelation on the other hand is defined as the correlation of a variable in time and space with itself, (Schanbenberger and Pierce, 2002). The autocorrelation between observation at plot  $x_i$  and  $x_j$  is

measured by the correlation.

$$Corr[Y(x_i), Y(x_j)] = \frac{Cov[Y(x_i), Y(x_j)]}{\sqrt{Var[Y(x_i)]Var[Y(x_j)]}} \quad (2)$$

The estimation of spatial variability effects were based on the spatial distances of the neighbouring plots to the referenced plots. Six different spatial distance groups were obtained and the distances are; 4.243, 3.606, 3.163, 2.828, 2.236 and 1.414 m. Members of the distance group range between 4 and 8 because some of the distances are unique (by repeating themselves in each of the quadrant) while, some are not.

**RESULTS**

**Descriptive statistics and test for normality**

Assuming the set of all points on an experimental plot is denoted by  $\{Z(s) : s \in D\}$  where  $s$  represents a spatial location vector in  $R$  and  $D$  defines a finite region of the plot. A set of measurements  $\{Z(s_1), \dots, Z(s_n)\}$  adjusted for treatment means at known location  $s_1, \dots, s_n$  are as contained in Table 1. It was noted that plots at different location returned different mean plant heights and no regular pattern was suspected across the different plots. It was also observed that the same plots that returned the highest plant height returned the highest stem girth, (Table 1). Similarly, the same plot that returned the least plant height had the least stem girth. This suggests similarity in the trend of variability of the 2 different growth indices (height and stem girth). However, the trends of variance obtained for the different growth indices were not similar with the means because the plots that returned the highest means for the various indices were not the one that returned same for the variance, (Table 1). At Ilora, the plot variability cannot be associated with the effects of the treatment on the plant because the same treatment that returned the highest mean value returned the lowest mean value at different plots location. The highest and least variances were equally not treatment dependent. For the plot variability at Ikenne however, the possible effects of the treatments could be suspected because the different treatments had both the highest and least mean height and stem girth. This was however contradicted by the fact that the trend was not maintained for both indices (height and stem girth). It could be obtained from these results that for stem girth at both sites no 2 plots of the same or different treatment had the same means. This is however different from the variances at the 2 sites (Ilora and Ikenne). For the stem girth at Ilora, some plots (17%) of the same treatments (V<sub>1</sub>S<sub>1</sub>) as well as others of different treatments but neighbours returned similar/the same variance. However, for stem girth at Ikenne, all plots having the same/similar variance are of different treatment but neighbours (Table 1). Two plots ( $x_{3,5}$  and  $x_{4,5}$ ) at Ilora returning the same

**Table 1.** Means and variances of different variables at different plots irrespective of the weeks.

Treatment	Plot Address	Stem girth – (cm) (Ilorra)	Variance	Stem girth- (cm) (Ikenne)	Variance	Height (cm ) (Ilorra)	Variance	Height (cm) (Ikenne)	Variance
V1S1	1,1	0.582	0.039	0.825	0.023	78.604	727.327	100.968	852.406
V1S1	1,2	0.660	0.063	0.824	0.042	92.388	928.969	73.893	797.328
V1S1	1,3	0.642	0.043	0.998	0.079	67.452	672.832	83.448	1448.335
V1S1	1,4	0.737	0.043	1.178	0.192	108.376	761.429	131.812	2236.439
V1S1	1,5	0.816	0.043	1.166	0.132	116.092	791.860	141.060	3577.834
V1S1	1,6	0.641	0.033	0.941	0.033	59.192	454.969	75.736	558.897
V2S1	2,1	0.518	0.043	0.758	0.041	43.640	177.289	64.028	851.239
V2S1	2,2	0.627	0.034	0.754	0.062	54.184	301.752	46.984	672.676
V2S1	2,3	0.708	0.031	1.256	0.162	96.872	911.496	126.168	2917.620
V2S1	2,4	0.744	0.032	1.232	0.176	99.304	545.690	136.256	2121.984
V2S1	2,5	0.987	0.057	1.118	0.125	133.704	770.340	139.672	2504.302
V2S1	2,6	0.762	0.025	1.026	0.054	98.316	535.321	118.052	2577.796
V3S1	3,1	0.534	0.031	0.844	0.034	74.060	549.246	89.316	723.825
V3S1	3,2	0.611	0.023	0.829	0.064	82.460	370.370	71.108	744.144
V3S1	3,3	0.791	0.057	1.225	0.292	113.108	656.282	122.820	2174.450
V3S1	3,4	0.809	0.103	1.033	0.117	72.168	880.843	99.068	2256.535
V3S1	3,5	0.627	0.019	0.965	0.097	44.920	302.203	97.464	1991.748
V3S1	3,6	0.638	0.017	0.963	0.047	54.336	454.670	125.520	2932.981
V2S2	4,1	0.695	0.036	0.856	0.047	95.556	437.521	84.032	556.016
V2S2	4,2	0.639	0.044	0.860	0.067	58.044	294.328	86.812	1380.568
V2S2	4,3	0.665	0.038	0.986	0.101	64.672	488.808	98.992	2479.741
V2S2	4,4	0.851	0.044	1.266	0.135	123.160	1510.566	155.940	3644.054
V2S2	4,5	0.581	0.056	0.896	0.023	44.920	302.203	74.508	642.724
V2S2	4,6	0.623	0.035	0.958	0.049	54.300	456.036	68.760	568.775
V3S2	5,1	0.676	0.035	0.766	0.046	52.260	302.273	66.172	854.861
V3S2	5,2	0.725	0.034	1.096	0.105	109.504	1138.860	139.328	3084.581
V3S2	5,3	0.777	0.030	1.256	0.170	118.012	435.807	134.156	2563.701
V3S2	5,4	0.797	0.060	1.194	0.109	108.952	702.939	148.384	2746.284
V3S2	5,5	0.688	0.042	1.032	0.062	102.164	1021.825	128.220	2735.813
V3S2	5,6	0.784	0.029	0.988	0.166	108.184	510.308	112.768	3516.609
V1S2	6,1	0.690	0.028	0.776	0.062	94.804	477.117	75.252	734.898
V1S2	6,2	0.798	0.031	1.187	0.134	117.920	1089.066	130.636	2046.241
V1S2	6,3	0.844	0.052	1.206	0.177	120.408	953.019	125.096	2373.249
V1S2	6,4	0.774	0.099	1.058	0.075	79.740	414.530	106.732	2325.458
V1S2	6,5	0.762	0.028	0.912	0.023	105.672	890.485	124.648	3102.044
V1S2	6,6	0.753	0.015	0.975	0.064	103.504	290.515	124.908	4438.358

mean plant height and variance were of different treatment ( $V_3S_1$  and  $V_2S_2$ ). For the plant height at Ikenne on the other hand, no 2 plots returned the same mean or the same variance (Table 1). The implication of this is the stability of the variance for some plots (usually neighbouring plots) and in patches. For the spatial variability effects of the stem girth at both sites, no 2 plots returned the same mean or variance. This is equally true of the plant height at both sites (Table 2). The implication of this is that spatial variation in experimental plots could be associated with spatial address and distribution of the

various plots. The spatial variability effect is found to be additive because the difference between the values with and without the treatment effects obtained for all plots is unity (Table 2).

The bivariate normality plots of the two indices (stem girth and plant height) at both stations followed a near linear and increasing trend, (Figure 1). This implied that plot variability notwithstanding the data from the experiment is still normally distributed. Also, worthy of note is that the trend is lower at the Ilora station for both girth and plant height than Ikenne. This was because the  $D^2$

**Table 2.** Means of different variables (with and without treatment) at different plots irrespective of the weeks.

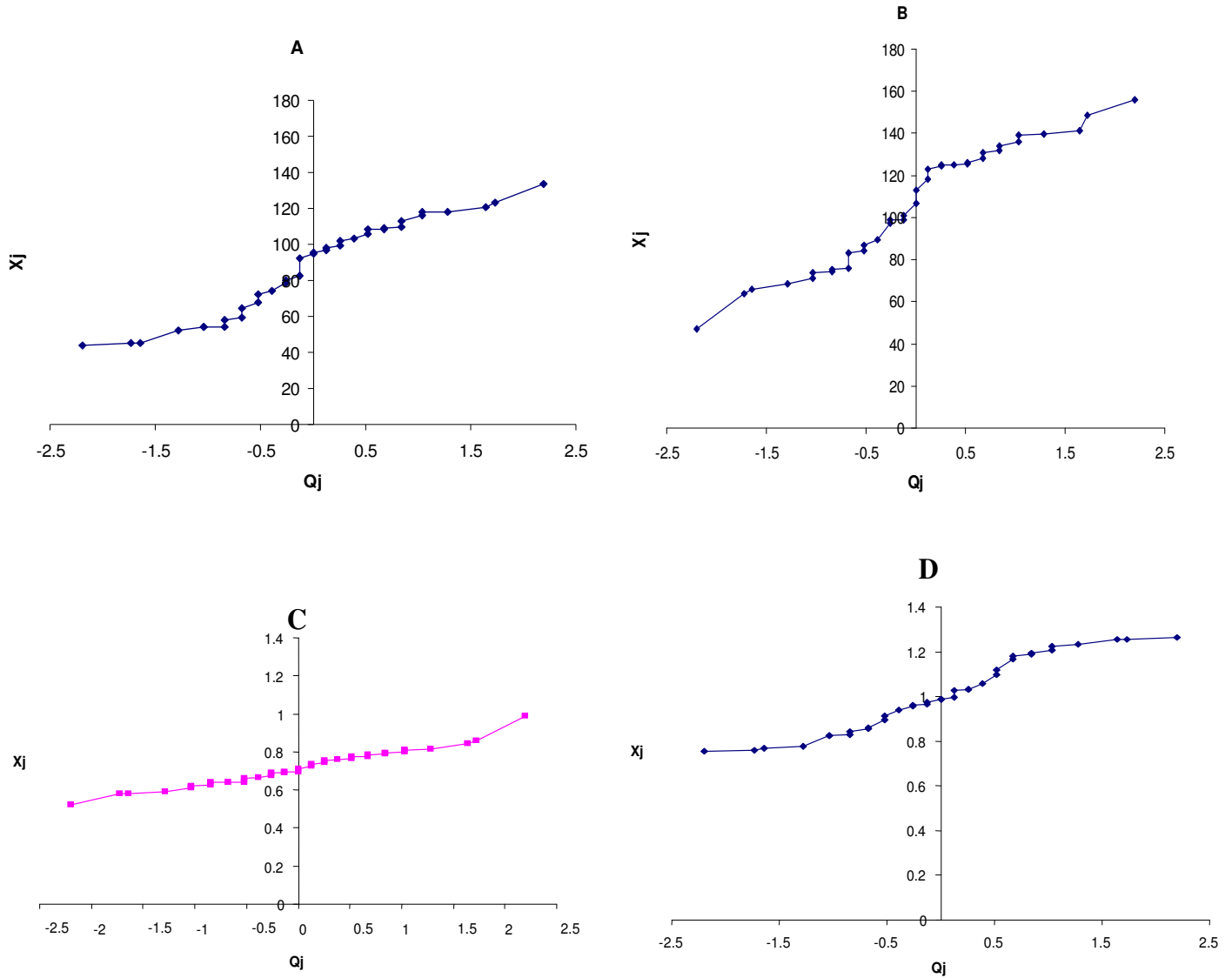
plot	Plots with treatment effects				Plots without treatment effects				Differences			
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>
1	0.582	0.825	78.604	100.968	-0.418	-0.175	77.604	99.968	1	1	1	1
2	0.660	0.824	92.388	73.893	-0.340	-0.176	91.388	72.893	1	1	1	1
3	0.642	0.998	67.452	83.448	-0.358	-0.002	66.452	82.448	1	1	1	1
4	0.737	1.178	108.376	131.812	-0.263	0.178	107.376	130.812	1	1	1	1
5	0.816	1.166	116.092	141.060	-0.184	0.166	115.092	140.060	1	1	1	1
6	0.641	0.941	59.192	75.736	-0.359	-0.059	58.192	74.736	1	1	1	1
7	0.519	0.758	43.640	64.028	-0.481	-0.242	42.640	63.028	1	1	1	1
8	0.628	0.754	54.184	46.984	-0.372	-0.246	53.184	45.984	1	1	1	1
9	0.708	1.256	96.872	126.168	-0.292	0.256	95.872	125.168	1	1	1	1
10	0.744	1.232	99.304	136.256	-0.256	0.232	98.304	135.256	1	1	1	1
11	0.987	1.118	133.704	139.672	-0.013	0.118	132.704	138.672	1	1	1	1
12	0.762	1.026	98.316	118.052	-0.238	0.026	97.316	117.052	1	1	1	1
13	0.534	0.844	74.060	89.316	-0.466	-0.156	73.060	88.316	1	1	1	1
14	0.611	0.829	82.460	71.108	-0.389	-0.171	81.460	70.108	1	1	1	1
15	0.791	1.225	113.108	122.820	-0.209	0.225	112.108	121.820	1	1	1	1
16	0.809	1.033	72.168	99.068	-0.191	0.033	71.168	98.068	1	1	1	1
17	0.627	0.965	44.920	97.464	-0.373	-0.035	43.920	96.464	1	1	1	1
18	0.638	0.963	54.336	125.520	-0.362	-0.037	53.336	124.520	1	1	1	1
19	0.696	0.856	95.556	84.032	-0.304	-0.144	94.556	83.032	1	1	1	1
20	0.639	0.860	58.044	86.812	-0.361	-0.140	57.044	85.812	1	1	1	1
21	0.665	0.986	64.672	98.992	-0.335	-0.014	63.672	97.992	1	1	1	1
22	0.851	1.266	123.160	155.940	-0.149	0.266	122.160	154.940	1	1	1	1
23	0.581	0.896	44.920	74.508	-0.419	-0.104	43.920	73.508	1	1	1	1
24	0.623	0.958	54.300	68.760	-0.377	-0.042	53.300	67.760	1	1	1	1
25	0.676	0.766	52.260	66.172	-0.324	-0.234	51.260	65.172	1	1	1	1
26	0.725	1.096	109.504	139.328	-0.275	0.096	108.504	138.328	1	1	1	1
27	0.777	1.256	118.012	134.156	-0.223	0.256	117.012	133.156	1	1	1	1
28	0.797	1.194	108.952	148.384	-0.203	0.194	107.952	147.384	1	1	1	1
29	0.688	1.032	102.164	128.220	-0.312	0.032	101.164	127.220	1	1	1	1
30	0.784	0.988	108.184	112.768	-0.216	-0.012	107.184	111.768	1	1	1	1
31	0.690	0.776	94.804	75.252	-0.310	-0.224	93.804	74.252	1	1	1	1
32	0.798	1.188	117.920	130.636	-0.202	0.188	116.920	129.636	1	1	1	1
33	0.844	1.206	120.408	125.096	-0.156	0.206	119.408	124.096	1	1	1	1
34	0.774	1.058	79.740	106.732	-0.226	0.058	78.740	105.732	1	1	1	1
35	0.762	0.912	105.672	124.648	-0.238	-0.088	104.672	123.648	1	1	1	1
36	0.753	0.975	103.504	124.908	-0.247	-0.025	102.504	123.908	1	1	1	1

V<sub>1</sub> = Stem girth, Ilora, V<sub>2</sub> = Stem girth, Ikenne, V<sub>3</sub> = Plant height, Ilora, and V<sub>4</sub> = Plant height, Ikenne.

plot of the Ilora station crosses the y-axis at 0.7 while that of the Ikenne crosses the y-axis at 0.98. For plant height also, the Ilora D<sup>2</sup> crosses the y-axis at 98 while that of Ikenne crosses at 110. These implied that the data sets obtained for both indices at Ikenne were higher than those obtained from Ilora and that they do not satisfied the assumption of normality. The results of run test for the different variables (stem girth and plant height) at both station (Ilora and Ikenne) using matrix  $A = a_{ij}$ ,  $i =$  Ilora and Ikenne,  $j =$  stem girth and plant height.

$$A = \begin{pmatrix} 17.0 & 3.50 \\ 3.50 & 2.50 \end{pmatrix} \dots \dots \dots (3)$$

This showed that similar data are followed by dissimilar ones indicating randomness of the data. The autocorrelation values of the stem girth at Ilora ranged from - 0.282 to 0.660 while those of Ikenne ranged between - 0.465 to 0.718. Similarly, the autocor-



**Figure 1.** Multivariate analysis of kenaf plant height at Ilora (A) and Ikenne (B) and stem girth at Ilora (C) and Ikenne (D).

relation values of the plant height at both stations showed that those of plant height at Ilora ranged between -0.715 and 0.563 while those of Ikenne ranged from -0.396 to 0.711 (Table 3). The autocorrelation of both variables at both sites were random. That is, the autocorrelation values were neither dominated by negative nor positive autocorrelation. Also, the autocorrelation values for the different variables at both sites returned the same trends (positive and negative) at the same lag and for the same number of lag (Table 3). The only exception to the number of negative autocorrelation values was the stem girth at Ilora where only 45% of the autocorrelation values were negative unlike others where 65% of the autocorrelation values were negative. The correlelogram for both stem girth and plant height at both sides followed an alternating series with successive observations on different sides of the overall means, (Figures 1A and B). Also, more than 50% of the

autocorrelation values falls within the range of  $\pm \frac{2}{\sqrt{n}}$  which equals to  $\pm 0.333$  thus the residual is random and for large n,  $r_k - N(0, 1/n)$  approximately. The autocorrelation values for the Ikenne stem girth however need some forms of appropriation, because less than 50% of the value falls within the range of  $\pm \frac{2}{\sqrt{n}}$  (Table 3). It therefore indicated that this data differs from white noise and would need some forms of appropriation. The correlelogram of the spatial variability effects (SVE) for both stem girth and plant height showed a more alternating and reducing series as the lag increases (Figures 2A, B, C and D). The implication of this is that the correlelogram of the SVE followed the same pattern as with the treatment and that the SVE is an additive implication of lack of autocorrelation in the entire plot.

**Table 3.** Autocorrelation table at Lag K = 35.

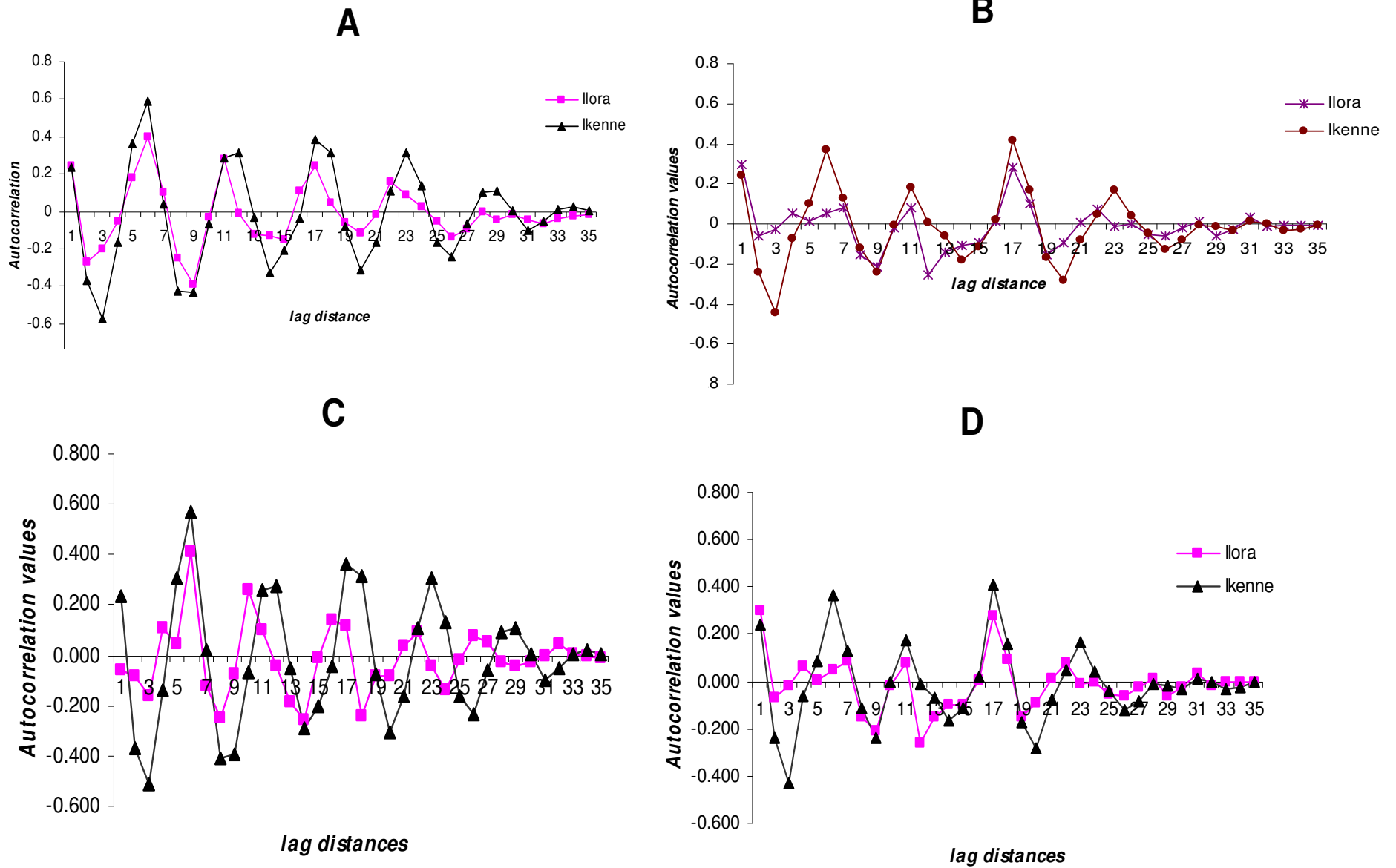
Lag distance	With treatment effects				Without treatment effects			
	Stem girth		Plant height		Stem girth		Plant height	
	Ilora	Ikenne	Ilora	Ikenne	Ilora	Ikenne	Ilora	Ikenne
1	0.244	0.237	0.293	0.242	0.244	0.237	0.228	0.242
2	-0.272	-0.372	-0.062	-0.244	-0.272	-0.372	-0.146	-0.244
3	-0.202	-0.573	-0.026	-0.446	-0.202	-0.573	-0.055	-0.447
4	-0.056	-0.164	0.055	-0.071	-0.056	-0.164	0.129	-0.071
5	0.177	0.36	0.012	0.099	0.177	0.360	0.014	0.099
6	0.396	0.587	0.053	0.368	0.396	0.588	0.042	0.368
7	0.102	0.042	0.08	0.13	0.102	0.042	0.012	0.130
8	-0.25	-0.423	-0.154	-0.12	-0.250	-0.423	-0.146	-0.120
9	-0.393	-0.43	-0.215	-0.244	-0.393	-0.430	-0.197	-0.244
10	-0.029	-0.069	-0.021	-0.004	-0.029	-0.069	0.076	-0.004
11	0.281	0.289	0.082	0.179	0.281	0.289	0.170	0.179
12	-0.013	0.314	-0.255	0.005	-0.013	0.314	-0.218	0.005
13	-0.122	-0.029	-0.142	-0.061	-0.122	-0.029	-0.124	-0.061
14	-0.132	-0.329	-0.106	-0.182	-0.132	-0.329	-0.046	-0.182
15	-0.15	-0.205	-0.093	-0.118	-0.150	-0.205	-0.099	-0.118
16	0.112	-0.039	0.011	0.022	0.112	-0.039	-0.064	0.022
17	0.241	0.382	0.283	0.414	0.241	0.382	0.193	0.414
18	0.045	0.31	0.098	0.166	0.045	0.310	0.093	0.166
19	-0.06	-0.083	-0.153	-0.165	-0.060	-0.083	-0.234	-0.166
20	-0.116	-0.314	-0.094	-0.284	-0.116	-0.314	-0.206	-0.284
21	-0.021	-0.167	0.008	-0.08	-0.021	-0.167	0.096	-0.080
22	0.155	0.109	0.077	0.045	0.155	0.109	0.022	0.045
23	0.086	0.311	-0.014	0.166	0.086	0.311	-0.059	0.166
24	0.027	0.136	-0.001	0.043	0.027	0.136	-0.102	0.043
25	-0.049	-0.167	-0.055	-0.045	-0.050	-0.168	-0.036	-0.045
26	-0.139	-0.245	-0.062	-0.124	-0.139	-0.245	-0.017	-0.124
27	-0.095	-0.064	-0.023	-0.081	-0.095	-0.065	0.023	-0.082
28	-0.003	0.099	0.012	-0.008	-0.003	0.099	0.054	-0.008
29	-0.047	0.109	-0.062	-0.015	-0.047	0.109	-0.013	-0.015
30	-0.019	0.003	-0.028	-0.034	-0.019	0.003	-0.048	-0.034
31	-0.048	-0.099	0.036	0.013	-0.048	-0.099	0.080	0.013
32	-0.067	-0.055	-0.015	-0.002	-0.067	-0.055	0.067	-0.002
33	-0.04	0.009	-0.007	-0.036	-0.040	0.009	-0.033	-0.036
34	-0.026	0.025	-0.003	-0.024	-0.026	0.025	0.022	-0.024

This does not however indicate total non autocorrelation because spatial autocorrelation have been suspected in effect (Table 2). In addition, the autocorrelation length of the stem girth with treatment inclusive were  $x_{28}$  for stem girth, Ilora and  $x_{33}$  for stem girth at Ikenne. For plant height at Ilora, the autocorrelation length was  $x_{34}$  while that of Ikenne was  $x_{31}$ . The autocorrelation length of the spatial variability effects for the stem girth at Ilora was found to be  $x_{27}$  while that of stem girth at Ikenne was  $x_{32}$  (Figure 2C and D). For the plant height at Ilora, autocorrelation length of the spatial variability effects was  $x_{26}$  while that of plant height at Ikenne was  $x_{30}$ . Thus, it could be observed that the autocorrelation length of the

spatial variability effects were shorter than those incorporating the treatment effects.

**DISCUSSION**

From the descriptive statistics, the spatial variability pattern (SVP) was observed to differ for different environment while it is similar for related growth indices. The similarity of the SVP for related growth variable could be hinged on the relationships existing between such related variables. Dauda et al. (2003) for instance have used a linear regression models to explain the relationships



**Figure 2.** Correlograms of the stem girth (A) and Kenaf plant height (B) as well as spatial variability effect of stem girth (C) and Kenaf plant height (D) at both Ilora and Ikenne.

between height and diameter at breast height of selected tree species. The SVP which include spatial variability and spatial similarities were suspected in patches. This is in contrast with Pfoser et al. (2000)'s approach of recording positional information for mobile objects. The suggested approach reduces objects to point data while ignoring their spatial extent. This disparity can however be hinged on the difference in the objects and change nature of such objects used by Pfoser et al. (2000) and this study. Two possible causes have so far been linked with spatial heterogeneity in any environment and are either naturally induced causes or artificially induced. It is also interesting to note that while spatial heterogeneity have been found to be caused by variety of disturbances and other biotic and abiotic factors in natural environment (Benwell et al., 2002) spatial heterogeneity in experimental field on the other hand could probably be traced to the naturally occurring situation to which treatment effects are cumulative.

The persistence of the highest plant height at the same plots could be hinged on the fact that the growth of plant is usually cumulative. The autocorrelation pattern as obtained from the result of this study is a function of the parameter because, while the stem girth of both sites produced similar autocorrelation on one hand, the plant height of the two sites produced different autocorrelation on the other hand. This similarity exhibited by these parameters implied proximity of observation. Exhibition of spatial autocorrelation is said to be a function of the proximity of observation (Schabenberger and Pierce, 2000). The irregular pattern of autocorrelation is in patches in the entire plots. The size of the range of autocorrelation values can be traced to the size of the data  $Z(s_i)$  obtained at each plots. That is  $\gamma(\tau) = f\{Z(x_i)\}$  and this autocorrelation of the datasets was shown in patches pattern. This was noticeable in the negative ridge displayed in 4 patches and across growth variables and sites. Lastly, the autocorrelation patterns were similar for both variables and sites but the size of the values of the parameters differs. In addition, randomness of the datasets was though obtained but autocorrelation of the datasets which were suspected in patches must be taken into consideration for proper model estimation. By this confirmation of randomness therefore, the univariate process can be modeled thus;

$$Y_i = A_0 + \varepsilon_i \dots\dots\dots(4)$$

Where  $\varepsilon_i$  is an error term, the  $Y_i$  is the autocorrelation and  $A_0$  is the lag period. Randomness as obtained from the autocorrelation and the correlelogram however has been said to be one of the three forms of spatial arrangements, (Benwell et al., 2002; Fagroud and Meirvenne, 2002). Others are clustered (where points are concentrated in one or more areas forming groups) and scattered uniform (when the points are distributed evenly).

These three forms can be found in any experimental field. The issue of spatial variability and uncertainty to conclude are often and widely discussed in geography and ecology due to dynamics of natural process. It had been less explored in agricultural field because activities on the agricultural field are artificially influenced.

However, based on this study spatial variability study is inevitable for any experimental field because;

i). The artificial influence on agricultural field notwithstanding, the baseline of these activities is still natural. For instance, the fertilization in this study would be influenced by the initial nutrients variability existing within the experimental plots. The artificial activities would thus be cumulative to the natural reserve.

ii). Subsequent to the artificial activities (otherwise termed treatment) on the experimental field, the response are keenly observed while the plants are allowed to remain within their natural environment.

This spatial variability has thus been incorporated into experimental agriculture where experimental activities are also based partly on natural phenomenon. Conceptually, the clear message is that uncertainty in the similarity of spatial points can be hinged on the analogy of spatial variability of other aggregate factors that enhances or inhibits the growth of such parameters. In as much as patchiness (the degree to which individuals are aggregated or dispersed) have been found to be crucial to how a species uses resources and to its reproductive biology, this study have also established that the spatial variability of the parameter is also crucial. This would chart the direction of the treatment to be applied on the field and at what coordinate such treatment should be concentrated.

In conclusion, the causes of spatial heterogeneity in any experimental field notwithstanding, spatial randomness and autocorrelation are real and are of valid concern. If it is neglected it can make the results of statistical experimentation and analysis untrustworthy. Based on these therefore, it could be recommended that the effects of plant type/ or species on the spatial variation in experimental plots is also recommended for further studies and method of patchiness delineation and definition needs to be evolved.

**REFERENCES**

Benwell GL, McLennan Grasberger T, Fryer J (2002). Spatial data analysis for aboriginal rock extraction sites at Brewarrina, NSW, Australia. Presented at the 14<sup>th</sup> Annual Colloquium of the Spatial Information Research Centre held at Victoria University of Wellington, Wellington, New Zealand between December 3<sup>rd</sup> – 5<sup>th</sup> 2002, p. 11.

Dauda TO, Ojo LO, Nokoe SK (2003). Height – Diameter Model of Some Tree Species in a Natural Forest. J. Trop. For. Resour. Department of Forestry, University of Ibadan, Ibadan, Nigeria, Vol 19(1): 200-219.

Fagroud M, Meirvenne MV (2002). Accounting for Soil spatial Autocorrelation in the Design of Experimental Trials. Soil Sci. Society Am. J. 66: 1134–1142.

Fike WT (1990). The rise and fall of kenaf as a fibre crop in North Carolina. In Janick J, Simon J (eds). Advances in New crops. Portland, OR; Timber press, pp. 297-299.

Fulton JP, Wells LG, Shearer SA, Barnhisel (1996). Spatial variation of



- soil physical properties; A precursor to precision tillage. ASAE paper No 961002, International Meeting, Phoenix, Arizona, July 14 -18, 1996 p. 24
- Liebhold AM, Gureitch J (2002). Integrating the statistical analysis of spatial data in ecology. *ECOGRAPHY*, 25: 553-557.
- Pfoser D, Jensen C, Theodoridis Y (2000). Novel approaches to the indexing of moving object Trajectories. *VLDB*, pp. 395-406.
- Presinger H, Coelho LF, Gasparotto L, Lieberei R (2000). Spatial and temporal changes of spontaneous vegetation in Agricultural field
- Richard J, Dean W (1998). *Applied Multivariate Statistical Analysis*, Prentice Hall, 1998, 2nd edition, p. 607.
- Schanbenberger O, Pierce FJ (2002). *Contemporary Statistical Models for the Plant and Soil Science*. Washington, D.C; CRC Press, p. 738.
- Song C, Kulldorff K (2008). *Stat. Med.* Vol. 15. 25(5): 825 -839.
- Vieira SR, Gozalez M (2003). Analysis of the spatial variability of crop yield and soil properties in small agricultural plots; *Brigantia Capinas*, 6(1):127-138.