CORRELATION BETWEEN CLAY CONTENT AND SEED DEPTH IN NO-TILLAGE CORN *(Zea mays L.)*

CORRELAÇÃO ENTRE O CONTEÚDO DE ARGILA E A PROFUNDIDADE DE DEPOSIÇÃO DAS SEMENTES MILHO *(Zea mays L.)* EM PLANTIO DIRETO

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ABSTRACT

The region of Campos Gerais, in the State of Paraná, is leader in grain yields and state-of-the-art no-tillage farming. The widely adopted no-tillage system tends to increment soil variability. There are several studies about spatial variability of soil characteristics affecting grain yield, but not enough attention has been given to the variability resulting of human actions. The objective of this study was to evaluate the correlation of soil clay content and the depth of placement of corn seeds on areas under no-till systems management. The four selected cornfields areas for the study are property of local farm cooperatives associates. The points for evaluation were defined considering the local mapping of soil texture. Clay content varied from 94 to 489 g kg^{-1} on Plot 1; from 222 to 414 g kg^{-1} on Plot 2; from 269 to 509 of rows to be considered for plant distribution and seed depth analyses. The coefficient of variation (CV) of plant distribution was between 23 and 56%. For seed depth, the CV was between 18 and 34%. The regression analysis showed high coefficients of determination (r^2) for plots 1 and 2 (r^2=0,85 and 0,83). The clay content was generally higher on plots 3 and 4. In this case, the analysis of variance was not significant, and the coefficients of determination were low (r^2=0,22 and 0,01). Results indicate that clay content values may be used to delimit g kg^{-1} on plot 3; and from 368 to 698 g kg^{-1} on plot 4. The type of planter determined the number management zones on the field, where the depth of seed placing in the planting process can be regulated in different ways.

Keywords: Soil Texture, Planting Process, Management Zones[5]

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RESUMO

A região dos Campos Gerais do Paraná é reconhecida pelo pioneirismo e estado de arte do sistema plantio direto no Brasil, que associado a outras tecnologias de produção, condições de solo e clima, propicia a obtenção de altos rendimentos das culturas de grãos. Entretanto, a variabilidade espacial que naturalmente ocorre nos solos desta região é acentuada pelo emprego do plantio direto. Existem vários estudos sobre o efeito da variabilidade espacial de atributos do solo no rendimento das culturas, mas pouca atenção tem-se dado à variabilidade resultante da ação antrópica. O objetivo deste trabalho foi avaliar a correlação do conteúdo de argila do solo e a profundidade de deposição de sementes de milho em áreas sob plantio direto. As quatro áreas de produção selecionadas para este trabalho são propriedades de associados de cooperativas agrícolas locais. Os pontos para avaliação foram definidos considerando o mapeamento local da textura do solo. O conteúdo de argila variou de 94 a 489 g kg^{-1} na área 1; de 222 a 414 g kg^{-1} na área 2; de 269 a 509 g kg^{-1} na área 3; e de 368 a 698 g kg^{-1} na área 4. O número de linhas a ser considerado para distribuição de plantas e profundidade de semeadura foi equivalente ao número de linhas da semeadora utilizada. O coeficiente de variação (CV) da distribuição de plantas observado variou de 23 a 56 %. Para a profundidade de semeadura, o CV variou entre 18 e 34%. A análise de regressão para profundidade de semeadura em função do teor de argila apresentou coeficientes de determinação (r^2) para as áreas 1 e 2 igual a 0,85 e 0,83, respectivamente. O teor médio de argila foi geralmente maior nas áreas 3 e 4. Neste caso, a análise de variância não foi significativa e os coeficientes de determinação foram baixos (r^2=0,22 e 0,01). Os resultados indicam que os valores de conteúdo de argila do solo podem ser indicativos para delimitar zonas de manejo, onde a regulagem de profundidade de deposição de sementes de milho pode ser em taxa variável.

Palavras-chaves: Textura do Solo, Processo de Semeadura, Zona de Manejo.

INTRODUCTION

The region of Campos Gerais, in the State of Paraná, is leader in grain yields and state-of-the-art farming technology. No-tillage system is widely adopted, and precision agriculture techniques are gradually being established. Precision Agriculture (PA) is defined as a production management system; it is based on process optimization, and considers spatial variability and correlated factors (MOLIN, 1997).

The division of the crop field in smaller areas, or management zones, based on variables that affect grain yield is an alternative to minimize the effects of variability. Some studies show a correlation between grain yield and soil physical characteristics (SWAN et al., 1987; BAKHSH et al., 2000).

The planting process is a source of variability, and the control over this process is a form of PA accessible to most farmers. Accuracy and precision during the planting process increase production rates and reduce the input of seeds and fertilizers.

The structure of the plant is important in the interception of solar radiation, and is a direct result of plant population and distribution on the field (MEROTTO JUNIOR et al., 1998, and FANCELLI & DOURADO NETO, 2000). SILVA & FREITAS (1994) observed that the distance measured in number of plants was more important than in metric units for pollination effectiveness.

In a study of the planting process, LIU et al. (2004) observed better correlation of corn yield to emergence variability, than to plant distribution variability, do not forgetting that problems in plant emergence can provoke a decrease on plant population. Several studies describe some form of correlation between corn yield and heterogeneity of emergence (NAFZIGER et al., 1991; MEROTTO JUNIOR et al., 1998). The temporal dissimilarity of plantlet emergence may cause losses up to 3.0 Mg per hectare (MEROTTO JUNIOR et al., 1998).

The higher the depth of seed placement, the higher the consumption of energy for emergence, implying negative influences by the lower temperatures of the soil and lower levels of oxygen; conversely, the lower the depth of placing implies higher susceptibility of the seeds to water deficits. Plants emerging at distinct speeds, in addition to the initial stress, are likely to face lower photosynthetic rates due to shading or having its pollination process affected (NAFZIGER et al., 1991).

Positive linear correlation between corn seed depth and emergence time in favorable temperatures was observed by GUPTA et al. (1988). PRADO et al. (2001) did not find significant differences in corn emergence speed at varying seed depths, with water supply. YORINORI et al. (1996) found inverse proportionality between seed depth and emergence speed of popcorn seeds.

The literature reports several interesting planting depths; FANCELLI & DOURADO NETO (2000) state it is 3 to 5 cm for clay soils, and 4 to 6 cm for sandy soils. WEIRICH NETO (2004) found the "mathematical optimum" seed depth; seeds placed above or below the optimum took longer to emerge.

Seed depth is an important variable, though very difficult to control. SATTLER (1992) has developed a device to control seed depth at planting. In no-tillage, there are common impediments such as residues, irregular surface and large variability of soil resistance (JANKE & ERBACH, 1985; MORISON JUNIOR & GERIC, 1985).

Different seed depths and ridge-opening depths for different water contents in the soil were observed by FEY (2000). BATEMAN (1972) found higher standard deviations for deeper projected depths.

The objective of this study was to evaluate the correlation of soil clay content and the depth of corn seed placing on areas under no-till systems management.

MATERIAL AND METHODS

The properties selected for this study belong to the project "Investigation on Precision Agriculture Practices" of Fundação ABC. The project was launched in 1998/1999 and includes properties in the region of Campos Gerais, in Paraná state.

Four properties (plots) were selected: Plot 1, 30 ha, is located at 50º 10' 00'' W and 25º 10' 00'' S; Plot 2, 25 ha, is located at 50º 03' 00'' W and 25º12' 00''S; in Ponta Grossa. Plot 3, 22 ha, is located in Castro, at 49º56'00''W and 24º51'00''S. Plot 4, 26 ha, is located in Tibagi, at 50º08'00''W and 24º20'00''S.

The points for evaluation were defined considering the local mapping of soil texture. Seed depth and plant distribution was evaluated at each point. To evaluate seed depth placement, the seedlings were cut close to the soil ten days after emergence, and after carefully taking out the roots, the distance from the cut to the seed was measured, employing ten replications by each sowing row. The number of sowing rows of the planter determined the number of rows to be considered for plant distribution analyses, and the length was the minimum enough.

Four distinct planters were employed; in the area 1 a John Deere planter, and in the areas 3, 4, and 5 a Semeato machine. On each area, the seeding was performed in the same day, employing the same machine, same operator, and the same adjustment. It was therefore expected the same depth of seed placement, not taking in consideration the likely spatial variability, which may have soils texture, in particular clay content, as the main reason.

The target adjustment for depth of placement was 5, 5, 4, and 5 cm, respectively to areas 1, 2, 3, and 4. All machines were adjusted to a final population of 65.000 pl ha^{-1}, and were executed by the mangers of each area.

The variability on depth of placement can reduce plant population, induce errors in the plant management associated to plant growing stages, and affect the pollination. Plant distribution was represented by population pressure, or the area occupied by a single plant, in m^2 or plants per hectare (SCHIMANDEIRO et al. 2006).

The data for seed depth and population pressure was analyzed with descriptive statistics. The analysis of variance for seed depth considered each point as one treatment. The relation between soil texture and seed depth was analyzed with linear regression analyses. The statistics for this study was calculated with the software MINITAB 12.2.

RESULTS AND DISCUSSION

Table 1 displays the descriptive statistics of clay content in the soil on the study plots. In soil texture studies in Campos Gerais, SÁ (1995) found clay content varying from 208 to 592 g kg^{-1}, and WEIRICH NETO (2004) observed an interval between 320 and 560 g kg^{-1}, with CV of 13%. It is clear that values on table 1 are typical to the Campos Gerais region.

Table 1 – Descriptive statistics of clay and sand content (depth 0-200 mm)

	Clay				Sand			
plots	1	2	3	4	1	2	3	4
Nr. Values	12	9	13	10	12	9	13	10
Average (g kg^{-1})	279	335	414	571	541	451	409	292
Standard Deviation (g kg^{-1})	117	55	76	95	133	63	87	104
Minimum (g kg^{-1})	94	222	269	368	299	361	291	160
Maximum (g kg^{-1})	489	414	509	698	766	568	587	509
Amplitude (g kg^{-1})	395	192	240	330	467	207	296	349
CV(%)	42	22	18	17	25	13	21	35

* coefficient of variation (CV)

Table 2 displays the descriptive statistics of seed depths found on field. There was a higher variability of planting depth on plots 2 and 3, as the CV was higher (see Table 2). Although a CV of 19% is statistically considered average, when referring to planting depth of corn seeds this value is considered low. Accordingly to CASÃO JUNIOR et al. (1998) and CASÃO JUNIOR et al. (2000) found seed depth CVs varying from 22.9 to 41.6%, and from 26.3 to 32.7%, respectively.

Table 2 – Descriptive statistics of planting depths (mm)

Plot	Nr. Values	Average	Standard Deviation	Minimum	Maximum	Amplitude	CV (%)
1	552	55	10	32	78	46	19
2	270	47	11	23	72	49	25
3	390	37	12	16	62	46	33
4	390	47	9	25	67	42	19

Initial climatic stress combined with varying seed depth may delay plantlet emergence, causing qualitative and quantitative variability in plant distribution.

Average seed depth in plot 3 was 37 mm, which lies within limits considering the soil texture variation from medium to clay (Table 2).

Table 3 displays the descriptive statistics of population pressure. The CVs of plots 1 and 4 are lower than in other plots. In plot 4, standard deviation was low, and there was an average of 73,850 plants per hectare. In this case, such numbers are a result of crop management, as the farmer aimed for a higher number of plants. In plot 2, the CV was 55%, characterizing a very high variability in plant distribution (Table 3).

An assessment of plant population pressure in Campos Gerais shows CVs higher than 55% in 3 out of 48 no-tillage cornfields (SCHIMANDEIRO et al., 2006); such variation is extremely high when maximum yields are expected. The source of missing or double plants may be irregular planting speed, machine adjustments, or biometric variations on the seed. Except for the area 1, population pressure were above the expected 65,000 pl ha^{-1}.

Table 3 – Descriptive statistics of population pressure (pl ha^{-1})

Plot	Nr. Values	Average	Standard Deviation	Minimum	Maximum	Amplitude	CV (%)
1	1,068	62,104	16,672	49,229	121,017	71,788	26
2	423	70,062	40,132	30,289	272,412	242,123	55
3	624	67,663	24,420	29,994	278,658	248,664	36
4	1,280	73,850	18,296	40,945	159,264	118,319	24

The correlation of soil texture and seed depth for plots 1 and 2 (Figures 1 and 2) shows a close association between the two variables. The analyses of variation of both regressions were extremely significant, with coefficients of determination (R-squared) of 0.85 and 0.83%, respectively. The relation is inversely proportional: the higher the clay content in the soil, the more superficial the seed was planted. In plots 3 and 4 the analysis of variation was not significant, and the coefficients of regression were low (Figures 3 and 4).

A tendency can be established considering the values on variability (Table 1) and correlation (Figures 1, 2, 3 and 4): the higher the CV, the stronger the correlation between seed depth and clay content in the soil. The minimum values of clay content on plots 1 and 2 were lower than on plots 3 and 4; a slight increase of clay content to the lower values would result in more severe variations to the soil structure, soil resistance to penetration, water content.

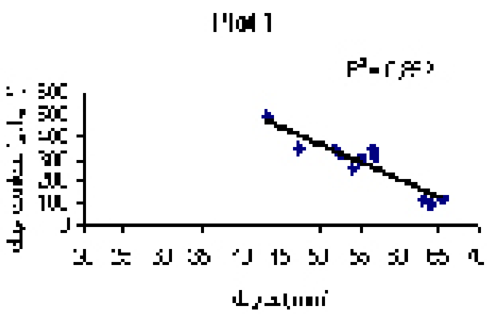


Figure 1 - Linear regression of average seed depth and average clay content.

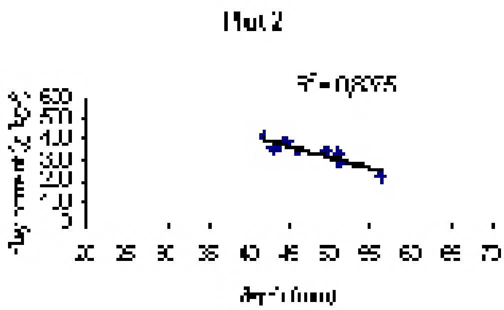
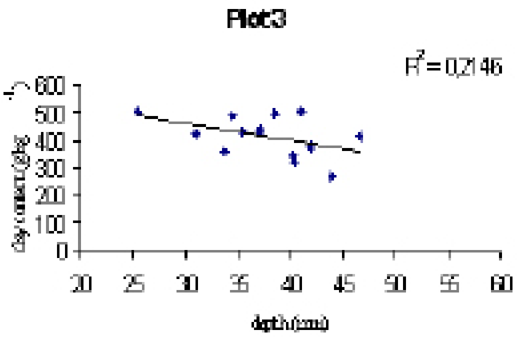


Figure 2 - Linear regression of average seed depth and average clay content.



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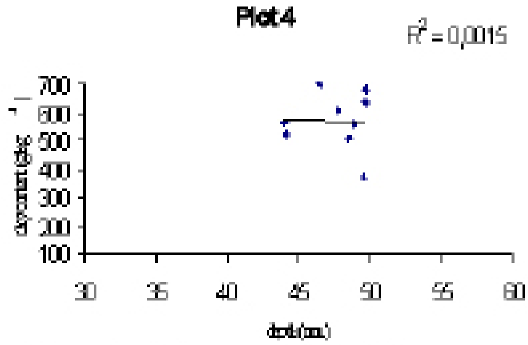

Figure 4 - Linear regression of average seed depth and average clay content.

On plots 3 and 4, the average clay content values were higher; in this case, a variation of the clay content would not have such strong influence to the soil structure. The adjustments of the planter would have more influence on the process; even though there is no correlation between seed depth and clay content on Plots 3 and 4 (Figures 3 and 4), there was an intense variation of seed depth values, especially on plot 3.

Soil clay content is an indicator for reviewing the adjustment of the depth of placement of corn seeds, as well as it can be an interesting variable as it concerns crop productivity and its tendency to influence on the depth of seed placement.

CONCLUSION

Two out of four study plots showed significant positive correlation between clay content in the soil and seed depth. The plots where the correlation was established had lower average values and higher variability of clay content.

On an area, where significant correlation was observed, there was a lower population pressure.

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