MANAGEMENT CROP PRODUCTION SYSTEM USING PRECISION FARMING CONCEPT FOR DECISION MAKING.

GERENCIAMENTE DO SISTEMA DE PRODUÇÃO UTILIZANDO CONCEITOS DE AGRICULTURA DE PRECISÃO PARA TOMADA DE DECISÃO.

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ABSTRACT

The change of data into information is the most important aspects when using precision agriculture concept, in order to understand crop yield differences in the same area of production. The objective of this paper is to present a Management Crop Production System Methodology to help farmers make decisions of a specific intervention on the low production and unprofitable areas. This work was developed in Sete Lagoas, Minas Gerais state, Brazil, during three years (1999 through 2002), in an area of 38 ha, irrigated by a center pivot, with corn crop under no-tillage system and the results applied for developing a methodology and then applied to a production area of 115 ha, Recanto Farm, Sidrolândia, MS, Brazil. The yield maps were obtained using a MF-34 combine, with an yield monitor and DGPS system. The proposed methodology is being used to identify and to analyze the intervention areas by two maps: trend and profitability. This methodology provides the farmers with a management system to analyze a specific production variable or adopted technology, by accepting or rejecting a certain intervention.

Keywords: Precision Agriculture, spatial and temporal variability, management system, corn production system.

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Recebido: Mai/07
Aprovado: Ago/07

RESUMO

A variabilidade dos dados é um dos mais importantes aspectos quando se usa o conceito de agricultura de precisão com o objetivo de entender as diferenças de produtividade em uma mesma área de produção. O objetivo deste trabalho foi o de estabelecer critérios para intervenção em áreas de produção de milho utilizando conceitos de agricultura de precisão a fim de ajudar aos agricultores na tomada de decisão para intervenções específicas em áreas de baixa produtividade. Esse trabalho foi desenvolvido em Sete Lagoas, estado de Minas Gerais, Brasil, durante três anos (1999 a 2002), em uma área de 38 ha, irrigada por um pivô central, em uma área de milho em sistema de plantio direto e os resultados foram utilizados para desenvolver uma metodologia, sendo aplicados em uma área de 115 ha, na Fazenda Recanto, em Sidrolândia, MS, Brasil. Os mapas de produtividade foram obtidos utilizando uma colhedora MF-34, com sistema de monitoramento de produtividade e DGPS. Esta metodologia proposta está sendo utilizada para identificar e analisar áreas de intervenção através de dois mapeamentos: tendência e rentabilidade. Essa metodologia fornece aos agricultores um sistema de gerenciamento para analisar uma variável de produção específica, ou uma tecnologia adotada, aceitando ou rejeitando determinada intervenção.

Palavras-chaves: agricultura de precisão, variabilidade especial e temporal, sistema de gerenciamento, sistema de produção de milho.

INTRODUCTION

In 1997, the Brazilian farms started to use corn combines with yield monitor as a tool to help them to manage corn production system. Yield maps were made from these harvest equipments and a criteria analysis could be made observing the spatial variability of the production fields. For many years the use of this technology was presented as one of a major contribution from the precision farming but it is only the first step of the all possible applications.

One of the most important aspects when using precision agriculture concept is to change data into information in order to understand crop yield differences. To identify and to analyze the intervention areas in order to help farmers make decisions about a specific agronomic recommendation is the last step to solve problem in areas of low production and unprofitable areas.

According to LARSCHEID et al. the recommendations of fertilize rate application are not precise and most of them are based on a specific yield goal for a soil map, despite of spatial variability of each unit of map and using average weather data. In the meantime the intervention stage didn't happen completely because of a lack of equipments in Brazilian market, and also efficient criteria, to determine parameters to classify yield levels in production stability classes. To implement this criterion, classifying by classes, at least three years of maps are required to estimate the temporal variability of the field crops. LARSCHEID et al. (1997) indicate that management decisions of a farm can be divided in three stages: the first one, long term decision, like crop rotation strategies; the second one, intermediate decision, related with the next planting time and the third one, short term decision, during the growing season. At least, three years of yield are required to apply this methodology develop by LARSCHEID et al. (1997).

These authors comment that yield maps are a useful tool to make long term and intermediary decisions mainly when a field will be planted for many years. Besides this, the technological level applied to the production system of a crop can change from farm to farm, and consequently the value of a yield alone will be not efficient to determine the value of these classes. Therefore, the economical analysis in these yield maps is important to determine the production cost, and also to know the break even point or a minimum yield necessary to pay the applied the costs. SWINTON & LOWENBERG-DEBOER (1998) show that the partial budget analysis has been an efficient tool used to evaluate profit in Precision Farming. This methodology only uses cost items and revenues that promote the changes when applying new practice and it is normally calculated in acres or by field.

GOMIDE et al (2000) showed a corn profitability map from an economic analysis of a field located in the experimental area, presenting the profitability calculated by differences between the revenues obtained by grain yield and total costs of the no tillage corn production system per hectare.

OBJECTIVE

The objective of this research was to present a Management Crop Production System Methodology-MCPSM to support farmer’s decisions.

MATERIAL AND METHODS

The site used in this research was a field crop of 38 ha located at Embrapa Corn and Sorghum Research Center, in Sete Lagoas, MG, Brazil.The altitude is 732 m, latitude South of 19°28' and longitude W est of 44°15'. Corn crop was cultivated under no-tillage system during three seasons 99/00, 00/01 and 01/02, and it was managed according to the agronomic recommendations to this area.To characterize the field, soil samples were collected (0-20cm depth) on a square grid basis within 25 m distance between sampling points.Sampling points were geographically referred using a GPS Trimble.Corn was harvested using a combine equipped with a Field Star AGCO yield mapping system in all three years. Yield maps data file were colleted and imported into SPRING Geographic Information System software to be analyzed.

Spatial variability in soil parameters is known to be one of the most important causes of yield variability. In order to understand one of possible factors causing yield variability, soil analysis was performed for Phosphorus, Potassium, Electric Conductivity, Soil Resistance, Organic Matter and pH. According to FRANÇA et al., 2001, one of recent techniques to study these correlations is to establish the management zones, in order to stratify field areas in homogeneous sub-areas based on all factors mentioned above.

The process adopted for generating a management unit maps was develop by LARSCHEID et al. (1997) and LARSCHEID & BLACKMORE (1996), and the following procedures were used:

- The normalized yield map was generated by calculating the average from the yield data and then, dividing each yield value by this average value and multiplying by 100. The normalized yield values are now expressed in percentage;

- The Yield Spatial Trend Map was generated by averaging the three years corn yield maps, using the same number of grid points;

- The Yield Temporal Stability Map was generated by using the normalized yield data and calculating the average and standard deviation for each row. The calculation of the coefficient of variation-CV is:

  Coefficient of variation = (Standard Deviation/ Normalized average) x 100 **Eq. 1**

- The CV indicates how variable the yield data is over time. The smaller the CV the more stable the yields are over the time.

Management Unit Map: The combination of yield spatial trend maps and yield temporal stability maps was done using a set of classification rules shown in Table 1.

TABLE 1 - Management units based on average normalized data and yield coefficient of variation.

Management Units	Average normalized	Yield coefficient of variation
Stable and High yield	> 100	< 30 %
Stable and low yield	< 100	< 30 %
Unstable	<> 100	> 30 %

This methodology was developed in Sete Lagoas, state of Minas Gerais, Brazil, during three years (1999 through 2002) in an area of 38 ha, with corn crop under no-tillage system. The results were then applied in a commercial farm (Recanto Farm, Sidrolândia, MS, Brazi)l using a production area of 115 ha, with rotation crop with no tillage: three years of soybean and one of corn.

The methodology to analyze costs from the production system was developed by MATOSO et al. (1989), and all input used to produce soybean and corn in field were included. To explore spatial yield variability within a crop field it was also necessary to determine the profit margin from the different areas of the field. One of the consideration was that all field inputs were done at a homogeneous rate (NPK, seed and herbicide, etc.), to exclude the variability of the components.

RESULTS AND DISCUSSION

Soil analysis

A statistics analysis was performed by OLIVEIRA et al. (2001), with yield values from the same place, using a Multivariate analysis for each soil parameter, electrical conductivity, soil resistance and yield. The results on Figure 1 shows the use of multivariate technique of principal components analysis applied to soil variables, in order to validate the management zones, established based on electric conductivity and altitude, Oxisoil under corn crop cultivation, which explain 63% of the total variation.

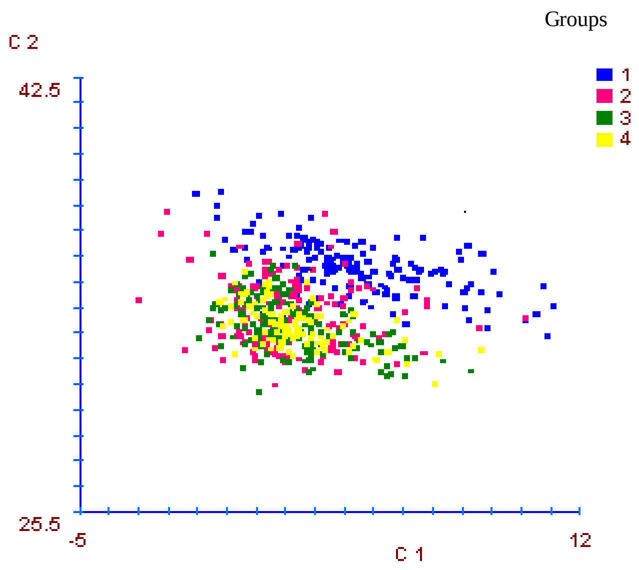

FIGURE 1 - Point dispersion based on two main principal components using soil variables, electrical conductivity, and altitude. The colors represent the initial management zones, established by FRANÇA et al. (2001).

Cost analysis

The results of cost analysis are shown in Table 2 where the break even point is equal to 1,916.25 kg ha^{-1}. This value gives an idea of how much soybean is necessary to be produced per hectare to pay the costs. With the break even points all the data from the yield maps were reclassified to show the spatial variability of the profit from the studied areas.

TABLE 2 - Soybean crop economical analysis of the break even point and returns costs.

Itens	Values
Yield – cost analysis (kg ha^{-1})	1.916,25
Price (R$)	0,30
Total Revenue (R$)	574,88
Gross Margin (R$)	56,19
Net Margin (R$)	0,00
Break even point over variable costs (kg ha^{-1})	1.728,95
Break even point over fixed costs (kg ha^{-1})	1.916,25
Return rate over variable costs	1,11
Return rate over fixed costs	1,00

Obs: Dollar rate Sept, 2007 = R$2.00 per US$1.00

To quantify the variability (spatial and temporal) two years of soybean yield and one year of corn yield maps were used, and the result is shown on Figure 2. The results were obtained in a field of 115 ha at Recanto MS, Brazil. It was possible to establish the spatial pattern for stable and unstable areas using LARSCHEID et al (1997) and LARSCHEID & BLACKMORE (1996) methodology.

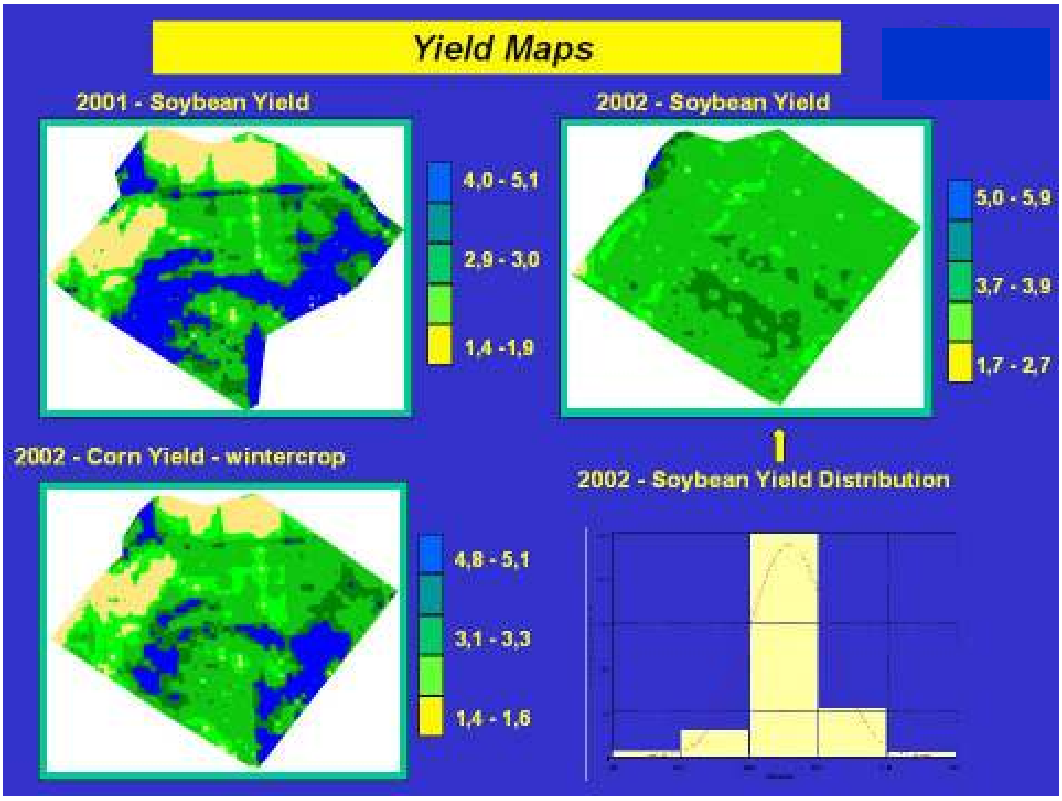

FIGURE 2 - Normalized Yield Maps of 115 ha production area for both soybean and corn rotational cropsunder no-tillage system at Recanto Farm. Sidrolândia, MS, Brazil (2000-2002)

After recalculating soybean yield maps using the economic analysis methodology the profitability maps can be established to support farmers to make decision with more reliable criteria. The results of this Profit crop production maps with the economic analysis on Table 2 give an indication of the behavior of each segment of the production area. The result analysis showed that the profitable areas are above the break even point and the percentage of losses are below, as shown in Table 3 and Figure 3.

TABLE 3 - Revenue Range of total field area under each net margin category in Recanto Farm, Sidrolândia, MS, Brazil.

Units	Profit Soybean Mean Yield ($kg\ ha^{-1}$)		Profit ($R\$\ ha^{-1}$)		Number of Ha	Revenue Range	
	2000	2002	2000	2002		2000	2002
1	1567	1916	-104.78	0.00	0.04	0.82	1.00
2	1917	2880	0.00	289.12	52.10	1.00	1.50
3	2881	3840	289.42	577.12	62.77	1.50	2.00
4	3841	4800	577.42	865.12	50.21	2.00	2.50
5	4801	5633	865.42	1,115.02	0.79	2.50	2.94

This new yield map of or management unit using the process developed by LARSCHEID et al (1997) and LARSCHEID & BLACKMORE (1996), shown in Figure 4 indicates a pattern of this field in soybean production, with long term spatial variability of yield for this area.

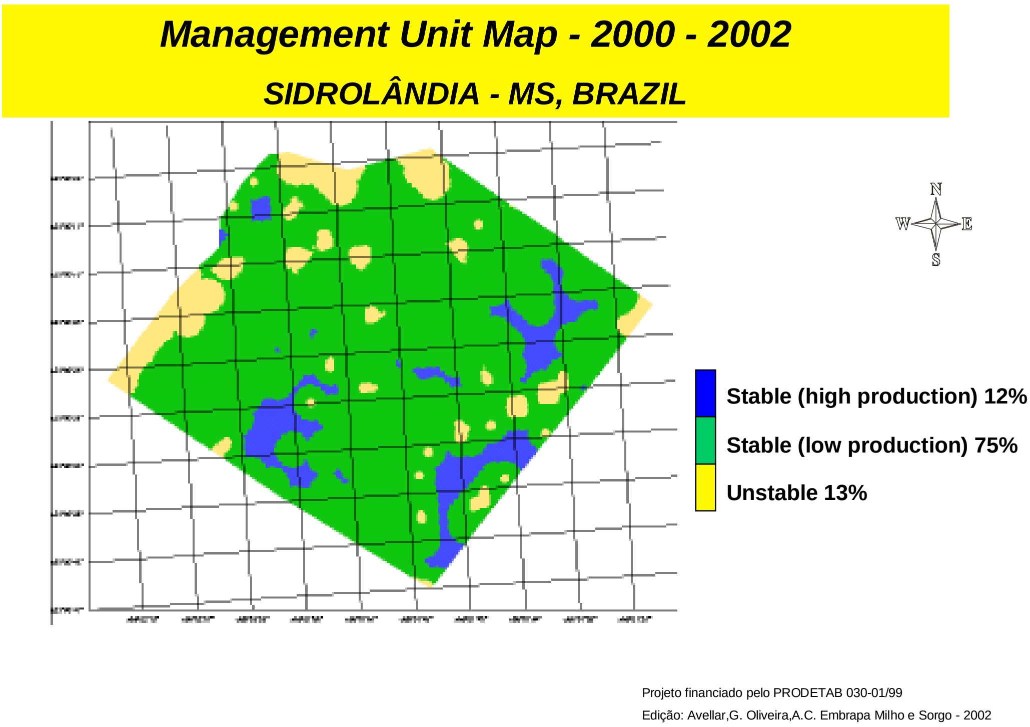

FIGURE 3 - Management Unit Map of 115 ha production area in Recanto Farm, Sidrolândia county, MS, Brazil

Using the procedure for building Figure 4 (LARSCHEID et al., 1997 and LARSCHEID & BLACKMORE, 1996) which classified the management units, the areas with low productivity can be located in these maps, and the input applications needed for correcting eventual problems is then done in distinct rates.

This precision farming concept increases the efficiency on fertilize or chemical applications, or any intervention to correct soil physics problems by the use site specific management. This represents an advantage over the traditional agriculture, as mentioned by LARSCHEID et al. (1997), where the inputs are applied by mean as homogeneous.

agronomic recommendations using the area

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FIGURE 4 - Profitability Map of a 115 ha field at Recanto Farm, Sidrolândia county, MS, Brazil (2000-2002)

The proposed methodology has been tried and accepted in the production area of the “Recanto” Farm and now is being used to identify and to analyze the intervention areas with the two maps:

Management Unit and profitability map. Therefore, the MCP System provided a useful tool to analyze a specific factor or adopted technology by accepting or rejecting a certain intervention.

CONCLUSION

The temporal variability of the field indicates that yield distribution was different in each growing season, while the spatial variability showed three major distinct areas: stable with high production, stable with low production and unstable production.

The cost analysis was found to be a useful tool to indicate the profitability as well as to help farmers to make decision over intervention on unstable and low production area. The costs analysis needs to be proceeded using agronomic recommendations before any intervention is actually done in the area to support farmer's decision.

ACKNOWLEDGEMENTS

The authors wish to thank PRODETAB Project 030-01/99 and EMBRAPA, for supporting this research.

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