

Monitoring of Nitrogenized Coverage Fertilization in Wheat Crops by Remotely Piloted Aircraft (RPA)

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Abstract— One of the factors that makes possible the variable condition within the same culture is known as agricultural georeferencing for the creation of maps and, more recently, the use of remotely piloted aircraft to acquire images of higher quality and more dynamically and cheaper, because it is a new technology, lacks regional technical-scientific information. The uses of remotely piloted aircraft help in the discovery of variables using images in a faster way, thus enabling the identification of factors that may interfere with production and take measures to correct them. The objective of this study was to monitor nitrogen fertilization coverage in wheat crops by remotely piloted aircraft (RPA). Nitrogen fertilization in wheat crops was managed of the two ways: conventional management and RPA management. The variables analyzed were yield (kg / ha) and economic analysis. The analysis of variance revealed a significant effect of nitrogen and non-significant between crops in relation to the variables response yield, revenue, expense and profit, evidencing the superiority of the RPA management in relation to the conventional one.

Keywords— *Economic analysis, RPA, management of nitrogen fertilization.*

I. INTRODUCTION

Precision Agriculture is the management of production variability and the factors involved in it, using recent technologies adapted to the agricultural system, with the objective of optimizing the use of inputs and reduce the impact on the environment. Because of this, commercial agriculture has suffered profound changes in recent years, triggered off mainly by the use of technology in the field, directed to the mechanization of processes, use of chemical inputs, direct sowing system and biotechnology (CIRANI and MORAES, 2010)

The use of remote sensors has many applications such as biomass identification, leaf index, diseases, pests, water stress, yield prediction, monitoring of soil properties and mapping. Chemical analysis in leaves, pest control and management and weeds, soil surface properties, biological conditions, chlorophyll parameters, nitrogen concentration in the leaf, vegetative cover, among other factors can be also monitored (ZHANG and KOVACS, 2012).

The application of these techniques consists of applying variable amounts of nutrients to heterogeneous crops, depending on the peculiar properties of each part of the crop (GÓMEZ-CANDÓN et al., 2014).

One of the factors that enables this variable condition within a single culture is known as agricultural georeferencing for map creation and, more recently, the use of remotely piloted aircraft (RPA) for higher quality, more dynamic and cheaper image acquisition, because it is a new technology, it lacks regional technical-scientific information.

For Primicerio (2015) remotely piloted aircraft helps in the discovery of variables with the use of images in a faster way, thus allowing the identification of factors that may interfere in production and take measures to correct them.

The current work aims to monitor the nitrogen fertilization of cover in wheat crops by remotely piloted aircraft. Its development seeks to compare the use of remotely piloted aircraft with the conventional management carried out by the farmers of the region, analyzing and presenting proposals that can optimize the use of nutrients in the crops.

II. MATERIALS AND METHODS

2.1 Climate and soil

The monitoring was carried out in two wheat crops (1 and 2) located in the western region of Santa Catarina, located in Araçá line, in the municipality of Maravilha / SC, 2017. According to the classification system of Köppen, the climate is of the type Cfa (MENDONÇA; DANNI-OLIVEIRA, 2007).

The main meteorological systems responsible for rainfall in the state are cold fronts, tropical convection, SACZ (South Atlantic Convergence Zone) and maritime circulation. In the regions closest to the mountain slopes, rainfall is more abundant, since the elevation of hot and humid air favors the formation of cumuliform clouds, resulting in increased local precipitation volume (MONTEIRO, 2001).

The meteorological conditions (temperature and precipitation) were obtained in INMET (2018) and can be seen in figure 1.

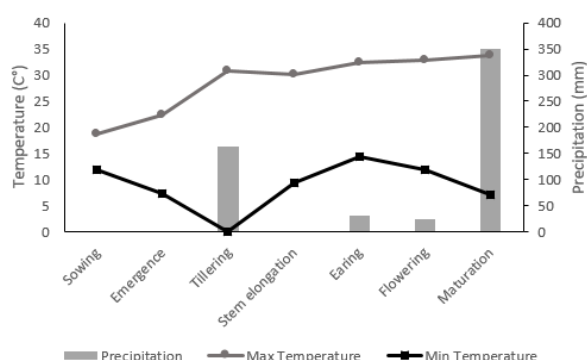


Fig 1 - Weather conditions during the experiment.

The soil is classified as CAMBISSOLO háplico (EMBRAPA, 2013).

2.2 Equipment

The wheat crops were conducted with localized management (georeferencing) and the area mapping was carried out with the help of a RPA Juno™ Series Trimble® navigation, which demarcated the area vertices for map generation and sampling mesh.

A square mesh was adopted totalizing sampling points, in order to configure a better spatial distribution of the points in the area.

The sampling mesh used was characterized by one point (sample) per hectare, which was determined and georeferenced through Farm Work Office® software.

The images were obtained at wheat grading stage through the use of a RIP DJI® Phantom 2 vision, through an embedded camera, its payload, which does not allow calibration of the light input, since it has fixed aperture of focal ratio 2.8G, with a focal length of 5mm. In this way, we chose to capture images in a video format, with a 140° Field Of View (FOV) lens (HARRIS, 2015) and a

resolution of 1280x720 pixels with a 1 / 2.3 CCD sensor', that is, 6,16mm x 4,62mm, in a flight approximately 2 meters above the ground with GSD of 1.92mm.

In the 2016 harvest, with the research entitled "Monitoring of nitrogen fertilization in coverage in dual-purpose wheat crop via REMONTELY-PYLOTED AIRCRAFT (RPA)" - Edital: nº28 / UNOESC-R / 2016, CNPq Normative Resolution nº17 / CNPq / 2016 and resolution nº203 / CONSUN / 2011", the computational analysis algorithm was created, which was validated in the 2017 crop in the respective wheat crops.

The wheat crops in relation to nitrogen fertilization were managed of the two ways: conventional management (CQFS-RS / SC, 2016) and management by RPA.

2.3 Management

In the conventional management nitrogen fertilization was 15 kg / hectare in the sowing of the crop, with single application of 67.5 kg of nitrogen in the tillering stage. 30 kg of P₂O₅ and 30 kg of K₂O per hectare were distributed in the sowing line, the N, P, K formulation used at sowing was 10:20:20.

The sowing of the cultivar was performed on July 1st, 2017 with a line spacing of 17cm and 51 seeds per linear meter. The germination index and seed purity were respectively: 92% and 98%, totaling a stand of 270 germinated plants per square meter.

Control of weeds, pests and diseases were carried out during the development of the crop.

The harvest was made when the wheat was fully ripened and at a moisture content of 13%. A square of 25cm x 25cm totaling 0.0625m² per sample used. In each one of the crops, 10 samples were collected, which were later threshed manually, weighed in analytical balance at UNOESC, and subjected to moisture and pH analyzes, with the appropriate discounts.

In the RPA management, 15 kg of nitrogen per hectare was applied to the sowing line, two aerial applications in the tillering stages (34.5 kg N per hectare) and stem elongation (5.17 kg N per hectare). 30 kg of P₂O₅ and 30 kg of K₂O per hectare were distributed in the sowing line, the N, P, K formulation used at sowing was 10:20:20.

The sowing of the cultivar was performed on July 1st, 2017 with a spacing between lines of 17cm and 51 seeds per linear meter. The germination index and seed purity were 92% and 98% respectively, totaling a booth of 270 germinated plants per square meter.

The other cultural treatments (phytosanitary treatments, harvesting, analysis of PH and moisture) of these crops were the same of the crops cultivated in conventional system.

The cultural practices were carried out according to the technical indications of the wheat crop (EMBRAPA, 2014).

The cultivar sown on wheat crops was TBIO TORUK®, with interesting characteristics for this producing region, it has medium cycle, with short stature of the plants, good tolerance to diseases, besides good tillering and uniform earing, its requirement for soil fertility is medium / high (BIOTRIGO, 2014).

The variables analyzed were yield (kg / ha), by the method proposed by MAPA (2009) and economic analysis, using the unlimited capital methodology based on the kg of nitrogen fertilizer (urea) and the kg of grain of wheat (MATUELLA and SIMIONI, 2015). The Test of F submitted the collected data to Analysis of Variance and the Tukey Test ($P \leq 0.05$), with the aid of Sisvar 5.0 Software (FERREIRA, 2010), compared the differences among the averages.

III. RESULTS AND DISCUSSION

The analysis of variance revealed a significant effect ($P \leq 0.05$) of the nitrogen fertilizer management and non-significant for the crops in relation to the yield response variable (Tables 1 and 2).

Table 1 - Yield of the experiment in relation to nitrogen fertilization management (Maravilha / SC - Harvest 2017)

Management of nitrogen fertilization	Yield (sc/ha)
Conventional management	33,64 b
RPA management	48,06 a
CV (%)	18,04

Results followed by the same letter do not differ by Tukey's test ($P \leq 0.05$).

Table 2 - Yield of the experiment in relation to crops (Maravilha / SC - Harvest 2017)

Wheat crop	Yield (sc/ha)
Crop 1	41,02 a
Crop 2	40,68 a
CV (%)	18,04

Results followed by the same letter do not differ by Tukey's test ($P \leq 0.05$).

The analysis of variance revealed a significant effect ($P \leq 0.05$) of the nitrogen fertilizer management and non-significant for the crops in relation to the variables revenue, expense and profit responses (Tables 3 and 4).

Table 3 - Revenue, expense and profit of the experiment in relation to nitrogen fertilization management (Maravilha / SC - Harvest 2017)

Management of nitrogen fertilization	Revenue (R\$/ha)	Expense (R\$/ha)	Profit (R\$/ha)
Conventional management	1110,20 b	186,00 b	924,20 b
RPA management	1609,78 a	139,50 a	1470,28 a
CV (%)	17,94	5,00	20,38

Results followed by the same letter do not differ by Tukey's test ($P \leq 0.05$).

Table 4 - Revenue, expense and profit of the experiment in relation to crops (Maravilha / SC - Harvest 2017)

Wheat crop	Revenue (R\$/ha)	Expense (R\$/ha)	Profit (R\$/ha)
Crop 1	1377,50 a	162,75 a	1214,75 a
Crop 2	1342,49 a	162,75 a	1179,73 a
CV (%)	17,94	5,00	20,38

Results followed by the same letter do not differ by Tukey's test ($P \leq 0.05$).

As observed in Table 1, the yield of wheat cultivated by RPA was significantly higher due to the splitting of the nitrogen applications, because when the N doses in tillering and stem elongation were fractionated, the definition of the yield components occurs.

The georeferenced management by RPA involves the obtaining and processing of detailed information on a particular area of wheat crop, allowing the definition of more efficient management strategies, especially in the rational use of inputs (nitrogen fertilization) according to its ecophysiology (EMBRAPA 2014).

The yield did not show differences among the crops (Table 2), because they were located within the same soil and climatic conditions (FIGURE 1).

In relation to the nitrogen dose, the recommendation has to relate with the previous crop, soil organic matter, climatic conditions, cultivar, among others (FLOSS, 2011).

As observed in Table 3, for the revenue variable, RPA management (R \$ 1609.78 per hectare) differed significantly from the conventional one (R \$ 1110.20 per hectare). Yields on crops of wheat and other crops are dependent on management and soil-climatic conditions (FLOSS, 2011).

In relation to expenses (TABLE 3), it is possible to notice that the RPA management presents significantly the lowest values (R\$) when compared to the conventional one.

The reading of the chlorophyll content by RPA (SPAD reading) is a technological tool that provides the farmer with a subsidy to verify the performance of wheat (and others), with nitrogen fertilization correlated with its ontogenic stages.

The use of the SPAD allows quick and easy results, allowing the farmer to apply only what is required by said culture, articulating technical, ecological, social and environmental aspects, thus providing the sustainability of the respective plant production system (HURTADO et al. 2008).

As shown in Table 3, the significantly higher profit, it was obtained in the RPA management when compared to the conventional one, because in this management, the revenue was higher and the expense was lower in relation to the conventional management, obtaining a difference of R\$ 546.08 more.

This explanation is due to the management by RPA (SPAD index) providing a better optimization of the nitrogenous fertilizer (HURTADO et al., 2008).

Based on the technical and economic results of the respective research, it can be noticed in a particular environment, the phenotypic manifestation is the result of the action of the genotype under influence of the environment. However, considering a series of environments, it is detected that, besides the effects of genotypes and environments, an additional effect, provided by their interaction. This interaction quantifies the differentiated behavior of the genotypes in the face of environmental variations and it is called interaction genotypes x environments (GxE) (CRUZ and REGAZZI, 1997; CRUZ and CARNEIRO, 2003).

IV. CONCLUSION

With this study can conclude that the georeferenced management with RPA is more efficient in relation to the conventional management, considering some technologies that allow applying the necessary amount of nitrogen, avoiding wastes, thus obtaining more efficiency of the plants in the absorption of this nutrient along of the cycle. It can also concluded that the management with RPA obtained greater profitability compared to conventional management, because it obtained lower expenses with nitrogen fertilization.

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