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Agronomic Characteristics and Productivity and Oil Content of Canola Crop as a Function of Poultry Litter Use

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Authors' contributions

All authors contributed to the elaboration of this work. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Poultry litter is an organic residue that can be used as fertilizer for crops such as canola that require high nutrient demand. The objective of this research was to evaluate agronomic characteristics, productivity and oil content of canola crop as a function of poultry litter use.
Study Design: The experiment was conducted in the field in a randomized block design with 4 replications.
Place and Duration of Study: The experiment was carried out in a property in the city of Serranópolis do Iguaçu, state of Paraná, between May and September, 2016.
Methodology: The treatments were the doses of 0, 1, 2, 4, 8, 16 and 32 t ha^{-1} of poultry litter from 6 lots of broiler chickens production. Hyola 433 hybrid was used. Sowing was performed on May 6 and harvest on September 30, totaling a 145-day-cycle. The row spacing used was 0.5 m, resulting in a density of 400 thousand plants ha^{-1}.
Results: In canola cultivation the poultry manure fertilization does not affected the leaf N and K contents, plant height, number of grains per silica, number of silica per plant and thousand grain

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mass. The leaf P content increased from the 16 t ha^{-1} as the doses increase. The highest yield (2.5 t ha^{-1}) and the highest oil content (43.2%) were obtained with the 8 t ha^{-1} dose.
Conclusion: In conclusion the canola fertilized with poultry litter was significant for some variables and for the productivity and quantity of oil in the treatment of v) 8 t ha^{-1} and vi) 16 t ha^{-1} for phosphorus content in leaf tissue.
It is also concluded that high doses of poultry litter doses not provide increase in canola crop variables.

Keywords: Organic waste; sustainable; nutrients.

1. INTRODUCTION

The canola crop (*Brassica napus*), which was developed by breeding rapeseed, belongs to the Brassicaceae family, and is of great economic importance because it is a plant grown in winter, providing oil extraction and for presenting about 34% to 38% oil in its grain and 24% to 27% protein [1,2].

Adequate and balanced nutrient supply is a limiting factor for canola productivity. In addition, the requirement for medium to high fertility soil and N fertilization is essential management for satisfactory crop responses [3,4,5]. In recent decades, Brazilian poultry has shown a high growth rate, becoming the third largest producer in the world, with a flock of 5.5 billion head of broiler and laying chicken, and being the leader in exports [6,7].

The poultry litter is rich in nutrients, with emphasis on N, P and K, which have a high demand for plants and microorganisms. Its application has been associated with improvements in soil chemical, physical and biological attributes, contributing to reduced erosion, increased water retention, and increased C and N content [8,9]. Melo et al. [10] point out that organic fertilization with poultry litter also provides greater nutrient recycling in the soil when compared to mineral fertilization because it promotes increase of organic matter and soil microbiota.

According to Kiehl [11] the use of poultry litter combined with chemical fertilization correspond to an increase in the production of several crops. In addition, organic fertilization brings benefits to the soil as it lowers the pH through inorganic complexes with Al and Fe, creasing the absorption of P, increasing its availability and other nutrients contained in the soil solution.

Given this, more and more alternatives are being sought for the safe use of poultry litter in order to avoid environmental contamination. The use of these organic residues in agriculture as a nutrient source for crops becomes an interesting alternative in view of the high price of mineral fertilizers, coupled with the low cost of production, as it can be generated within the rural property.

Canola, as characteristic of the species, is demanding in soil fertility, and can be benefited by the use of poultry litter as organic fertilizer. Therefore, the present work aimed to evaluate agronomic characteristics, productivity and oil content of canola culture as a function of the use of poultry litter.

2. MATERIALS AND METHODS

The experiment was conducted in a property in the city of Serranópolis do Iguaçu, state of Paraná (latitude 25°22 'S, longitude 54°03 'W, 325 m). According to the Köppen climate classification, the local climate is defined as humid subtropical (Cfa), characterized by hot summer without dry season, with annual average temperature ranging from 17°C and 19°C and rainfall of 1200 and 2000 mm, distributed during the year.

The climatic data obtained at the weather station Agritempo in Serranópolis do Iguaçu indicated that the precipitation was adequate for canola crop, affecting only in the grain filling phase that there was a water deficit. The temperature during the development of the canola showed an average of 23°C and the average grain filling and harvest above 25°C.

The soil of the area is classified as Eutroferric Red Latosol, with very clayey texture, with the contents of sand, silt and clay of 9.8%, 13.5% and 76.6%, respectively presenting a density of 2.9 g cm^{-3}. Sampling was performed to analyze soil fertility in order to know the need for acidity correction for sampling from 0-20 cm and for 20-40 cm. The following results were obtained: Ca^{2+}:

4.2; 3.5; Mg^{2+}: 1.7; 1.1; K^{+}: 0.4; 0.3; Al^{3+}: .0; 1.2; H+Al: 2.9; 5.3; these are cmol dm^{-3}. P: 27.0; 9.8; in mg dm^{-3}; Soil organic matter: 26.2; 9.8; in g kg^{-1}; pH ($CaCl_2$): 5.2; 4.9; and base saturation 68.4%; 47.9%. A correction of 20-40 cm was performed with the management of plaster in order to increase the availability of nutrients.

The poultry litter used for the experiment was removed after the production of six lots of broiler chicken, composed of poultry residues and materials that are used for management between batches, such as shavings and lime. The material was exposed to the environment for decomposition for 60 days before applying it to the soil. A sample of the material was taken for chemical analysis at the time of application to the soil in order to know the chemical composition of the organic fertilizer as follows: N: 3.2%; P: 3.4%; K: 3.9%; Ca: 4.2%; Mg: 1.3%; S: 0.8% and Organic matter (OM): 73.2%.

The experimental design was a completely randomized block design with four replications, in plots of 13.7 m² of usable area (7.5 x 4.5 m) in the density of 30 plants per m^2. Seven treatments referring to the poultry litter doses were used: i) 0 t ha^{-1}; ii) 1 t ha^{-1}; iii) 2 tha^{-1}; iv) 4 t ha^{-1}; v) 8 t ha^{-1}; vi) 16 t ha^{-1}; vii) 32 t ha^{-1}.

The poultry litter doses were manually applied to the surface without incorporation, three days prior to sowing. After canola sowing, the experiment was weekly monitored to identify weeds, pests and pathogens and, when necessary, control was performed with agrochemical applications throughout the experimental area.

The climatic aspect during the instalation the culture was apropriate for hybrids cultivate in Brasil, with regular humidity aabout 60% and the avarage temperature of 23°C in the moment canola sowing.

The variables that were subjected to evaluation in this experiment were: number of final plants, plant height, number of pods per plant, number of grains per silica, mass thousand grains and yield, amount of N leaf, P leaf and K leaf, and oil content.

The data obtained were subjected to analysis of variance by applying the F test at 5% probability of error. Significant results were evaluated by regression analysis also at 5% error level. The statistical program used was the SAS INSTITUE [12].

3. RESULTS AND DISCUSSION

The variables number of final plants, plant height, number of pods per plant, number of grains per silica, mass thousand grains and yield, amount of N leaf, P leaf and K leaf, and oil content there were no differences between treatments. But there was difference for the P leaf content, grain oil content and grain yield variables. Oliveira et al. [13] showed that the fertilization supplementation using the poultry litter in the cabbage crop, species of the same canola family, increased leaf contents of N, P, K, Ca and Mg.

The results presented by the variable leaf N content in canola can be explained by several authors, where the efficiency of the high N concentration applied to the soil was unbalanced with the S nutrient, which presented low concentration in the poultry litter presenting low N efficiency in the soil plant [14,15,16]. Lucas et al. [17] observed increasing results of N content in chemical analysis of canola leaves using increasing rates of N fertilization in cover. For Lourenço et al. [18], the poultry litter when used in common bean crop does not meet the nutritional demand of the plant by presenting unavailable N and P contents compared to the use of mineral fertilizer.

Kiehl [11] reports that the application of organic residues that constitute high C/N ratio results in decreased N absorption making the plant deficient for this nutrient for its development. Considering that the ratio of C/N is lower due to the high amounts of N applied to the compost soil in the poultry litter, the absorption of this nutrient may be influenced by the lack of expressive action of microorganisms and the availability of nutrients from the aviary bed.

There was difference only for P in leaf content, which presented quadratic adjustment in which from the dose of 16 t ha^{-1} resulted in increased leaf P content (Fig. 1).

The amount analyzed for the highest P content in the leaf was 6.7 g Kg^{-1}, which is almost double the amount of 3.5 g Kg^{-1} suitable for canola cultivation in the state of Paraná [19]. By observing this higher dose content and comparing the productivity in this same treatment, there is a decrease in productivity with increasing dose. This shows that the P content found in the leaf at high doses applied to the soil results in concentrations within the critical zone affecting plant growth and yield [20].

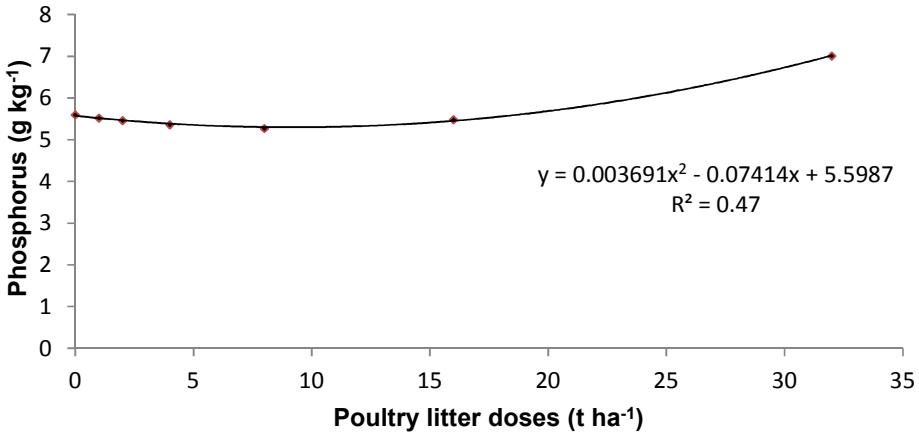

Fig. 1. Phosphorus content in leaf tissue (g kg^{-1}) in canola in poultry litter doses

Knowing that canola received high levels of this nutrient in the doses applied from 2 t ha^{-1} according to the recommendation of Pauletti et al. [21] and when observing the high P content in the soil, the appropriate amount to be applied is up to 60 kg ha^{-1}. But considering the efficiency index presented by CQFS (2004), which is 80% for the first crop still the doses from 4 t ha^{-1} of poultry litter becomes too high values to fertilize the canola.

With increasing application of animal residue doses to soil there was an increase of P availability, Kiehl [11] occurred by the decrease of P adsorption in clay colloids through Fe and Al inorganic complexes.

Another reason is that in characteristic weathered soils such as Oxisols when applying high doses of organic fertilizers the P contained in these compounds is adsorbed on soil colloids and a part becomes available to plants when it supplies the soil sorption capacity [22,23].

Regarding plant height, probably the fact that no difference was observed for this variable may be related to the high fertility content presented in the soil as the acidity tolerated by the crop as well as nutrient content such as P and K in that the experiment was performed. The average height was 1.34 m, higher than the data observed by Rigon et al. [24] and Melgarejo [25], who evaluated the same hybrid and the same sowing season used in this experiment observed values of 1.09 m and 1.23 m, respectively. This fact can also be attributed to the high soil fertility in which this experiment was conducted.

In the variables number of silica per plant, number of grains per silica and mass of one thousand grains there was no effect in relation to the applied poultry litter doses. The average presented of these variables was 305; 17.8; and 3.02 g, respectively. These values resemble the results of experiments conducted at the same sowing date and for the same hybrid [26,27].

Studies conducted in two consecutive years with canola cultivation showed a reduction in the number of pods per plant, one thousand grain mass and yield as a function of water stress ranging from 20 to 45% losses [28,29]. In this experiment between June and early August there was a water deficit in the flowering phase and formation of plant syllables explaining the effect of not presenting difference for these variables.

Izli et al. [30] reported that the increase in the mass of one thousand canola grains is related to the increase in moisture. This explains the fact that in this experiment there was no difference for this variable because it presented very low moisture contents for this phase of canola development.

Marco et al. [31] concluded that the hybrid 433, when produced under average temperature conditions of 24.6°C, shortens its cycle to 90 days and that it has its highest water consumption at the flowering stage. The average temperature presented in this experiment was 20.2°C representing the ideal for canola cultivation, but in relation to rainfall distribution was irregular which led to water deficit in the most demanding times of the crop.

The oil content (Fig. 2) contained in the canola grain presented significance where its maximum point was 8 T ha^{-1} in the amount of 43% oil content, which was higher compared to the result of 39% oil content maximum oil obtained by Melgarejo et al. [26].

Oil yield and quality are closely related to canola crop fertilization, and balanced nutrition will provide sustainable nutrient management [32]. The balanced fertilization that the previous author explains was confirmed by Firmes et al. [33] who observed that N efficiency is influenced by correct S fertilization which results in canola oil content and quality.

Regarding the S available for canola cultivation, 950 kg ha^{-1} of gypsum plaster was applied in addition to the concentration presented in the poultry litter, which represented 8.5 to 272 kg ha^{-1} in relation to the applied dose. These amounts represent high S values compared to the amounts of N contained in the doses of organic fertilizer used in this experiment.

Rathke et al. [3] observed that the correct use of N in canola culture results in proportional increases of oil and protein production in the grain and in contrast the amount of oil decreases and the protein increases with the excessive use of N both in mineral fertilization and in fertilizerof organic fertilization. This explains the fact that the oil content decreased with the increase of poultry litter doses due to higher N content.

The dose evidenced as excess N for canola culture in relation to the oil content presented in the work of Rathke et al. [3] was 240 kg ha^{-1} corroborating the results presented in this experiment in which from the 16 t ha^{-1} dose corresponding to the amount of 516 kg ha^{-1} there was a decrease in the oil contents in the canola grain.

Sanches et al. [5] observed response of the morphological and productive components of the canola Hyola 61 hybrid in the presence of irrigation, and in this same experiment worked with the use of three N rates in coverage at the true four leaf stage (B4) and obtained significant results increasing the oil content.

The reduction in oil content of rapeseed grain is inversely related to the average temperature during the grain filling phase. The author confirms that temperatures above 21°C result in a marked decrease in the amount of oil and among other consequences as deformed grains produced by heat stress [34].

These works show that N is an element that relates to oil content and temperature also influences that in this experiment high doses of N were applied through the composition of the poultry litter and the temperature favored the development of the plant for a production satisfactory content of oil content in canola grain.

Grain yield had effect with quadratic adjustment and the 8 t ha^{-1} dose obtained the highest yield (Fig. 3).

The poultry litter composition has amount of organic matter. Rodrigues et al. [35] concluded that animal manure provides satisfactory results in plant production when used as fertilizer because it provides complex nutrients through organic matter.

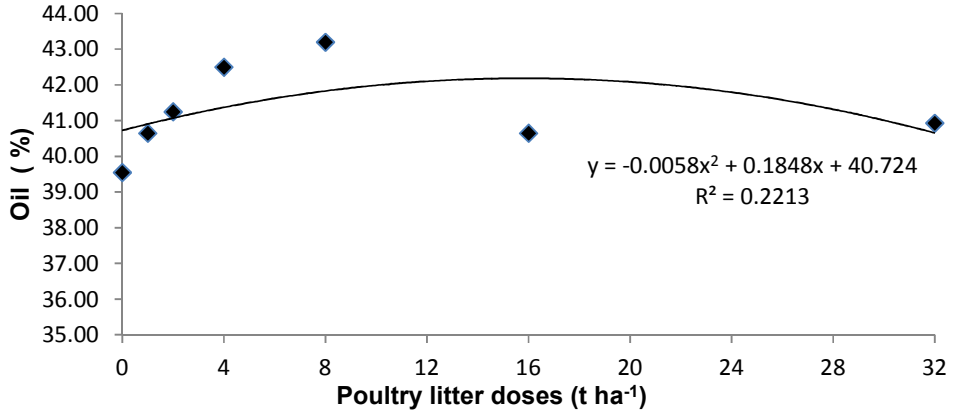

Fig. 2. Oil content (%) of canola grain in poultry litter doses

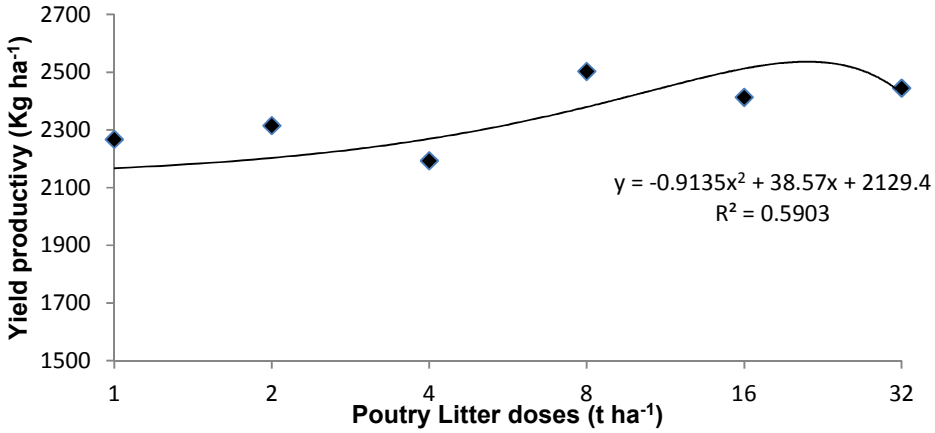

Fig. 3. Productivy (Kg ha^{-1}) of canola grains in poultry litter doses

The results presented by Ben et al. [36] in which they evaluated the efficiency of poultry litter in common bean crop, observed that the best performance in organic fertilizer in the crop was when applied to the surface compared to that used in the row, and the management employed in the application of fertilizer in this work. In the canola crop was the surface haul indicating a better effect on the result of the variables of P leaf content, grain yield and oil content. Oliveira et al. [37] using the yam culture (*Colocasia esculenta*) observed increase in productivity where poultry litter was used as a cover fertilizer and N source which corresponded to 4.4 t ha^{-1} litter aviary at its maximum productivity.

Carvalho et al. [38] evaluating doses of 0, 3, 6 and 9 t ha^{-1} of poultry litter in soybean, observed a linear increase in yield, one thousand grain mass and number of vegetables per plant.

Corroborating the result presented in this paper Santos et al. [39] observed an increase of N content in oat crop at doses higher than 7.5 t ha^{-1} and an increase in corn crop yield when the poultry litter was used to replace mineral N fertilization.

In the experiment conducted by Brito et al. [40] where the effect of soil nutrient availability was analyzed by laying manure applications (3 t ha^{-1}); chicken litter (6 t ha^{-1}); sheep manure (6 t ha^{-1}); and silage residue; the laying manure promoted the highest P availability compared to the other evaluated organic residues.

Timossi et al. [41] used 0, 2.88, 5.76, 11.52 and 17.28 t ha^{-1} of soil poultry litter which corresponds to 0, 50, 100, 200 and 300%, respectively, of the amount of N recommended for corn crop and compared with mineral fertilizer, obtained results in which the amount of 200% N of the poultry litter dose equaled the corn productivity obtained with the use of mineral fertilizer.

Scherer and Spagnollo [42] observed in nine years of cultivation, higher productivity in corn and bean crop with the use of poultry litter compared to several other sources of organic fertilizers. However, it was observed that in the early years the fertilization with poultry litter was lower compared to other organic fertilizers, this shows that the organic fertilizer takes a while to make nutrients available to the soil.

The use of poultry litter makes it an economical and sustainable alternative in bean crop [43]. This information corroborates the results of canola productivity, with the highest productivity dose being 20 t ha^{-1} of released poultry litter in surface without incorporation corresponding to the amount of 646 kg ha^{-1} of N which is equivalent to 500% of the recommended for the canola culture [19].

These results highlight the efficiency of poultry litter in supplying the most demanding nutrient needs of canola crop, and the highest yield was 2500 kg ha^{-1} at a dose of 20 t ha^{-1}. It is also noteworthy that this productivity is above the national average productivity which in the 2016 harvest was 1514 kg ha^{-1} and the state of Paraná with 1479 kg ha^{-1} [44].

Melgarejo et al. [26] evaluating different sowing dates and different genotypes, observed that low rainfall during the experiment affected the

productive potential of Hyola 433 hybrid because it had higher soil moisture requirement compared to Hyola 61 with average yield of 1359 kg ha^{-1} and 1222 kg ha^{-1} respectively, inferior results in relation to the average obtained in this experiment of 2311 kg ha^{-1}.

According to Mohammadi et al. [45] and Dogan et al. [46] water deficit in the flowering and grain filling phases of canola results in decreases in the vegetative period and affects oil quality. Other studies have shown that in two consecutive years there was a reduction in the number of pods per plant, one thousand grains mass and productivity as a function of water deficit ranging from 20 to 45% losses [28,29].

Another explanation of not having significant results for all components of canola productivity is the use of poultry litter, which is a residue that favors an increase in nutrient availability over time due to the mobilization and mineralization of the elements which are necessary for plants [47], since in this experiment the poultry litter was thrown to the ground at the time of canola sowing.

These studies present a relationship in which the use of organic waste or N fertilizers for species demanding this nutrient have an effect on yield results, as well as canola that when using poultry litter doses that have high N content resulted in productivity gains.

The rate of nutrient release efficiency such as N, P and K provided by animal waste is of paramount importance to ensure that the recommendation of the amount to be used does not compromise the environment [48].

The delay in canola sowing date from may onwards has influence on the duration of each crop phase consequently will affect the yield, considering that in this region of this work was not affected by the sowing delay [49].

Tizzot et al. [50] concluded that delaying canola sowing in particular to the Hyola 433 hybrid reduces 19 kg ha^{-1} of grain yield per day after May 9 in the state of Rio Grande do Sul and the climate of the region is classified as subtropical. Cfa type, with no defined dry season, according to Köppen and the soil is typical dystroferric Red Latosol. This study relates high productivity results to this work in which it was sown at the beginning of May, causing no productivity losses.

4. CONCLUSION

In conclusion the canola fertilized with poultry litter was significant for some variables and for the productivity and quantity of oil in the treatment of v) 8 t ha^{-1} and vi) 16 t ha^{-1} for phosphorus content in leaf tissue.

It is also concluded that high doses of poultry litter doses not provide increase in canola crop variables.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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