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QUALITY OF SELF-PROPELLED SPRAYERS THROUGH PERIODIC INSPECTION

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ABSTRACT - The inspection of agricultural sprayers is a vital tool for the increment of quality of spray technology for phytosanitary products. The objective of this work was to evaluate the performance conditions of self-propelled sprayers on-farm, using the periodical inspection methodology for sprays and analyzing the climatic conditions during the spraying. The evaluations were carried on farms visited randomly. A questionnaire was filled out by the operator or farmers and the inspection itself of the sprayers. The items evaluated were the condition and location of hoses, presence of leaks, monitor performance, spacing between nozzles, spray nozzles, in-line filter, primary filter, the performance of anti-dripping gauges, and limiting environmental conditions. Most interviewed operators and farmers did not know the methodology for inspecting agricultural sprayers, demonstrating the need to create specific training programs in the region. Self-propelled sprayers have a few technical problems when they were new, however, spraying beyond the ideal weather conditions can reduce the spraying quality.
Keywords: agricultural machinery, maintenance, spray technology, operator, PPE.

QUALIDADE DE PULVERIZADORES AUTOPROPELIDOS POR INSPEÇÃO PERIÓDICA

RESUMO - A inspeção de pulverizadores é uma importante ferramenta para incrementar a qualidade da tecnologia de aplicação de produtos fitossanitários. O objetivo do presente trabalho foi o de avaliar o estado de performancede pulverizadores autopropelidos em propriedades rurais, utilizando a metodologia de inspeção periódica de pulverizadores e analisando as condições climáticas no momento das pulverizações. As avaliações foram realizadas em propriedades rurais visitadas aleatoriamente. Utilizou-se de um questionário preenchido pelo operador ou produtor rural e da inspeção propriamente dita dos pulverizadores. Os itens avaliados foram o estado e a localização das mangueiras, os vazamentos, o funcionamento do monitor, o espaçamento entre bicos, os bicos de pulverização, o filtro de linha, o filtro principal, o funcionamento dos antigotejadores e os fatores climáticos limitantes. A maioria dos operadores e produtores rurais entrevistados não conheciam a metodologia de inspeção de pulverizadores agrícolas, demostrando a necessidade da criação de programas específicos de treinamento na região. Os pulverizadores autopropelidos possuem poucos problemas técnicos de funcionamento quando eles são novos, entretanto, pulverizações fora das condições climáticas ideais podem comprometer a qualidade da aplicação.
Palavras-chave: máquinas agrícolas, manutenção, tecnologia de aplicação, operador, EPI.

INTRODUCTION

Agricultural sprayers are the most used machines in spraying applications. Consequently, the correct calibration and adjustment of sprayers are essential for the improvement of the quality of the application of pesticides, reducing losses, maximizing the effect of the applied product, and reducing possible impacts on the environment. The choice of the machine and its correct use are essential to obtain satisfactory quality in the application and effectiveness of pesticides in pest control (FARIAS et al., 2015). The quality of the application depends on factors such as the weather condition, the target to be reached, the crop canopy, the choice of drop size, the application volume, among others.

Among the obstacles found by the farmers in the field, the sprayer regulation and the use of good practices during the application of pesticides have been the constant challenges. These issues indicate that rural workers lack information about the correct use and maintenance of sprayers in agricultural practices, particularly because of the absence of technical assistance and guidance in the field, which directly implies possible chronic contamination, the over-use of pesticides, environmental impacts, and rise in the costs for agricultural production (SILVA et al., 2016).

Periodic inspections of agricultural sprayers are performed in several countries. In Brazil, knowledge of the conditions of these machines can guide experiments and investments in recommendations for their use and maintenance (GANDOLFO et al., 2013). Knowledge of the current conditions of agricultural sprayers is essential, and it justifies the creation of an inspection program whose goal is to reduce the environmental impact, enhance the

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efficiency of applications and collaborate with certification programs (ANTUNIASSI; GANDOLFO, 2005).

Data surveys regarding the condition of sprayers can contribute to the realization of a thoroughly mapping of the quality of the sprayers in the main Brazilian agricultural regions (SICHOCKI et al., 2014). Therefore, the objective of this work was to evaluate the performance conditions of self-propelled sprayers on farms, using the inspection methodology for Brazilian conditions and climatic conditions for spraying, and to verify the level of knowledge of the operators.

MATERIAL AND METHODS

The experiment was carried out at the Federal Institute of Education, Science and Technology of Mato Grosso do Sul (IFMS), Ponta Porã *Campus*, in cooperation with the company Ciarama Máquinas Agrícolas and the Laboratory of Integrated Oilseed Production Systems (Laprooleo) of the Federal University of Grande Dourados (UFGD). The questionaries and local inspection were carried out in grain-production farms located in the municipality of Ponta Porã, State of Mato Grosso do Sul (MS), belonging to the Brazilian Cerrado. The climate, according to the classification of Köppen is Am (tropical monsoon) (ALVARES et al., 2013). The total rainfall in the region is 1,400-1,500 mm and the average annual temperature is 22ºC (PEEL et al., 2007). Figure 1 shows the average climate data from 2008 to 2016, referring to a minimum, average and maximum temperatures (ºC) and average relative humidity (%). In the same period, the average recorded wind speed was 2.43±0.256 m s^{-1}.

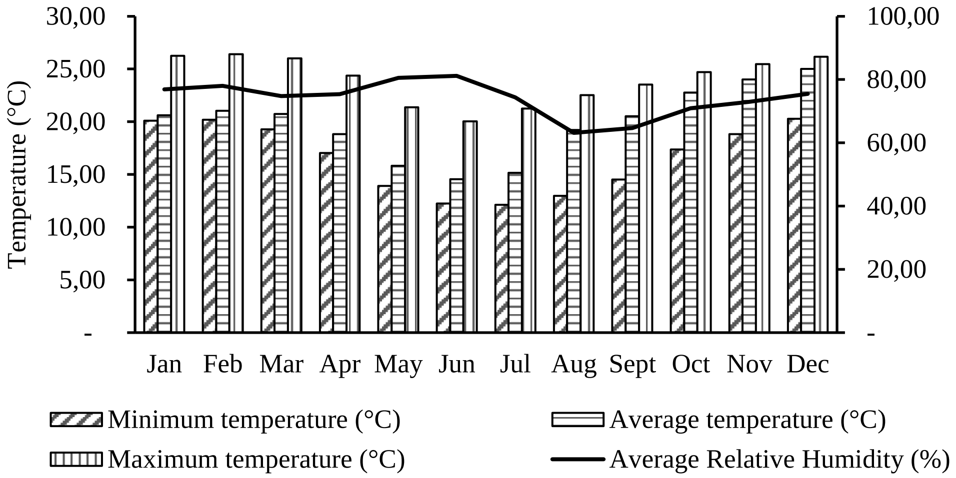

FIGURE 1 - Minimum, average and maximum temperatures (ºC) and average air relative humidity (%) in Ponta Porã (MS), in the 2008-2016 period. Source: Instituto Nacional de Meteorologia (INMET).

Seventeen randomly chosen farms that use self-propelled sprayers were visited. The evaluated sprayer models were the 4630 and 4730, both from John Deere®. The evaluations were carried out in two steps, the first consisting of the actual inspection of the sprayers, and the second was the application of the questionnaire to the operators and/or owners of the machines. The evaluations followed the methodology proposed by Gandolfo and Antuniassi (2003), with some modifications to fit the characteristics of self-propelled sprayers. The items evaluated were: condition and location of hoses, leaks, monitor operation, spacing between nozzles, spray nozzles, in-line filter, primary filter, and performance of the anti-dripping gauges.

Broken, cracked, and bent hoses or those with any other type of damage that could have influenced the spraying operation were identified and located. Equipment that presented such a problem was considered unsuitable for applying pesticides. Leaks, when they occurred, were identified and located, regardless of the quantity and location found. This evaluation was carried out by operating the machine and observing its occurrence. Care was taken so that the technicians did not interfere with the machine's original condition and thus did not cover the real result of the sprayers operating on the farms.

Regarding the spray nozzles, the spacing between them was checked and observed if they were all the same. The flow was measurement on all nozzles and, when they were greater than 10% of the indicated flow, or the sprayers that had different spray nozzles on the boom, were considered inadequate for carrying out the spraying operation. The primary filter was removed after the dynamic evaluation, and the observation was carried out considering the presence of cracks and obstructions resulting from the accumulation of residues from the products applied and the use of poor-quality water besides product agitation in the tank or other types of damage, both in the mesh, as in the carcass. For in-line and nozzle filters, their presence was also verified.

In addition to their presence, the anti-dripping gauges were evaluated for their performance. When, after water pumping, they completely and instantly prevented the passage of liquid through the nozzles, they were considered functional.

The following information was obtained from the questionnaire applied to operators and farmers: the age of the sprayer, the volume of application used (L ha^{-1}), whether the operators wear personal protective equipment (PPE), whether they are aware of the need for inspection of sprayers, the performance of the triple washing of pesticide containers and the greatest difficulty found during pesticide applications.

Climatic conditions were analyzed during the experimental period in 2017, and four parameters were considered in the selection of the period of the unfavorable hours for the spraying operations using agricultural sprayers. The estimate for this period was made based on the study of the maximum temperature of 30°C, the minimum relative humidity of 55%, the wind speed below 10 km h$^{-1,}$ and the occurrence of rainfall (NASCIMENTO et al., 2013). To obtain the unfavorable and favorable hours recommended for spraying, a computer program was developed in Visual Basic Application language, associated with Microsoft Excel 2016, where the unfavorable hour was considered to be that which did not meet at least one of the climatic requirements, as proposed by ANDEF (2004) and Nascimento et al. (2013).

RESULTS AND DISCUSSION

It can be seen in Table 1 the percentage values of the evaluation outcomes of the self-propelled sprayers, demonstrating the existence of problems with three of the nine evaluated items. Because they are machines with more embedded technology, the self-propelled ones have fewer defective items than hydraulic tractor sprayers (GANDOLFO; ANTUNIASSI, 2003; ANTUNIASSI; GANDOLFO, 2005; BALESTRINI, 2006; ALVARENGA; CUNHA, 2010). The major issues observed were leaks, which were found anywhere in the sprayer.

TABLE 1 - Evaluation of self-propelled sprayers using data from the technical inspection in the region of Ponta Porã (MS).

Evaluation	Defective sprayers (%)
Hose condition	0.0
Position of the hoses	0.0
Leaks	52.9
Monitor performance	0.0
Spacing among nozzles	0.0
Spray nozzle	0.0
In-line filter	0.0
Primary filter	17.6
Performance of anti-dripping gauges	17.6

Among the factors affecting the volume of application, the control effectiveness and that burden the application of agrochemicals is the presence of leaks and, because they are found in most equipment in different sizes and locations, their importance was underestimated (ALVARENGA; CUNHA, 2010). It was observed that 52.9% of the evaluated sprayers have some type of leakage, a value lower than those found in tractor sprayers (GANDOLFO; ANTUNIASSI, 2003; ANTUNIASSI; GANDOLFO, 2005; BALESTRINI, 2006; ALVARENGA; CUNHA, 2010), but still high for sophisticated and technological machines, and these problems can be easily adjusted most of the time.

Considering the components evaluated by Dalmora and Pereira (2013) in the inspection of sprayers in a sugar-energy plant in Ponta Porã, the state of Mato Grosso do Sul, the authors observed that the biggest nonconformity was found in the conservation of the nozzles, which had irregular flow or leakage. Concerning filters, the sprayers had greater problems in the primary filter (17.6%). The function of the filters is to retain the impurities in the volume to be sprayed, so the defective filters were those with torn screens or in bad conservation conditions. Silva et al. (2016), in a similar study, evaluating self-propelled and tractor-sprayers, found that the primary filter was present in all sprayers, but 20% of them had blockages or cracks.

The analysis of the anti-dripping gauges, which were found in all inspected sprayers, showed that 17.6% were worn with use and not working properly. Machado (2014) concluded that the most frequent defects were the irregular flow of the nozzles and the anti-dripping system, problems that can affect the quality of the application.

Table 2 shows the results obtained from the questionnaires applied to operators and farmers. The sprayers had an average age of 3.2 years of use. Dedordi et al. (2014) found that the majority (61.9%) of sprayers in use were aged between 1 and 5 years. The shorter the time of use, the fewer technical and operational problems for the machines and the higher the quality of the sprays. Regarding the operators' responses, only 23.5% wear PPE. Similar data were obtained by Silva et al. (2016), where only 20% of operators said they own and wear PPE. The correct use and proper maintenance of personal protective equipment are essential. According to Matthews et al. (2016), operators are at greater risk when mixing concentrated formulations, and during the application, the risk of exposure is lower, but wearing the PPE suit is necessary.

Awareness of the need for technical inspection of sprayers for a better quality of sprays was reported by only 47%, which may affect the quality of the application, as the machines may be performing in unsuitable conditions. The execution of the triple washing was said to be performed by 100% of the operators, a fact that shows that this technique is more widespread and accepted by the operators (Table 2).

Among the difficulties reported during the applications of agricultural pesticides, the climatic condition stands out, according to 82.3% of respondents. During spraying, some of the applied product is lost in the environment, particularly because of drift and due to lack of knowledge about the ideal climatic conditions for application (SILVA et al., 2016). Complexities were also found when mixing the product in the spray volume and due to irregularities in the terrain, representing 11.8 and 5.9%, respectively. Gazziero (2015) concluded that tank mixes are usual field practices and adopted by 97% of respondents from private technical assistance, linked to the government, cooperatives, and autonomous rural producers in various regions of Brazil, and the problems found in the tank mixes were: difficulty in dissolving the mixed products, increased phytotoxicity, excess foaming, clogging of nozzles and decanting (precipitation) of products in the tank.

TABLE 2 - Evaluation of self-propelled sprayers with data from questionnaires applied to operators and producers in the municipality of Ponta Porã (MS).

Sprayer	Means
Average age (manufacturing)	3.2 years
Average application volume	93.1 L ha^{-1}
Operator	
Wear PPE	23.5%
Aware of the need for inspection of sprayers	47.0%
Perform tripe washing of pesticide containers	100%
Application challenges	
Weather condition	82.3%
Product mixing in the spray volume	11.8%
Terrain	5.9%

The greatest obstacle is the application in favorable climatic conditions in the municipality of Ponta Porã (MS) during the year, where the black part of the graph (Figure 2) represents the unfavorable hours for spraying the crop. It is observed that 56% of the available time is not suitable for spraying as it violates at least one of the limiting factors (Figure 3A). The analysis of climatic parameters showed that the high wind speed during the day was the most limiting factor, corresponding to 58% of cases, followed by relative humidity, temperature, and rainfall (Figure 3B). This situation reduces the time available to have a suitable weather condition for spraying, leading to the need for faster spraying to use the best weather condition, increasing the size of the equipment and its operating costs, and design inadequacy.

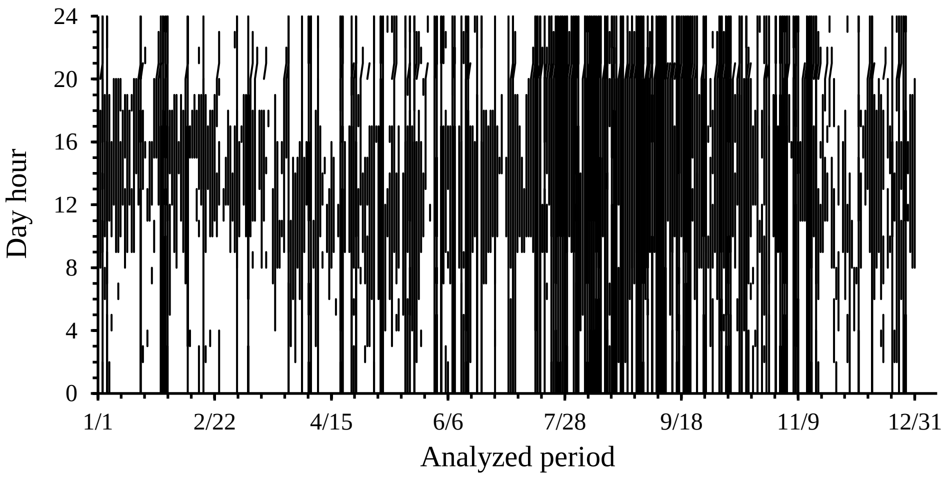

FIGURE 2 - Average unfavorable hours for spraying in 2017, in Ponta Porã (MS).

Silva et al. (2016), in a study evaluating sprayers for the region of Minas Gerais, found that 90% of operators were aware of the weather conditions for the application, but they performed the spraying at inappropriate hours, such as at the hottest hours of the day and with low relative humidity, due to the urgency of the applications and the lack of favorable climatic conditions at the application time.

Preference should be given to spraying performed outside the period from 10 a.m. to 6 p.m., corresponding to more than 62% of the unfavorable hours (Figure 4). However, with the periodic monitoring of climate data, and using the climate history of the location and the operational capacity of the equipment, it is possible to optimize the operation with application technology tools, precision agriculture, and agricultural systems engineering.

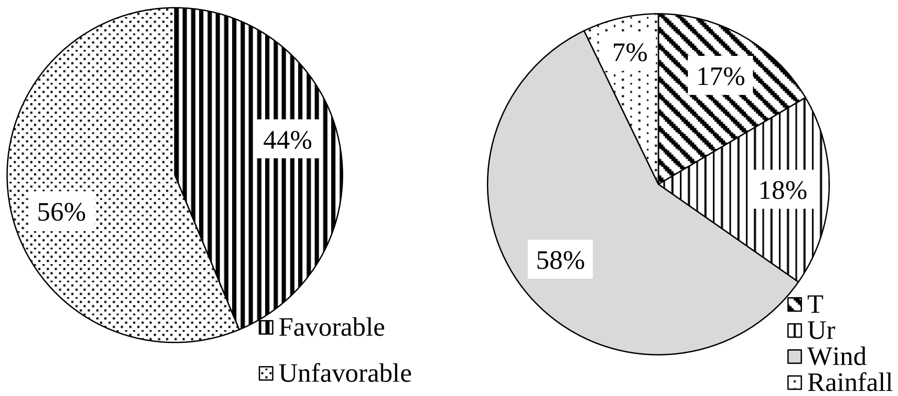

FIGURE 3 - Relationship between favorable and unfavorable hours (A) for spraying, and the proportion of limiting hours by climatic parameters (B), in the municipality of Ponta Porã (MS) in 2017. T - temperature. Ur - relative humidity.

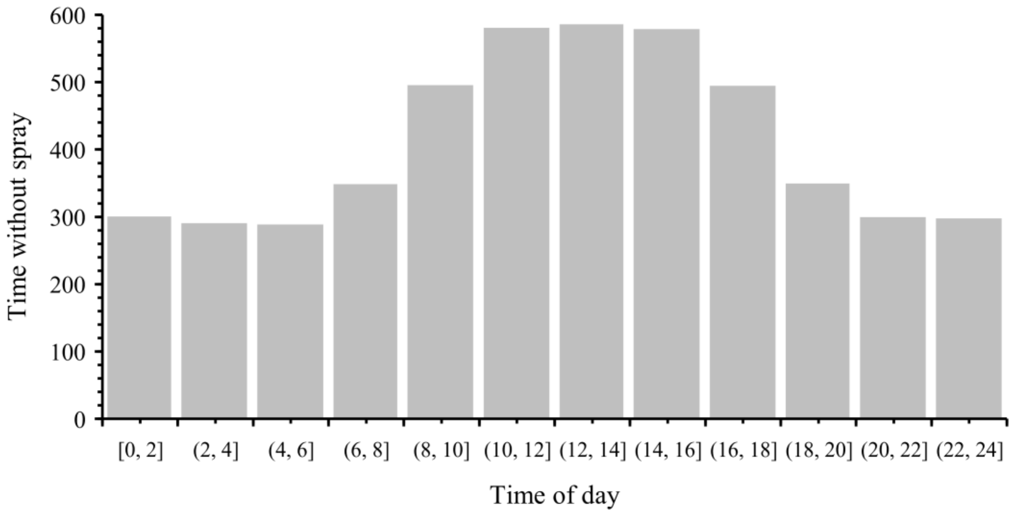

FIGURE 4 - Number of limiting hours for spraying during the day in the municipality of Ponta Porã (MS), in 2017.

After the analysis, the feedback for the farms and information transfer for the operators and farmers would be the best to be done, in order to correct the flaws, for which greater investment in research and rural extension is necessary. Further works can be developed to assist in decision-making on spraying at recommended spray times. The analysis of this and other works on this subject showed the poor technical training of operators, both in technical issues and in the use of personal protective equipment.

CONCLUSIONS

The need for inspecting agricultural sprayers was not known by most of the interviewed operators and farmers, which demonstrates the need to create specific training programs in the region.

Self-propelled sprayers have few technical operating problems, however, spraying beyond the ideal climatic conditions can compromise the quality of the application.

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