

## TECHNICAL INSPECTION OF AGRICULTURAL SPRAYERS IN BRAZIL

Alfran Tellechea Martini<sup>1\*</sup>, José Fernando Schlosser<sup>2</sup>, Gustavo Oliveira dos Santos<sup>2</sup>, Gilvan Moisés Bertollo<sup>3</sup>, Marcelo Silveira de Farias<sup>4</sup>, Juan Paulo Barbieri<sup>2</sup>

<sup>1</sup>Coordenadoria Acadêmica, Universidade Federal de Santa Maria, Campus Cachoeira do Sul, 96503-205, Cachoeira do Sul - RS, Brasil.

<sup>2</sup>Departamento de Engenharia Rural, Universidade Federal de Santa Maria, 97105-900, Santa Maria - RS, Brasil.

<sup>3</sup>Curso de Agronomia, Universidade Tecnológica Federal do Paraná, Campus Santa Helena, 85892-000, Santa Helena - PR, Brasil.

<sup>4</sup>Departamento de Ciências Agrônomicas e Ambientais, Universidade Federal de Santa Maria, Campus de Frederico Westphalen, 98400-000, Frederico Westphalen - RS, Brasil.

\*E-mail: [alfrantm@gmail.com](mailto:alfrantm@gmail.com)

Recebido em: 08/12/2020

Aceito em: 07/07/2021

DOI: 10.17058/tecnolog.v25i2.16075

## ABSTRACT

The periodic maintenance of agricultural sprayers is essential to ensure safe spraying from an environmental point of view and technically efficient, with respect to acceptable quality limits. Aiming to optimize the use of pesticides for protecting farming, many countries worldwide have been developing projects on the inspection of agricultural sprayers. In Brazil, regardless its tradition of being an agricultural country, still now these inspections are done in a voluntary way, showing that most agricultural sprayers are not in use conditions, which can affect the technical efficiency of the operation, offer a risk of environmental contamination and, intoxication of the operator. This review aim describe the results got through projects on inspection of agricultural sprayers in different Brazilian regions. The methodology was based on the survey of data published in scientific articles and thesis. The most serious problems detected in those agricultural sprayers are mainly in terms of absence of environmental and user safety, no protection of the cardan tree, of belts and pulleys as well as leakage occurrence. Furthermore, the most common problems related to spraying activities are those of manometer precision as well as those of worn spray nozzles and spray transverse distribution wear and tear that in all justifies the obligation for technical inspection of agricultural sprayers in Brazil. Besides that, it is important to emphasize the necessity of public policies for development and approval of research centers for tests on agricultural implements.

**Keywords:** Periodic inspection. Quality in the application. Spraying.

## 1 Introduction

Following what happens in other Latin American countries, researches on Brazilian sprayers have showed how much these machines need for improvement. In 1998, under the coordination of the Professor Ulisses Rocha Antuniassi, the pioneering project entitled *Inspecção Periódica de Pulverizadores Agrícolas* (IPP Project), written by Marco Antonio Gandolfo, was implemented in the Brazilian States of Paraná and São Paulo. In that occasion, all the 76 sprayers under assessment presented both inappropriate use conditions and maintenance, requiring some repairs for improving the efficiency in the

application of the pesticides [1]. After that, the IPP project was under José Luiz Siqueira's hands, which expanded the evaluations and the research covering area. In all, 137 sprayers were under inspection in four Brazilian states, as follow: Paraná, Rio Grande do Sul, Mato Grosso do Sul and Mato Grosso [2].

According to the data analyses obtained by Siqueira & Antuniassi [3] from 2006 to 2008, the methodology of the IPP project suffered improvements in terms of reducing the error rates in some specific aspects. However, the authors also point out that due to the fact that this kind of research is fairly new in Brazil, once that the first works in this area were just carried out

in 1998, there was no significant improvement in terms of maintenance and calibration of sprayers, as well as that the previous errors remain almost all the same kind.

In this sense, in 2008, in order to minimizing the losses, reducing the error rates in the application of pesticides and consequently reducing the environmental contamination, through the *Laboratório de Agrotecnologia of the Núcleo de Ensaios de Máquinas Agrícolas*, the project *Inspecção Técnica de Pulverizadores Agrícolas* in the state of Rio Grande do Sul, Brazil, was created under the coordination of the Professor José Fernando Schlosser, from the Federal University of Santa Maria (UFSM). This project covered all the Central region of the state of Rio Grande do Sul, and according to Dornelles et al. [4] aimed to collect data about the sprayer's and tractor's states of conservation.

The first stage of this project covered 16 cities of the Central region in which 84 sprayers in all were under inspection from 2006 to 2007 [5]. The second stage of it was concerned with the reevaluation of those same sprayers from 2010 to 2011. According to Casali [6], not including those equipments which had been replaced by new ones, there was no significant improvement in the sprayers under inspection. The third stage consisted in the evaluation of 56 agricultural sprayers in the Central region and in the region of the Western border of RS, totalling nine cities. According to Martini et al. [7], the objective was to determine the state of use and conservation of agricultural sprayers, to identify the most frequent problems and to evaluate the applicability of the ISO 16122 [8] standard in an unprecedented way in Brazil.

This review aim describe the results got through projects on inspection of agricultural sprayers in different Brazilian regions. The methodology was based on the survey of data published in scientific articles and thesis.

## 2 Inspected items

### 2.1 Time of use of sprayers

It is broadly known that sprayers have a time of use and that this fact must have some influence on the results of spraying activities. However, when under an efficient maintenance plan, the problems related to it may be solved [9]. According to Gandolfo [1], 67.1% of the sprayers under evaluation presented on average of 9.2 years of use and 30.2% of them presented more than 10 years of use. Dornelles et al. [4] said that 21.4% of the

sprayers under evaluation presented a maximum of five years of use, 25.0% of all were placed between five and 10 years of use, 16.7% of all were placed between 10 and fifteen years of use and at last what shocked the most was that 36.9% of the equipments under inspection presented more than 15 years of use. The oldest machine in use presented 41 years and the average time of the sprayers was 17.3 years [5]. During the second stage of inspection carried out by the same group of researchers from these sprayers, Casali [6] said that the time of use for sprayers with more than 15 years reduced from 36.9% to 24.8%. However, the average time of use for those sprayers followed this scale: 17.4% of the sprayers presented a maximum of five years of use, 39.1% of all were placed between five and 10 years of use and 18.8% were placed between ten and fifteen years of use.

When inspecting 34 sprayers in 26 different corn, soybeans and beans properties around Uberlandia city in the state of Minas Gerais, Brazil, Alvarenga [10] said that the average time of use for those sprayers is around five or 10 years, which represents 42.9% of the sprayers under evaluation. The sprayers with the average time of use between one and five years represent 32.1% of the sprayers under evaluation, the sprayers with more than 10 years of use represent 14.3% of all sprayers and just 10.7% of the sprayers may be considered as new ones, with a maximum of one year of use. Martini [11], on the other hand, found that the use of sprayers with more than 15 years of manufacture reduced, representing only 10.7% of the equipment inspected in the third stage.

### 2.2 Leakage occurrence and anti-drip valve use

In terms of leaking, it is possible to say that it must occur in two different versions: the continuous casting process and dripping. Both of them may increase the process costs as well as represent some risk of environmental contamination. Comparing second hand sprayers with brand new ones, Gandolfo [1] realized that all in all second hand sprayers must represent much more prejudices than the brand new ones once that leakage occurrence in those second hand sprayers was 10 times greater. According to the author, in a total of 76 sprayers under inspection, 56.6% of them presented some kind of leakage occurrence, mainly in terms of the connection between the spraying nozzle and its caps and in terms of in-line filters, representing 58.1 sprayers or 9.3% of all. Considering leakage losses, the data published by Martini et al. [12] are highlights, when of the 56 sprayers inspected, 23.2% had static leaks and 43.7% had dynamic leaks.

According to Gandolfo et al. [13], the use of anti-drip valve was present in 89.0% of the sprayers evaluated. However, in 11% of them there was at least one valve with some kind of operating problems what means an average of 2.7 non-operating anti-drip valves for equipment. Data which corroborate with Martini et al. [7], taking account that in 89.3% of the sprayers inspected, the anti-drip valve was present, however, in 16.1% of the cases, they presented malfunction. In relation to the presence and operation of old drip valves, more worrying data were reported by Sichoeki [14], although present in 97% of hydraulic sprayers, in only 7% they presented adequate operator.

The most common reasons for no approval of the sprayers under evaluation in the states of Paraná, Rio Grande do Sul, Mato Grosso do Sul and Mato Grosso are related to the conservation status of the sprayers, the uniform distribution of nozzle sprayers and the leakage occurrence [2]. Considering the leakage occurrence, the highest levels of it were observed in the state of Mato Grosso do Sul (62.5%) while the lowest ones were observed in the state of Rio Grande do Sul (18.5%). Moreover, the leakage occurrence was most observed in the anti-drip valves, in the in-line filters holders and in the connection between the spraying nozzles and their caps [2].

When analyzing hydraulic and hydropneumatic sprayers, Sichoeki [14] observed that 43% of the hydraulic sprayers and 13% of the hydropneumatic sprayers presented leakage occurrence in the sprayer tank, and in 6.6% of the sprayer tanks there were some cracks. In terms of the hydraulic sprayers, in 77% of the sprayers under evaluation the hydraulic system presented leakage occurrence, while in terms of the hydropneumatic ones this occurrence got lower just observed in 44% of those sprayers. In a similar study, it was said that 61.8% of the sprayers under evaluation presented some kind of dynamic leaking while 47.1% of them presented the static one [15]. An example of static leaking is related to the leaking of spraying nozzles after spraying due to the lack of the anti-drip valve or still due to the fact that this valve is not working properly. In previous studies, this fact had already been reported by Dornelles [5] who said that just 50% of the sprayers observed by him had anti-drip valves and that it might be usual for machines with more than ten years of use.

### 2.3 Hydraulic circuit

It is extremely important that hydraulic circuit hoses are placed suitably in order to avoid cracking or dripping concentration in the structure of the sprayers as well as to avoid

obstruction in the sprayer tank and pressure variation along the sprayer bar. In this sense, it is said that 48.7% of the sprayers under evaluation presented at least one damaged hose and in 60.5% of these machines the hydraulic hoses were placed unsuitably in the sprayer bar ending up making an angle that made it hard to the nozzle sprayers reach the target place [1]. The researches made by Alvarenga [10] also confirm the unsuitable positions of the hydraulic hoses once that in 26.5% of the sprayers and in 14.7% of the machines under his inspection presented cracking in both hoses and their connections. Gandolfo [1] also points out that 42.1% of the sprayers presented hoses interval at a rate of three unsuitable positions per each sprayer. Martini et al. [7], observed spacing error between nozzles in 50% of the sprayers inspected.

In the same way, Siqueira [2] reported had found great variability among hose intervals mainly in the state of Rio Grande do Sul (44.4%), Mato Grosso (44,1%), Paraná (33.3%) and Mato Grosso do Sul (25.0%), in 2006. However, in 2007, the author realized a decrease in those initial rates for the states of Paraná (22.2%) and Rio Grande do Sul (25.0%) [3].

According to Sichoeki [14], in just 43.0% of the bar sprayers under evaluation the hydraulic hoses and the nozzle sprayers were placed suitably, it means respecting the intervals imposed on the nozzle sprayers. However, when the slot angles of the spraying nozzles were put under evaluation through a spar water jet, the author observed that in 53.0% of these sprayers the slot angles were considered inaccurate what resulted in inadequacy in relation to the spraying bar. For hydropneumatic sprayers, it was reported that 97.0% of those sprayers followed that imposition correctly [14]. In the Central region of the state of Rio Grande do Sul, the inaccuracy in relation to the intervals imposed on the nozzle sprayers was an average of 22.7% and the differences amount those intervals were great once the most noticeable inaccuracies were of those between -34.2 to 76.3% for each interval [5].

A similar data was reported by Alvarenga et al. [16], which observed that 24.0% of the sprayers had some inaccuracy in relation to the nozzle sprayers intervals. This inaccuracy may turns in prejudice for the efficiency of the pesticide application once that it may result either in the concentration of the product (very near nozzle sprayers) or in the lack of the applied water jet overlapping (very far nozzle sprayers).

#### 2.4 Syrup filtering systems

A proper use and maintenance of filters in a syrup filtering system may guarantee the extension of the time of use for the sprayer parts, mainly in terms of avoid the obstruction and wear and tear of the spray nozzles. In this sense, it is said that all the sprayers under evaluation presented the suction filter, but in 11.8% of them there was some kind of obstruction or wear and tear of the spray nozzles. In terms of in-line filters, it is said that in 47.4% of those sprayers these filters were absent and in 22.5% of them the in-line filters presented some kind of damage [1].

According to Alvarenga [10], in 3.2% of those sprayers there was absence of the spraying nozzles filters as well as in 12.9% of them the spraying nozzles filters were poorly maintained. In terms of in-line filters, it is said that in 6.5% of the sprayers they were absent and in 12.9% of them the in-line filters were damaged. In relation to the pump filter, the author points out that in 3.3% of the sprayers under evaluation those filters were ripped or punctured due to mainly the poor maintenance conditions of them.

When analyzing the filters, Dornelles [5] realized that just 19.0% of the sprayers under evaluation were in good conditions, it means neither presenting residues nor deteriorated strainers, while 26.0% of them presented at least one in-line filter damaged. Besides that, the author says that 50.0% of the inspected sprayers did not present any filtering element. Therefore, from a second inspection of agricultural sprayers in the Central region area of the state of Rio Grande do Sul, it is possible to say that there was not significant improvement on those syrup filtering systems because 47.8% of the in-line filters and 52.2% of the pump filters were in good conditions when inspected again [6]. However, for Martini et al. [7], the pump and line filters were classified as in good condition in 96.4% of the evaluated sprayers, as well as the tip filters in 94.6% of the inspections.

#### 2.5 Manometers

In order to be done a suitable application, it is extremely important that the sprayers have readable and accurate manometers [9]. According to Gandolfo [1], 81.6% of the sprayers under evaluation presented manometers, but just 17.7% of those manometers presented accuracy in terms of reading and scale. However, when compared to a precise manometer under a bench of evaluation, just 29.0% of those manometers were considered accurate ones. In another research developed in the

region of Alto Parnaíba in the state of Minas Gerais, from the 97.0% of the hydraulic sprayers that presented manometers, 30% of them were considered accurate ones, while from the 87% of the hydropneumatic sprayers that presented manometers, 33.0% of them were considered accurate ones [14]. However, Alvarenga et al. [16] points out that 14.8% of those manometers were considered non-functional ones and 13.6% of them did not present accuracy when compared with a precise manometer.

In the first phase of inspection in the Central region of the state of Rio Grande do Sul, Dornelles et al. [17] pointed out that 9.1% of the agricultural sprayers did not present any manometer. However, from those ones that presented this equipment, in 30.6% the manometers were damaged and so useless, while in 60.3% the manometers were working, but not in good conditions once that just 19.4% of them got approval under conditions like pressure reading, external diameter and glycerin levels. However, according to Casali [6], 34.7% of the manometers were in good use conditions. In contrast, Martini et al. [7] highlight that in 96.4% of the sprayers the pressure gauge was present, however, in only 35.7% showing accuracy approved.

#### 2.6 Protective and security elements for sprayers

Aiming security during pesticide applications, it is said that the elements of protection for mobile parts as for example those ones related to the cardan tree, to the belts and the pulleys and to the free pump shaft must be present and working properly in sprayers. In this sense, it was observed that in 64.5% of the sprayers there were no elements of protection for mobile parts as well as that in 100% of them there was not any protection in terms of cardan tree [1]. However, Dornelles et al. [4] observed that in 53.6% of the sprayers there was no protection in terms of cardan tree, in 38.1% of them this protection was ineffective and just in 8.3% of them it was working properly. In the same sense, Casali [6] points out that the protection of the cardan tree was observed in 30.4% of the sprayers, and that the protection of the belts and the pulleys was observed in 87.0% of them.

According to Martini et al. [12], of the 56 sprayers inspected, only 23.2% of these complied with the ISO 16122 standard with regard to the presence and operation of the cardan tree protection mechanism. The authors point out that in 33.9% of cases, sprayers were being used with this damaged safety item and in 41.1% they were without the protection of the cardan tree.

According to Sichoeki [14], has obtained similar results when observing the protection of the cardan tree. According to this author, just 60.0% of the hydraulic sprayers had this equipment and it was working properly. Alvarenga and Cunha [15] had also previously obtained results like those ones once that in 25.0% of the samples evaluated by them the protection of the cardan tree was not efficient enough or was just not working. Sichoeki [14] reported that the worst condition in terms of security was that in which just 43.0% of the hydropneumatic sprayers were under protection of the cardan tree. However, when considering the protection of the mobile parts, this author realized that just 10.0% of the hydropneumatic sprayers did not present that protection as well as that for hydropneumatic sprayers there were not cases of vulnerable belts and pulleys [14].

In terms of protective and security elements, Dornelles [5] has showed that just 33.0% of the sprayers under evaluation presented pesticide tanks in good conditions of use. In 38.1% of those sprayers there were not any syrup level gauges and for those which had it in 5.95% the syrup level gauges were unreadable. Martini et al. [7] reported that the pesticide incorporator was in good condition in 42.8% of cases, however, 53.6% of the sprayers inspected did not have this device and in 3.6% the pesticide incorporator was not used to prepare the syrup because it was damaged.

It is considered extremely important for agricultural sprayers to present clean water in their tanks as well as under pressure washers for cleaning of empty packages. Empty packages are just accepted in the collection centers after washed. Analyzing under pressure washers in sprayers, Sichoeki [14] observed that in 90.0% of the hydraulic sprayers there were under pressure washers and that they were under suitable work conditions. On the other hand, in just 63.0% of the hydropneumatic sprayers the under pressure washers were working. Besides that, still worst is the fact that for most sprayers under evaluation the cleanness of the packages was done through their own spraying syrups, considering that 53.0% of the hydraulic sprayers and 37.0% of the hydropneumatic ones presented clean water in their tanks to wash the packages [14]. Martini et al. [7] reported worrying results, taking account that 71.4% of the sprayers inspected did not have a clean water tank for washing the packages.

## 2.7 Spray bar and distribution profile

It is known that factors such as alignment and stability of the spray bar may interfere directly in dripping concentration and distribution. According to Sichoeki [14], 36.0% of the sprayers under evaluation presented some problems in terms of the horizontal alignment while 20.0% of them presented some problems in terms of the vertical alignment. Problems with alignments may result in spray nozzles height differences which in turn may end up altering the spray bar distribution profile. According to Martini et al. [7], of the 56 sprayers inspected, 39.3% had serious problems with horizontal uniformity and 10.7% serious problems with vertical uniformity of the spray bar.

Taking into account the distribution profile evaluation as described in ISO 16122 [8], the coefficient of variation (C.V.) for volumetric distribution along the bar will be considered acceptable when it reaches about 10.0% of maximum amplitude. However, in case of no spray nozzle alignment along the bar, inaccuracy in terms of spacing between the nozzles or bad quality of the spray nozzles used the distribution profile will suffer some alteration. Following this evaluation premise described in ISO 16122, according to Martini et al. [7], in only 26.8% of the sprayers inspected, the cross distribution was considered approved.

When analyzing the distribution profile of 39 sprayers, Gandolfo [1] has concluded that just one sprayer presented the C.V. inferior to 10.0% and that the average rate for it was 18%. On the other hand, Siqueira [2] has observed that 87.5% of the sprayers under evaluation in the state of Mato Grosso do Sul presented a C.V. inferior to 10.0%. In relation to the states of Rio Grande do Sul, Paraná and Mato Grosso, this author pointed out that in these states it was also realized a C.V. inferior to 10.0% in respectively 84.5%, 80.7% and 76.5% of the sprayers under evaluation. It was also in the state of Mato Grosso where the sprayers under evaluation presented the greatest quantity of damaged nozzles, what represented 82.4% of the nozzles analyzed.

From those sprayers under Sichoeki's researches [14], just 26.0% of them presented suitable volumetric distribution. Besides that, the author has said that the sprayers with flat spray nozzles presented better distribution when compared with the sprayers with cone spray nozzles. However, it was Alvarenga [10] that presented the most worrying rates when observing that 93.3% of the sprayers under evaluation had presented a C.V. superior to 15.0% in terms of volumetric distribution.

### 2.8 Spray nozzles flow

According to Martini et al. [9], the nozzles represent one of the main components of the sprayers, ensuring the quality and safety of the spraying. However, the spray nozzles flow may suffer some modifications whether in terms of reduction or in terms of increasing when there is no suitable maintenance of the sprayer's hydraulic system. On the one hand, the reduction of the spray nozzles flow is related mainly to obstructed filters. The increasing of it is caused by spray nozzles wear and tear usually due to overpressure systems, absence of filters or even use of filters with unsuitable meshes for the kind of the spray nozzles used. According to Dornelles et al. [18], the use of unsuitable as well as extremely worn out spray nozzles may cause environmental contamination besides compromising the efficiency of the applications.

In this sense, Gandolfo [1] has said that from the sprayers under inspection 18.4% of them presented flow within the limits of about 10.0% of the average for the spray bar flow. On the other hand, he also said that on average 5.5 nozzles for each sprayer presented overflow under an average error rate of 39.8%, as well as that the maximum error rate reached was of 290.8%. Considering the kind of the spray nozzles used, Gandolfo [1] said that just 2.6% of the sprayers under evaluation presented suitable nozzle kinds along the spray bar.

For the state of Paraná, Antuniassi and Gandolfo [19] say that 80.5% of the sprayers under evaluation presented some problems in relation to the spray bar nozzles. In a similar way, when analyzing spray nozzles conservation, Siqueira [2] said that 82.4% of the sprayers under evaluation in 2008 presented wear and tear nozzles. Although presenting the lowest rate for this kind of evaluation, it was also said that in the state of Paraná 44.0% of the spray nozzles were considered out of the acceptable limits, a rate still considered high [3].

According to Sichoeki [14], 23.0% of the hydraulic sprayers under evaluation presented spray nozzles flow within the acceptable rate for it. However according to Ruas [20], just 17.0% of the hydropneumatic sprayers under evaluation presented nozzles flow ranges lower than 10.0% when compared to the average total rate for it. Already, according to Martini et al. [7], more satisfactory results were obtained regarding the flow of the nozzles, since 80.4% of the evaluated assemblies were approved according to the methodology described in ISO 16122 standard. Considering both hydraulic and hydropneumatic sprayers, it is said that 32.5% of them presented at least one out

of the acceptable limit nozzle whether due to syrup obstruction or worn nozzles [10]. According to Dornelles [5], there was an average of 3.3 unsuitable nozzles for each sprayer and the worst case reported was that in which there were 16 unsuitable nozzles in just one sprayer. Already, according to Martini et al. [7], more satisfactory results were obtained regarding the flow of the nozzles, since 80.4% of the evaluated assemblies were approved according to the methodology described in ISO 16122 standard. According to Alvarenga [10], 26.5% of the sprayers under evaluation presented unsuitable nozzles in the spray bar whether in terms of the kind of nozzle used or of the spray angle.

### 2.9 Calibration of sprayers and application rate

For sprayers, the calibration phase is the one which demands more care because it is in this phase that the application rate will be effectively determined. Analyzing the calibration of sprayers, Dornelles [5] said that 73.8% of the sprayers under his evaluation presented some calibration errors due to both worn ties and leakage occurrence, and that those errors ended up leading to unsuitable application rates. Casali [6], on the other hand, reported having observed such kind of errors in 34.72% of the sprayers under his evaluation. Martini et al. [12] indicate that the calibration error was found in 44.2% of sprayers that did not use a flow meter and in 7.7% of those equipped with a flow meter that. According to the authors, part of these errors were related to the absence of the manometer or the use inaccurate pressure gauges, but mainly due to the erroneous use of the PTO rotation and lack of knowledge of the proper methodology for calibration.

According to Gandolfo [1], 80.2% of the sprayers under evaluation presented calibration errors in terms of application rates either for most or for less the rate wished by farmers under an average error rate of 18.9%. In this sense, it is said that 32 of the sprayers under evaluation presented application rates for most the rate wished, while 29 of them presented application rates for less the rate wished. It means that 75.5% of the sprayers under evaluation got no approval for this standard because the calibration rate was considered incorrect [13]. In the study of Siqueira [2], it is said that in proportion application rate errors were observed more in the states of Paraná (70.6%), Mato Grosso (61.8%), Rio Grande do Sul (60.2%) and Mato Grosso do Sul (37.5%). However, it is said that in proportion overlaid applications were observed more in the states of Mato Grosso do Sul (30.2%), Mato Grosso (29.1%), Paraná (26.6%) and Rio Grande do Sul (15.6%). When considering the sub application rates, it is said that in proportion they were observed more in the

states of Mato Grosso (44.9%), Paraná (43.9%), Rio Grande do Sul (31.4%) and Mato Grosso do Sul (29.5%) [2].

For the State of Minas Gerais, it is said that application rate errors were observed more in hydropneumatic sprayers in a proportion of respectively 54.8% for the sprayers below the standardized application rate and 53.6% for the sprayers over the standardized application rate. When considering the hydraulic sprayers, it is said that 26.9% of those sprayers were considered below the standardized application rate while 23.3% of them were considered over the standardized application rate [14]. Still, according to the author, also points out that in general 50.0% of the sprayers under evaluation of both kinds did not apply the syrup levels expected from them.

Considering still the application rate, it is said that 64.5% of the sprayers under evaluation presented some calibration errors in proportions of respectively 41.9% for those sprayers that applied less syrup levels than expected from them and 22.6% for those ones that applied syrup levels over the standardized application rate. Inadequacy in calibration implies directly in things such as application performance, contamination of farming area and costs with pesticides treatments [10].

The correct selection of the PTO rotation allows the spray pump to perform at its maximum efficiency, keeping the pressure of the sprayer hydraulic system constant, as well as the application volume and the spray return to the reservoir. The power take-off (PTO) rotation misuse has direct interference in the application rate and so in the quality of this activity [11]. When the PTO rotation is not according to the technical recommendation, it may interfere in the syrup stirring leading to filters and spray nozzles obstruction in case of the syrup precipitation. In this sense, when analyzing the PTO rotation, Alvarenga [10] pointed out that 73.9% of the sprayers under evaluation were not working under the standard rotation (540 rpm) due to both presenting PTO rotation superior to 550 rpm (30.4%) and PTO rotation inferior to 530 rpm (43.5%). According to Casali [6], 42.0% of the sprayers under evaluation were working with the PTO rotation in the wrong way.

In this sense, it is said being essential both the development of new spraying equipments and the operator's continuous training in order to get better results in terms of efficiency in the application of pesticides in Brazilian farms [21]. In Europe, the projects under inspection of agricultural sprayers consider not only the machine work conditions in terms of use

and maintenance, but also the qualification of employees (machine operators) and rural landowners [19].

Unlike the European reality, the Brazilian agricultural sprayer's condition neither attends the standardized way nor presents perspectives of doing that in a short term. Considering the previous two phases research under the project *Inspecção Técnica de Pulverizadores Agrícolas* in the state of Rio Grande do Sul, Brazil, from the Federal University of Santa Maria (UFSM), it is said that there was no significant improvement in the sprayers under inspection. Under Dornelle's methodology [5], 60.7% of the sprayers under evaluation did not attend the standardized recommendation, 34.5% of them partially attended it and only 4.8% fully attended it. Four years later, in a second evaluation, it was realized that those conditions remained almost the same once that in this case 47.8% of the sprayers under evaluation did not attend the standardized recommendation, 39.1% were said as partially attending it and 13.1% were said as fully attending it [6]. Also worrying results are those reported by Martini et al. [12] when using the ISO 16122 standard as an inspection methodology, since only 5.4% of the sprayers were classified as compliant, 26.8% already in partial compliance and 67.9% non-conforming to the methodology.

Therefore, based on the several previous researches presented in this work, it is possible to say that more specific studies on agrochemical spraying in the Brazil is still necessary in order that agricultural landowners start doing this activity in the right way, aiming to improvements in pest control as well as to the reduction of pesticides waste which will end up also reducing both the costs of the activity and the environmental contamination.

### 3 Conclusions

Through this review, it was possible to conclude that the most serious problems detected in the Brazilian agricultural sprayers under analysis were related mainly to things like absence of environmental and user safety, no protection of the cardan tree, belts and pulleys as well as leakage occurrence. Furthermore, it was still detected that the most common problems related to spraying activities are those of manometer precision, worn spray nozzles and spray transverse distribution wear and tear.

In this sense, it is said that inspections on agricultural sprayers must be mandatory for spraying activities in Brazil likewise it is for the European Union member states. Besides that, it is important to emphasize the necessity of public policies

for development and approval of research centers for tests on agricultural machineries.

### Acknowledgements

The authors are grateful to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for supporting this study.

## INSPEÇÃO TÉCNICA DE PULVERIZADORES AGRÍCOLAS NO BRASIL

**RESUMO:** A manutenção periódica de pulverizadores agrícolas é fundamental para garantir pulverizações seguras, do ponto de vista ambiental e, eficientes tecnicamente, ao que diz respeito aos limites aceitáveis de qualidade. Assim, visando otimizar o uso de agrotóxicos para a proteção de culturas, em diversos países são desenvolvidos projetos destinados a inspeção de pulverizadores agrícolas. No entanto, embora o Brasil seja um país estruturalmente agrícola, atualmente, as inspeções ainda são realizadas de forma voluntária, mostrando que grande parte dos pulverizadores agrícolas não estão condições adequadas de uso, o que pode afetar a eficiência técnica da operação, oferecer risco de contaminação ambiental e, intoxicação do operador. Diante disso, esta revisão bibliográfica tem como objetivo descrever os resultados obtidos por projetos de inspeção de pulverizadores agrícolas em diferentes regiões do Brasil. A metodologia baseou-se no levantamento dos dados publicados em artigos científicos, teses e dissertações. Desta forma, pode-se inferir que os problemas mais graves encontrados nos pulverizadores utilizados na agricultura brasileira relacionam-se, principalmente, à segurança do operador e do ambiente, pela ausência de proteção da árvore com junta cardânica, correias e polias, bem como, presença de vazamentos. Ainda, os problemas mais frequentes relacionados à atividade de aplicação, estão relacionados à precisão do manômetro, desgaste das pontas de pulverização e distribuição transversal da barra de pulverização, justificando desta forma que as inspeções de pulverizadores agrícolas no Brasil tornem-se obrigatórias. Também há necessidade de políticas governamentais destinadas à criação e homologação dos centros de pesquisa destinados a realização de ensaios em máquinas e implementos agrícolas.

**Palavras-chave:** Inspeção periódica. Qualidade na aplicação. Pulverização.

### References

- [1] GANDOLFO, M. A.; Inspeção periódica de pulverizadores agrícolas. 2001. 92 f. Tese (Doutor em Agronomia) – Faculdade de Ciências Agronômicas, Universidade Estadual Paulista Júlio de Mesquita Filho, Botucatu. 2001. Available from: <<https://repositorio.unesp.br/handle/11449/101752>>.
- [2] SIQUEIRA, J. L.; Inspeção periódica de pulverizadores: análise dos erros de calibração e impacto econômico. 2009. 117 f. Tese (Doutor em Agronomia) – Faculdade de Ciências Agronômicas, Universidade Estadual Paulista Júlio de Mesquita Filho, Botucatu. 2009. Available from: <<https://repositorio.unesp.br/handle/11449/101944>>.
- [3] SIQUEIRA, J. L.; ANTUNIASSI, U. R.; Inspeção periódica de pulverizadores nas principais regiões de produção de soja no Brasil. Revista Energia na Agricultura, Vol. 26, nº. 04, p.92-100, 2011. Available from: <<http://revistas.fca.unesp.br/index.php/energia/article/view/305>>. doi: 10.17224/EnergAgric.2011v26n4p92-100.
- [4] DORNELLES, M. E.; SCHLOSSER, J. F.; BOLLER, W.; RUSSINI, A.; CASALI, A. L. Inspeção técnica de tratores e pulverizadores utilizados em pulverização agrícola. Engenharia na Agricultura, Vol. 19, nº. 1, p.36-43, 2011. Available from: <<http://www.seer.ufv.br/seer/index.php/reveng/article/viewFile/222/149>>.
- [5] DORNELLES, M. E. de C. Inspeção técnica de pulverizadores agrícolas no Rio Grande do Sul. 2008. 125 f. Dissertação (Mestre em Engenharia Agrícola) – Universidade Federal de Santa Maria, Santa Maria. 2008. Available from: <<https://repositorio.ufsm.br/handle/1/7508>>.
- [6] CASALI, A. L. Condições de uso de pulverizadores e tratores na região central do Rio Grande do Sul. 2012. 109 f. Dissertação (Mestre em Engenharia Agrícola) – Universidade Federal de Santa Maria, Santa Maria. 2012. Available from: <<https://repositorio.ufsm.br/handle/1/7554>>.
- [7] MARTINI, A. T.; SCHLOSSER, J. F.; GIL, E.; FARIAS, M. S.; BERTOLLO, G. M.; OLIVEIRA, L. F. V.; NEGRI, G. M. Agricultural spray inspection according to ISO 16122. Journal of Agricultural Science, Vol. 11, nº. 4, p.60-75, 2019. Available from: <<http://www.ccsenet.org/journal/index.php/jas/article/view/0/38712>>. doi: 10.5539/jas.v11n4p60
- [8] ISO 16122 Agricultural and forestry machinery – Inspection of sprayers in use. 2015. Geneva. 88p.
- [9] MARTINI, A. T.; SCHLOSSER, J. F.; BARBIERI, J. P.; BERTOLLO, G. M.; NEGRI, G. M.; BERTINATTO, R. Aspectos relevantes da inspeção de pulverizadores agrícolas: Impactos na precisão das pulverizações de agrotóxicos. Acta Iguazu, Vol. 6, nº. 4, p.72-82, 2017. Available from: <<http://e-revista.unioeste.br/index.php/actaiguazu/article/view/16479/12089>>.
- [10] ALVARENGA, C. B. Avaliação de pulverizadores hidráulicos de barra na região de Uberlândia – MG. 2009. 62 f. Dissertação (Mestre em Agronomia) – Universidade Federal de Uberlândia, Uberlândia. 2009. Available from: <<https://repositorio.ufu.br/handle/123456789/12105>>.



- [11] MARTINI, A. T. Inspeção técnica de pulverizadores agrícolas conforme a Norma ISO 16122. 2017. 190 f. Tese (Doutor em Engenharia Agrícola) – Universidade Federal de Santa Maria, Santa Maria. 2017. Available from: <<https://repositorio.ufsm.br/handle/1/11349>>.
- [12] MARTINI, A. T.; SCHLOSSER, J. F.; GIL, E.; FARIAS, M. S.; SANTOS, G. O.; BERTOLLO, G. M.; BARBIERI, J. P. Agricultural spray inspection according to ISO 16122: Part II – Determination of the state of use and conservation of agricultural sprayers. *Journal of Agricultural Science*, Vol. 11, nº. 13, p.11-19, 2019. Available from: <<http://www.ccsenet.org/journal/index.php/jas/article/view/0/40194>>. doi: 10.5539/jas.v11n13p11
- [13] GANDOLFO, M. A.; ANTUNIASSI, U. R.; GANDOLFO, U. D.; MORAES, E. D.; RODRIGUES, E. B.; ADEGAS, F. S. Periodic inspection of sprayers: Diagnostic to the northern of Paraná. *Engenharia Agrícola*, Vol. 33, nº. 2, p.411-421, 2013. Available from: <<http://www.scielo.br/pdf/eagri/v33n2/19.pdf>>. doi: 10.1590/S0100-69162013000200019.
- [14] SICHOCKI, D. Metodologia de inspeção de pulverizadores hidráulicos e hidropneumáticos na região do Alto do Parnaíba – MG. 2013. 67 f. Dissertação (Mestre em Agronomia) – Universidade Federal de Viçosa, Rio Parnaíba. 2013. Available from: <<https://www.locus.ufv.br/handle/123456789/2021>>.
- [15] ALVARENGA, C. B.; CUNHA, J. P. A. R. da. Aspectos qualitativos da avaliação de pulverizadores hidráulicos de barra na região de Uberlândia, Minas Gerais. *Engenharia Agrícola*, Vol. 30, nº. 3, p.555-562, 2010. Available from: <<http://www.scielo.br/pdf/eagri/v30n3/19.pdf>>. doi: 10.1590/S0100-69162010000300019.
- [16] ALVARENGA, C. B.; CUNHA, J. P. A. R. da. TEIXEIRA, M. M. Aspectos da avaliação de pulverizadores hidráulicos de barra na região de Uberlândia, Minas Gerais. *Idesia*, Vol. 29, nº. 3, p.25-31, 2011. Available from: <<http://www.scielo.cl/pdf/idesia/v29n3/art04.pdf>>. doi: 10.4067/S0718-34292011000300004.
- [17] DORNELLES, M. E.; SCHLOSSER, J. F.; CASALI, A. L.; NOLLER, D.; FARIAS, M. S. de. Conformidade de manômetros utilizados em pulverizadores agrícolas. *Engenharia na Agricultura*, Vol. 20, nº. 3, p.244-249, 2012. Available from: <<http://www.seer.ufv.br/seer/index.php/reveng/article/view/264/218>>.
- [18] DORNELLES, M. E.; SCHLOSSER, J. F. CASALI, A. L.; BRONDANI, L. B. Inspeção técnica de pulverizadores agrícolas: histórico e importância. *Ciência Rural*, Vol. 39, nº. 5, p.1601-1606, 2009. Available from: <<http://www.scielo.br/pdf/cr/v39n5/a204cr514.pdf>>. doi: 10.1590/S0103-84782009005000133.
- [19] ANTUNIASSI, U. R.; GANDOLFO, M. A. Projeto IPP – Inspeção de pulverizadores. In: II Simpósio Internacional de Tecnologia de Aplicação de Agrotóxicos: Eficiência, Economia e Preservação da Saúde Humana e do Ambiente. Jundiá. Anais... Jundiá, 2001.
- [20] RUAS, R. A. A.; SICHOCKI, D.; DEZORDI, L. R.; FILHO, A. C.; GOD, P. I. V. G. Proposta de método para inspeção em pulverizadores hidropneumáticos. *Coffee Science*, Vol. 10, nº. 1, p.76-82, 2015. Available from: <<http://www.coffeescience.ufla.br/index.php/Coffeescience/article/view/772>>.
- [21] MATUO, T. Fundamentos da tecnologia de aplicações de agrotóxicos. In: GUEDES, J. V. C.; DORNELLES, S. H. B. Tecnologia e segurança na aplicação de agrotóxicos: novas tecnologias. Campinas, 1998, p. 95-103.