

CHARACTERISTICS AND RISKS IN THE APPLICATION OF ADJUVANTS IN AGRICULTURAL SPRAYING

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ABSTRACT

There are several factors that influence effectiveness in the application of pesticides. They comprise relative humidity, wind speed and air temperature. The use of inert products, called adjuvants, has been on the increase to highlight efficiency in spraying under different aspects. Due to lack of knowledge of their activities, efficiency itself is often compromised by the interaction between adjuvants and phytosanitary products, with unintended consequences. Current study reviews some adjuvants and their mode of action, which may vary from an improvement in absorption by activity on the cuticle to the reduction of the iteration of ions of water and the active ingredient molecule. Since few studies on the use and effectiveness of adjuvants combined to specific pesticide formulations are extant, the use of adjuvants becomes a risky operation. Therefore, consulting specialized people who are familiar with the products and their possible interactions is mandatory before using or recommending the products. Loss of efficiency in phytosanitary control and environmental contamination may be thus avoided.

Keywords: application technology, herbicides, spraying, chemical mixture in tank, surfactants, additives.

ANÁLISE DAS CARACTERÍSTICAS E RISCOS DA UTILIZAÇÃO DE ADJUVANTES PARA PULVERIZAÇÃO AGRÍCOLA

RESUMO

Na aplicação de produtos fitossanitários, existem diversos fatores que influenciam na eficácia de tal operação, tais como: umidade relativa, temperatura do ar e velocidade do vento. Com a proposta de aumentar a eficiência da pulverização sob diferentes aspectos, o uso de produtos inertes chamados adjuvantes tem sido cada vez maior. Muitas vezes, por falta de conhecimento do modo de sua ação, a própria eficiência é comprometida devido às interações entre adjuvantes e produto fitossanitário com consequências indesejadas. Este trabalho traz uma revisão sobre alguns tipos de adjuvantes e o modo de sua ação, que pode variar desde a melhoria de absorção por ação sobre a cutícula até a redução da interação de íons da água e a molécula de ingrediente ativo. Por ainda existirem poucos trabalhos relativos ao uso e a eficiência dos adjuvantes em combinação com formulações de defensivos específicos, o uso de adjuvantes

torna-se uma operação que exige muito cuidado. Portanto, antes da utilização ou recomendação destes produtos, é recomendável a consulta de pessoas especializadas que conheçam os produtos e as possíveis interações entre tais produtos, buscando evitar perdas de eficiência no controle fitossanitário e também a contaminação do ambiente.

Palavras-chave: tecnologia de aplicação, pulverização, mistura de tanque, surfactantes, aditivos.

INTRODUCTION

Perhaps one of the most important fields in agriculture which requires special precautions is the technology for the application of pesticides which, according to MATUO (1985) and JACTO (2001) is the melting-pot of all the knowledge acquired for the economical application of the proper quantity of active ingredients. The compliance with these rulings would lead towards a type of efficiency in the application of pesticides which is very far from that actually done on most farms and homesteads.

Several factors are highly important to reach such efficaciousness in the application of pesticides among which the products' characteristics (its formulation) for the control of the targeted organism may be highlighted. Aiming at a greater efficiency in application and, consequently, phytosanitary control, inert ingredients, also known as adjuvants, are being more and more frequently employed during spraying (MINGUELA; CUNHA, 2011; BALASTREIRE, 1990, apud AZEVEDO; FREIRE, 2006).

According to KISSMANN (1998 apud QUEIROZ et al., 2008), adjuvants are compounds that increase the efficiency of the product and make easier its application when added to the product's formulation or its broth. Increase in the efficiency of pesticide application may occur due to changes in certain features of the solutions

which decrease drifts and improve leaf wetting and absorption (CUNHA et al., 2003).

However, LAN et al. (2007 apud LEMOS et al., 2010) report that adjuvants work differently in different applications and their addition may alter spraying performance. Their effect may actually be positive or negative according to the product's application on the target.

HOLLOWAY (1994 apud QUEIROZ et al., 2008) registers drop dispersion on the surface of leaves and the manner it may undergo certain phenomena, such as being reflected or fragmented in smaller drops, mainly dependent on the physical characteristics of the broth with changes when adjuvants are employed.

The indiscriminate use of adjuvants without knowing their characteristics may also lead to unwanted consequences due to the risk in their interactions with the agrototoxic product. This fact justifies the care that such an event requires (RAMSDALE; MESSERSMITH, 2001, apud CHECHETTO et al., 2010).

Current assay comprises a bibliographical review of the main characteristics of adjuvants that may be used in the composition of the broth (external adjuvants) or in the formulation of agricultural pesticides (internal adjuvants) and an assessment of possible negative effects in their incorrect employment.

BIBLIOGRAPHICAL REVIEW

CHRISTOFOLETTI (1996 apud COSTA, 2009) reports that an increase in the difficulty to obtain manpower to attend to agricultural labor is due to more and more extensive cultivated areas. A way to minimize this problem would be an increase of productivity with an improvement in the management of crops, with the subsequent updating of innovations on the market and new technologies in the application of the products.

The correct application of pesticides is highly relevant to guarantee a higher efficiency of the operation with precautions in environmental, social and human safety, coupled to positive economical results (AZEVEDO; FREIRE, 2006).

According to Ozeki & Kunz (1998 apud COSTA, 2009), so that phytosanitary control would be successful, highly efficient and quality products must be employed, coupled to the compliance with recommendations to climatic conditions during application, such as relative air humidity with at least 55%; temperature below 30°C and wind speed between 2 and 5 km.h⁻¹. BRIDGES (1989) & YORK et al. (1990 apud MONTÓRIO et al., 2004) report that the efficiency of post-emergent herbicides, for instance, may be affected by such factors as size and species of weeds, environmental conditions on application, application rates and interaction with other products, among which the adjuvants may be mentioned.

The products' efficiency may frequently depend on the morphological changes of the plant's components, such as the cuticle. One of the cuticle's functions is the formation of a barrier between the leaf and the environment, impairing excessive water waste and protecting the plant from stress conditions. If chemical and morphological variations occur in the structure of the epicuticular wax of weeds, alterations in selectivity and in the efficiency

of herbicides may be detected (BACHER & CHAMEL, 1990; NEWSOM et al., 1993, apud MONTÓRIO et al., 2004).

Most phytosanitary products are applied on the surface of the plant's upper part. According to their class and function, some products remain on the surface after application while others are absorbed or translocated to the interior of the vegetal tissues. Certain adjuvants may facilitate translocation and improve the product's efficiency (KISSMANN, 1997 apud QUEIROZ et al., 2008).

DURIGAN & CORREA (2008 apud CHECHETTO et al., 2010) report that one of the main advantages in the use of adjuvants is the easy penetration of the defensive broth by the cuticle. The absorption of the ingredient is thus facilitated by the plant. Due to the above facilities, the use of adjuvants has been intensified. However, effects may turn to be contrary to those expected. In fact, the addition of certain chemical components to the spraying broth may cause negative interactions among the products. The application and its results may be thus impaired by the loss of efficiency of the applied products. Normally the above may be due to lack of knowledge of the product's activity and of the implication of its mixture (ANTUNIASSI, 2006, apud COSTA, 2009).

According to OZEKI (2006 apud COSTA, 2009), this may occur due to the great number of adjuvants on the market, with several different functions, and thus difficulties in knowing all the products available. The author also reports that the efficiency of some adjuvants is highly contested and a new area for important research is still open to assess the activity of each component.

ANTUNIASSI (2012) comments that the classification of the main spray adjuvants follows their expected function and the needs for their employment. Some examples

of adjuvant classes would be surfactants, adhesive and penetrants, humectants, broth conditioners (acidulants, buffers and

sequestrants), drift reducers, anti-foam agents and protectors. Their characteristics are given below.

TYPES OF SPRAY ADJUVANTS

Surfactant sprayers

Surfactant sprayers are mainly employed to increase the area of contact of the drops with the chemical target to improve the efficiency of broth spreading and the wetness of the plant. Contact area increase is obtained by reducing surface tension which is the liquid's internal force that maintains united its molecules and makes difficult its spreading on the surface (ANTUNIASSI, 2012).

Excellent leaf coverage is highly important for products with localized action or low translocation. In this case, a more uniform coverage of the treated parts is

required. This is obtained by the addition of the spreading adjuvants. According to VARGAS & ROMAN (2006), efficiency increase in the application of herbicides may also be in the decrease of up to 50% in dosage when compared to those without adjuvants, with important cost savings.

The main recommendation in the use of spreading adjuvants would be the application on leaves which have wetting difficulties, extensive leaf surface to be covered and the need for the products' emulsification (ANTUNIASSI, 2012).

Adhesive and Penetrating Sprayers

According to ANTUNIASSI (2012), one of the most important functions in the addition of oil in the broth is to facilitate penetration and adhesion of pesticides to the leaves, mainly done by an increase in chemical affinity of the broth with the addition of oil onto the waxy surface of the cuticle. It also works in the process of drop formation by increasing their mean size and decreasing the formation of very fine drops in the spectrum. Drift is thus reduced. Adhesive and penetrating sprayers are classified according to these categories:

- Mineral oil with 43 - 93% of mineral oil plus inert products (surfactants, emulsionants and others) (ANTUNIASSI, 2012). Mineral oils are composed of hydrocarbons whose molecules are based on paraffin, naphthene, olefinic and aromatic oils. Parafinic oils are the most employed (DOURIGAN; CORREIA, 2008, apud CHECHETTO et al, 2010);

- Vegetal oil with 80 - 93% of vegetal oil added to inert products (surfactants, emulsionants and others) (ANTUNIASSI, 2012);
- Modified vegetal oil (MSO) with 72 - 80% of methylated or ethylated esters added to inert products (surfactants, emulsionants and others) (ANTUNIASSI, 2012);
- Pure vegetal oil are non-modified vegetal oils, such as de-gummed soybean or cotton oil) which must be employed together with emulsionants so that they could be mixed in the broth (ANTUNIASSI, 2012).

Adhesion and penetration functions in the use of oils as adjuvants are based on the oil characteristics, act as solvents of waxes and of the leaves' surface layers. Penetration is thus made easy and applications are protected in the case of rainfall (ANTUNIASSI, 2012; FLECK, 1993, apud VARGAS; ROMAN, 2006).

Humectants Sprayers (polyglycerol, sorbitol, polysaccharides and others)

Humectant sprayers reduce the risk of evaporation and stick the drops for more time on the treated surface, with an increase in the absorption of the applied product. In fact, they are greatly used in places with relative low air humidity (less than 55%) and high temperatures (over 30°C) since the fast evaporation of the drops may form the crystallization of the molecules of the product on the leaf's surface and impair its absorption by the plant (ANTUNIASSI, 2012). According to GIL & SINFORT (2005 apud QUEIROZ et al., 2011), in several cases the active ingredient is lost due to inadequate environmental conditions.

Water evaporation during spraying is one of the most important loss factors in the process of agricultural application, with a

reduction of efficiency. An increase of the liquid's specific surface occurs due to the fragmentation of the broth in small drops and, consequently, the volatility during its trajectory to the target. The use of anti-evaporation products or humectants in the preparation of the broth significantly contributes towards the control of evaporation. Further studies are needed to improve the performance of the products in agricultural spraying (SCHIRATSUCHI, 2002).

Evaporation decrease causes an increase in coverage (QUEIROZ et al., 2011), which is relevant for a greater deposit of the active ingredient on the treated surface.

Broth conditioners: acidificants (acids), buffers (citric acid) and sequestrants (EDTA)

In the case of water hardness, the most important factor is carbonate, sulfate, chlorate and nitrate rates of several cations (BUHLER; BURNSIDE, 1983, apud QUEIROZ et al., 2008) which may bond to the molecules of the active agents of the pesticides and decrease the amount of active ingredients available with an impairment of efficiency and the clogging of spraying nozzles.

According to Kissmann (1997 apud QUEIROZ et al., 2008), the water's pH may affect the application results. If the pH is high, an acceleration of the active ingredient's degradation of the formula occurs by alkaline hydrolysis. The

dissociation constant of several molecules, especially of herbicides, depends on pH. Its absorption by vegetal tissues varies and depends whether the molecules is integral or dissociated in cations and anions.

Water hardness should be corrected for a correct phytosanitary application. KISSMANN (1998) reports that there are two manners for its correction: the use of adjuvants, with the addition of a non-ion tensoaction which corrects the broth's physical characteristics and the insertion of a chelant in the water prior to the preparation of the broth. They will isolate the electric charges and supplement the molecules' and ions' reactivity.

Drift reducers (polymers, polysaccharides, oils, phospholipids and others)

According to BUTLER-ELLIS (2004 apud MOREIRA JÚNIOR, 2009), drift reducers mainly reduce drift risk in the application due to decrease in the formation of very fine drops within the drop spectrum

or in the increase in the median volumetric diameter (DMV).

The addition of different adjuvants to the spraying broth was assessed by CUNHA & CARVALHO (2005 apud REIS, 2010) within the distribution band of aerial

applications in the drift's potential risk. The researchers concluded that the additions of adjuvants modified the behavior of

volumetric distribution by aerial application with a reduction of drift and increase in the deposit of the broth on the target.

Foam inhibitors (some types of organo-silicones)

Antifoam inhibitors are primarily employed to inhibit foam formation in the formulation and in the application of the product. Adjuvants increase the absorption of the product applied on the leaves and branches and on other parts of the plant, with an increase in the efficiency of spraying. It is often required to diminish problems during filling and not necessarily in its employment (ZAMBOLIN et al., 2003).

The most employed types of anti-foaming are silicone-based even though there are difficulties in retail commercialization. A home-made and cheap solution is the addition of kerosene to the broth at a spoonful per tank of broth. Replacement is less efficient than specific products but it is a very practical alternative (KISSMAN, 1998).

Protectors (“extenders”): polymers + UV filter

Adjuvants with protecting molecules (*extenders*) have an adhesive function and retain the spray more quickly on the target, with a speed reduction in volatility and the inhibition of degradation by solar rays. These adjuvants have been mainly employed in fruit culture in the application of insecticide and fungicide formulations (HOCK, 1998 apud OLIVEIRA, 2011).

According to GREEN (2001 apud OLIVEIRA, 2011), components of natural

lights and specifically UV rays may degrade the active ingredients of some herbicides. Aiming at reducing the above-mentioned effect, some herbicide ingredients that protect against the deleterious effects of solar light are already available on the market. Protection may be provided by certain physical and chemical processes such as an increase in the retention rate of active ingredients by the cuticle or by the absorption of UV rays.

RISK IN THE IMPROPER USE OF ADJUVANTS

Interaction with other products

The mixture of two or more products in spraying tanks is not allowed in Brazil (Law 4074 art. 22, published in 2002), even though the practice is frequent throughout. Mixtures may cause adverse effects in the product to be applied, classified as additive, synergic and antagonist effects (QUEIROZ et al., 2008).

– Additive effect: a product does not interfere in the efficaciousness of the other and the result is the same as the

individual application of the involved products;

- Synergic effect: a product may improve the efficaciousness of the other and the result is higher than that obtained by the sole application of the product;
- Antagonist effect: a product may worsen the efficaciousness of the other and the result of phytosanitary control is lower than that obtained by the individual application of the products.

Formulation of precipitates in tanks

Another form of incompatibility between products is the formation of precipitates in spraying tanks or the formation of pastes, with the impairment of the spraying hydraulic circuit device. Similar

to the case with antagonistic effects above, it is important to replace incompatible products or apply the products alone (QUEIROZ et al., 2008).

Loss of efficiency in application

Research by ANTUNIASSI & BAILO (2005) and DURIGAN & CORREIA (2008 apud MOTA, 2011) shows the importance of knowing the issues involving the inadequate use of adjuvants. The above authors state that lack of knowledge on the manner the

products work in a tank mixture may impair the efficiency of the operation and even delete any significant changes in the application. This would imply in additional costs in the buying of the adjuvant with no benefit in the process.

Changes in the size of the drops

The adjuvant's mode of action may interfere in the formation process of the drops due to changes in the physical characteristics of the broth. The DMV of the

drops and their spectrum may change; they may even be lost by drift and may jeopardize the deposit of the active ingredient on the plants.

Brazilian legislation on the use of pesticides

Pesticides are currently ruled by high legal strictures which are mandatory for all rural producers. The set of laws aims at the preservation of the environment, among which the following may be underscored:

- Law 9605, published on 12/02/1998, punishes people who damage the environment, and deal with other sanctions (BRASIL, 1998);

- Decree 6.514, published on 22/07/2008, rules Law 9605/98 (Environmental crimes) punishes people who damage the environment, and deal with other sanctions, and establishes a federal administration suit to investigate disobediences (BRASIL, 2008). It deals with Crimes related to Pollution and other Environmental Crimes:

“Art. 61. The causing of any type of pollution at such levels that result or may result in harm to human health, or cause the killing of animals or the significant destruction of biodiversity: Fine of R\$ 5.000,00 (five hundred reais) to R\$ 50.000.000,00 (fifty million reais)”;

- CONAMA resolution 334, published on the 03/04/2003, disposes on procedures of environmental permissions for establishments which receive empty bottles

of pesticides (BRASIL, 2003), with no difference between agricultural fertilizers and pesticides, all being considered agricultural toxic agents (BRASIL, 2003);

- Norm 31 (NR 31), approved by Decree 86, published on the 03/03/2005, which deals with work safety and health in fields, cattle-ranches, forests, forest exploitation and aquiculture (BRASIL, 2005). In item 31.8 on agricultural poisons, adjuvants and similar products, there are procedures for employees and employers, such as personal equipment to be complied with.

With regard to research on the development, manufacture, selling and use of agricultural pesticides, Brazilian law is among the most rigorous in the world. Current challenges comprise the harmonization of procedures for the acknowledgements of laboratory competence between agriculture, health and

CONCLUSIONS

Several chemical products are currently in use in agriculture to obtain good quality products. However, chemical products are applied in excessive doses and inadequately with great risks for the contamination of the environment and for the applicators. This is due to disordered applications, excess product and incorrect mixtures.

The employment of adjuvants has become extremely popular to combat and ration product excess. Adjuvants may participate in several stages for the application of phytosanitary products since the formations of drops till their extension of permanence time on the plant after spraying.

The employment of adjuvants has increased to increase the efficiency of the products and decrease their costs. Several products bear tags with recommendation on

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environment with regard to the Ministries' common activities and establish the mutual acknowledgement of laboratory data between Brazil and countries of the Organization for Cooperation and Economic Development (MENTEN et al., 2011).

When these laws are analyzed, it becomes clear that the lawgiver's intention was the protection of the environment and of human life. Legislation on agricultural production should also deal with production competitiveness. The legal text with such aspects and regulations shows unequivocally the evolution of occurrences in the area. In fact, there are still much to do technologically and legally to guarantee the safe and adequate use of adjuvants.

the use of determined adjuvants although few studies are extant on the most adequate methods for the products' use. In fact, their addition to the spray broth may cause undesirable effects.

The addition of adjuvants to spray broths is highly interest because they cause great doubts and controversies. Their benefits are dissemination constantly, coupled to their availability on the market. There is, nonetheless, a lack of awareness of the risks in their indiscriminate use.

Prior to the employment of adjuvants, it is highly important to obtain more technical information on their activities and possible interactions with the formulations of pesticides used. Contrary effects that would compromise significantly the efficiency of phytosanitary control would be avoided.

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