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Description of pesticides and personal protective equipment used in floriculture in Santa Ana Ixtlahuatzingo, Estado de México

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Abstract

Currently, the number of pesticides used is high and their composition is varied. The toxic and environmental effects are diverse. Floriculturists are the agricultural group with the highest risk of exposure to pesticides, they apply them three times a week and in mixtures. In the town of Santa Ana Ixtlahuatzingo their main economic activity is floriculture, to contribute to the pesticide use pattern in floriculture, was documented and described the use and type of pesticides, as well as the hygienic habits and personal protective equipment of 50 volunteer floriculturists in this community. 86% of them spray directly, while 14% use watering. The pesticides used were 36% Captan, 20% Dichlorvos, 20% Carbofuran, 12% Chlorothalonil and 12% (Iprodione, Metazachlor, 2,4-DB, Aldrin and Aldicarb). The most frequent mixture was Dichlorvos plus Captan (28%). Only 10% of floriculturists shower daily. 66% wear waterproof boots, 62% a mask, 32% waterproof apron, 12% gloves, 10% hat and 8% waterproof romper. 28% do not use any personal protection equipment. The flower growers are unaware of the official regulations, so it is necessary for the competent authority to promote and supervise the use of pesticides and the working conditions are in accordance with the agricultural regulations.

Keywords: floriculture, protective equipment, toxicity, pesticides, environment, health.

Descripción de plaguicidas y equipo de protección usados en la floricultura en Santa Ana Iztlahuatzingo, Estado de México

Resumen

Actualmente, el número de plaguicidas usados es alto y de composición variada. Los efectos tóxicos y ambientales son diversos. Los floricultores son el grupo agrícola con más alto riesgo por exposición a plaguicidas, los aplican tres veces por semana y en mezcla. En Santa Ana Ixtlahuatzingo, Estado de México, la principal actividad económica es la floricultura. Para contribuir con el padrón del empleo de plaguicidas en la floricultura, se documentó y describió el uso y tipo de plaguicidas, hábitos higiénicos y equipo de protección personal de 50 floricultores voluntarios de esta comunidad. El 86% de ellos fumigan directamente, mientras 14% usan riego. Los plaguicidas utilizados de acuerdo al porcentaje varían en un 36% de Captan, 20% de Dichlorvos, 20% de Carbofuran, 12% de Chlorothalonil y 12% de (Iprodione, Metazachlor, 2,4-DB, Aldrin y Aldicarb). La mezcla más frecuente fue Dichlorvos más Captan (28%). Solo el 10% de los floricultores se bañan diario. El 66% usan botas impermeables, 62% mascarilla, 32% delantal impermeable, 12% guantes, 10% gorro y 8% mameluco impermeable. El 28% no utiliza ningún implemento de protección personal. Los floricultores desconocen la normatividad oficial, por lo que es necesario que la autoridad competente promueva y supervise el uso de los plaguicidas y las condiciones laborales sean acordes a la normatividad agrícola.

Palabras clave: floricultura, equipos de protección, toxicidad, plaguicidas, medio ambiente, salud.

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Introduction

The number of pesticides currently used is high and of varied composition. The panorama of pesticide use at the national level in México is far from complete. The patterns of pesticide use in agricultural practices in México have been poorly documented. The publications are often qualitative reports obtained through interviews or through the count of empty containers. No national statistics exist on the use of these compounds (García-Hernández *et al.,* 2018; Herrera-Moreno *et al.,* 2018; Silveira-Gramont *et al.,* 2018). The health damages caused by exposure to organophosphates, carbamates, pyrethroids and organochlorines pesticides have been studied in agricultural workers in the Mexican population. There are reports of the different damages due to exposure to Parathion, Methamidophos, Endosulfan, Dimethoate, Diazinon, Chlorpyrifos, Malathion, Dicofol, Permethrin, Carbaryl, Azinphos methyl, Metasystox, Acephate, Trifluralin, Dichlorvos, Paraquat, Aldicarb, Cypermethrin, Dicamba, Monocrotophos and Carbosulfan, among others (Recio *et al.,* 2005; Pérez-Herrera *et al.,* 2008; Martínez-Valenzuela *et al.,* 2009; Zúñiga-Violante *et al.,* 2012; Carbajal-López, Gómez-Arroyo, Villalobos-Pietrini, Calderón-Segura & Martínez-Arroyo, 2016).

The agricultural sector is considered the population group with the highest risk of exposure to pesticides. Floriculturists stand out, since flower harvesting is performed every day and pesticides are applied two or three times a week. In addition to this, they are used in mixtures and the compounds used differ between floriculturists (Castillo, 2011).

In México, regulations exist establishing measures to protect floriculturists, the general population and the environment from the harmful effects of agricultural activities. The two main ones are NOM-003-STPS-1999, which establishes the conditions of safety and hygiene for handling, storing and transferring pesticides and raw materials for plant nutrition or fertilizers, as well as emergency actions in cases of acute exposure or poisoning. The second one is NOM-017-STPS-2008, which dictates the safety conditions for floriculturists and the protective equipment to be used in the workplace.

Any reports have been made on the practices for the use and application of pesticides reflecting the occupational risk to which farmers are exposed to the formulation of pesticide mixtures, incorrect use or absence of protective equipment (García, Ramírez & Lacasaña, 2002) and manual application on crops (Blanco-Muñoz & Lacasaña, 2011). Effects on the health of farmers have also been reported, since the presence of carbamates, pyrethroids, organochlorines and organophosphates has been detected in samples of breast milk, urine and serum (Castillo-Cadena *et al*., 2006; López-Gálvez, Wagoner, Beamer, de Zapien & Rosales, 2018). The manifestation of symptoms due to exposure such as headache, dizziness and skin burning sensation (Cortés-Genchi *et al.,* 2008).

In floriculture, a high number of workers are employed in relation to land area, approximately 16 people per hectare, so it is considered a labor intensive activity (Ascoflores, 2002), using insecticides, fungicides, acaricides and herbicides (Ortiz, Avila-Chávez & Torres, 2017).

The use of pesticides and agrochemicals requires specific measures. However, in countries such as Greece, Spain, India, Australia, Colombia and México, pesticide application is carried out with poor or no personal protective equipment (García *et al.,* 2002; Macfarlane *et al*., 2008; Singh & Gupta, 2009; Damalas-Christos & Hashemi-Seyyed, 2010; Blanco-Muñoz & Lacasaña, 2011; Feola, Gallati & Binder, 2012). This affects the health of farmers, since it is estimated that every year 300,000 cases of pesticide poisoning occur around the world, making it a public health problem (Sabarwal, Kumar & Singh, 2018). The after-work hygiene practices of workers contribute to the levels of pesticides in their homes. Preventive measure training is needed to decrease the risk of home contamination, such as removing work shoes before entering the home, changing clothes before going home or after arrival, showering promptly after work, and so, fore (McCauley *et. al*., 2003).

Prolonged exposure and retention of pesticides within the body can cause damage to human health, such as dermatological, gastrointestinal, neurological, carcinogenic, respiratory, reproductive or endocrine damage (Mostafalou & Abdollahi, 2013; Nicolopoulou-Stamati, Maipas, Kotampasi, Stamatis & Hens, 2016) and congenital malformations (Castillo-Cadena, Mejia-Sanchez & López-Arriaga, 2017).

The floricultural zone of Estado de México covers 6,740 hectares. Floriculture is the main economic activity in the municipalities of Tenancingo de Degollado, Zumpahuacan, Coatepec Harinas, Villa Guerrero, and Ixtapan de la Sal. It is estimated that it contributes up to 80% to flower exports from Mexico (Castillo-Cadena *et al.,* 2017). In these municipalities, the cultivation and harvest of flowers is carried out all year round. Furthermore, pesticides and mixtures of them are applied massively throughout the year and these vary despite being the same crop (Ortiz *et al.,* 2017; Castillo-Cadena *et al.,* 2006; Castillo-Cadena *et al.,* 2017). In addition to this, there is an underreporting of pesticides use, the form of application and precautionary measures if any, which makes it difficult to assess the risk of damage to health and make decisions to avoid them. In order to contribute to the registration of pesticides in flower crops and occupational risk, the objective of this work was to describe the hygienic habits, type of pesticides and personal protective equipment used by floriculturists in Santa Ana Ixtlahuatzingo, Tenancingo, Estado de México.

Methodology

Location of study

Santa Ana Ixtlahuatzingo is a community in the municipality of Tenancingo de Degollado and geolocated in the coordinates 18°57′38″N 99°34′32″O (Figure 1). Its main economic activity and trade is the production of flowers and ornamental plants. Men, women, children and the elderly carry out this activity (Mejia-Sanchez, Montenegro-Morales & Castillo-Cadena, 2017).

Group under study

The invitation was made to small floriculturists from Santa Ana Ixtlahuatzingo, Tenancingo. The participants were of legal age, voluntarily accepted their participation and signed an informed consent letter. The study group consisted of 50 men floriculturists.

Information gathering

The compilation of information related to the use and application of pesticides was carried out using a questionnaire where general data of floriculturists and their work activity were recorded. Such as the type of cultivation they carry out, pesticides used, frequency and form of application, as well as the protective equipment used, according to previous studies (Castillo-Cadena *et al.,* 2006; Castillo-Cadena *et al.,* 2013; Martínez-Luna, Mejia-Sanchez, Serment-Guerrero & Castillo-Cadena, 2014). The correlation analysis of the different variables was performed with the software Sigma Stat 12.0.

Results

Characteristics of the study group

The results on the hygienic habits and use of protection equipment by floriculturists are summarized in Table I. The group of floriculturists consisted of 50 men (100%). Regarding hygiene habits, 5 floriculturists (10%) shower daily and 45 (90%) every other day. About work clothes, they reported that they do not use any special garments in particular, they use their daily clothes, 14 floriculturists (28%) change them daily and 36 (72%) every other day. Concerning the cleaning of their clothing, 36 floriculturists (72%) wash their work clothes every other day and 14 (28%) daily. For washing, 38 floriculturists (76%) separate their clothes and use a specific treatment and 12 (24%) wash them regularly with the clothes of the rest of the family. The analysis did not show any correlation between hygiene habits.

As regards the personal protective equipment used during the application of pesticides, 36 floriculturists (72%) used some personal protective equipment and 14 (28%) did not use any protection. The protective equipment used was: 33 floriculturists (66%) wear waterproof boots, 31 (62%) face masks, 16 (32%) waterproof aprons, 6 (12%) gloves, 5 (10%) hat and 4 floriculturists (8%) waterproof rompers. The results on the hygienic habits and use of protection equipment are summarized in Table I. No floriculturist wears full or adequate protective equipment. The most frequent combination of

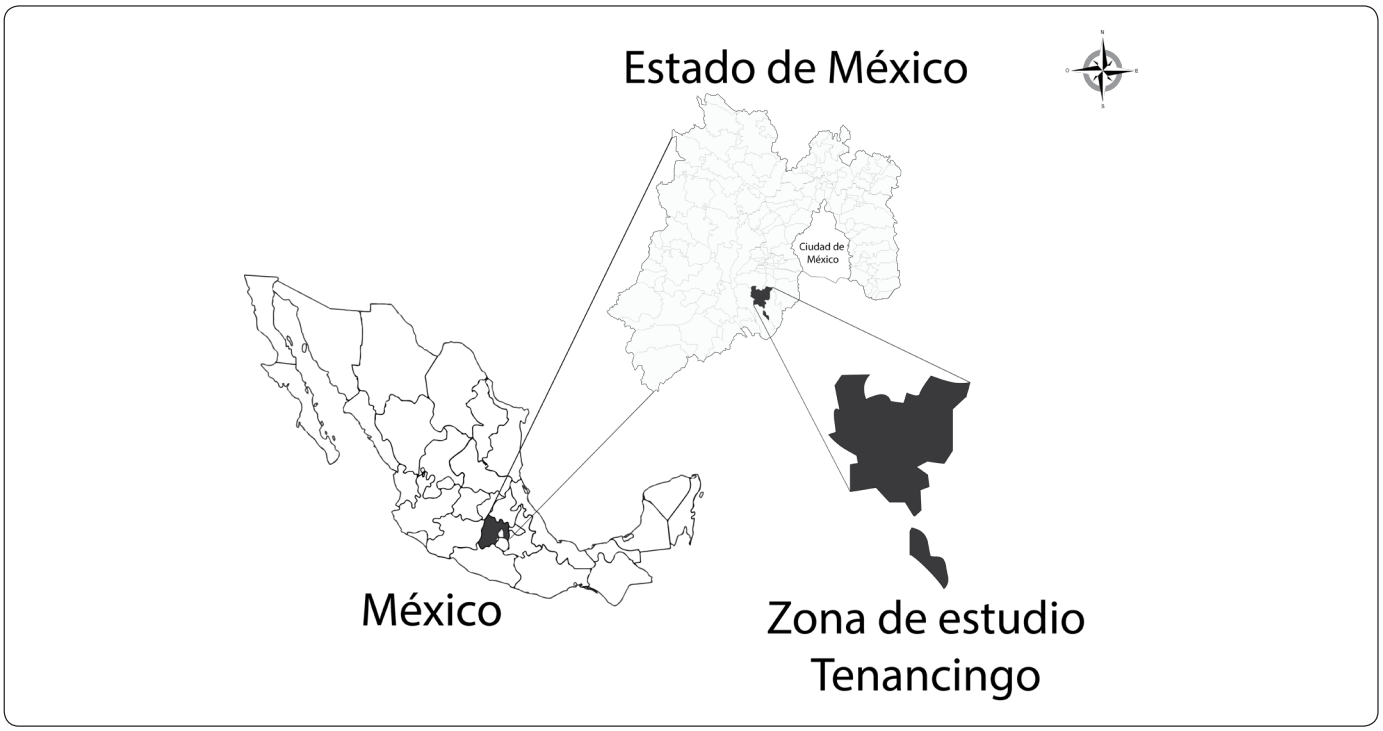

Figure 1. Location of Santa Ana Ixtlahuatzingo, community of the municipality of Tenancingo de Degollado (Saldívar-Iglesias, Laguna-Cerda, Esquivel-Álvarez & González-Esquivel, 2012).

Table I. Results on the hygienic habits and use of protection equipment by floriculturists n=50.

	Floriculturists (%)
Shower	
Every day	5 (10)
Every other day	45 (90)
Change clothes	
Every day	14 (28)
Every other day	36 (72)
Use of waterproof romper	
Yes	4 (8)
No	46 (92)
Use of waterproof boots	
Yes	33 (66)
No	17 (34)
Use of mask	
Yes	31 (62)
No	19 (38)
Use of waterproof apron	
Yes	16 (32)
No	34 (68)
Use of waterproof cap or hat	
Yes	5 (10)
No	45 (90)
Use of waterproof gloves	
Yes	6 (12)
No	44 (88)

protective implements were waterproof boots and a mask with 64%. Correlation analysis was performed between the variables of personal protective equipment and hygienic habits, but no significant differences were found. The statistical analysis did not show any correlation between the different elements of the protective equipment.

Use and application of pesticides

The results showed that 22 floriculturists (44%) work in the cultivation of rooted plants and 28 (56%) in the cultivation of various flowers. Direct fumigation is the most frequent form of pesticide application 43 floriculturists (86%), while 7 floriculturists (14%) apply pesticides while watering. Table II shows the pesticides used, their biological activity, the chemical group to which they belong, according to the Diccionario de Especialidades Agroquímicas, 2012. As well as the frequency of use and their classification by PAN. Considering the biological activity of pesticides, the results show that they focus on the elimination of fungi and insects. 25 floriculturists (50%) use fungicides, which are improbably dangerous or slightly dangerous for human health, followed by 20 (40%) that apply highly dangerous insecticides.

Apropos the type of pesticide used, it was found that 18 floriculturists (36%) apply Captan, 10 (20%) Dichlorvos, 10 (20%) Carbofuran, 6 (12%) Chlorothalonil and 12% apply Iprodione, Metazachlor, 2,4-DB, Aldrin and Aldicarb. In general terms, pesticides are applied in mixtures. The most frequent mixture is Dichlorvos plus Captan by 28% of the workers. These results showed the use of 3 pesticides (Carbofuran, Aldicarb and Aldrin) not registered by the Federal Commission for Protection against Health Risks (COFEPRIS) and 6 banned by the International Pesticide Action Network (PAN) (Dichlorvos, Carbofuran, Chlorothalonil, Iprodione, Aldicarb and Aldrin). The latter are used by at least 60% of floriculturists.

In relation to the frequency of use, 88% of floriculturists reported that they apply them weekly, 8% every other day and 4% every day.

Discussion

The Environmental Guide for Floriculture from Colombia (Ascoflores, 2002), recommends that the use of pesticides requires safe handling to protect workers and the environment where the activity takes place. This to avoid negative impacts on the environment and human health due to the handling of pesticides, considering it necessary to take preventive and control measures in some cases.

To this context, the work of floriculturists in Mexico has a higher risk to human health, compared to other types of agriculture. One of the main differences is the frequent application of pesticides, an activity that is carried out three times a week and throughout the year, increasing the exposure to these substances. (Mejia-Sanchez *et al.,* 2017). Despite the existence of specific official regulations on the use of personal protective equipment for handling and application of pesticides (NOM, 1999), the actual practice in the horticultural and floricultural community of Santa Ana Ixtlahuatzingo is far from what is established in said regulations.

Bad practices in the cultivation of flowers are common in the floricultural zone of the Estado de México and have been reported in previous investigations in which the lack of exclusive areas for cultivation, and the presence of crops and greenhouses in the central parts of towns and populated areas are mentioned (Ortiz *et al.,* 2017; Mejia-Sanchez *et al.,* 2017). This makes floriculturists and the open population susceptible to developing harmful effects on health, as a consequence of exposure to these toxic substances and the contamination of water, soil and air (Bolognesi, 2003; Hernández-Antonio & Hansen, 2011).

Table II. Pesticides used by floriculturists in Santa Ana Ixtlahuatzingo, Estado de México.

Tradename	Chemical group	Active ingredient	Chemical name	Pesticide use	Toxicity WHO	Frequency of use (%)
Captan	Phthalimides	Captan	N-trichloromethvlthio-A-cyclohexene-1,2-dicarboximide	Fungicide	Improbably dangerous	36
Anaphos[+]	Chlorinated Organophosphate	Dichlorvos	2,2-dichlorovinyl dimethyl phosphate	Insecticide	Highly dangerous	20
Furadan*[+]	Carbamate	Carbofuran	2,3-Dihydro-2,2-dimethyl-7-benzofuranol	Insecticide Nematicide	Highly dangerous	20
Daconil[+]	Chloronitrile	Chlorothalonil	Tetrachloroisophthalonitrile	Fungicide	Improbably dangerous	12
Iprodiona[+]	Imidazolidine Dicarboximide Chlorinated	Iprodione	3-(3,5-dichlorophenyl)-2,4-dioxoimidazolidine-1-carboxamide	Fungicide	Slightly dangerous	4
Sultan	Chloroacetamides	Metazachlor	2-chloro-N-(1-phenyl-3-propyl-1H-pyrazol-5-yl)acetamide	Herbicide	Unknown	2
Butyrac	Chlorophenoxy	2,4-DB	Ácido 4-(2,4-diclorofenoxi)butírico	Herbicide	Moderately dangerous	2
Temik*[+]	Carbamate	Aldicarb	2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime	Insecticide Nematicide	Extremely dangerous	2
Aldrin*[+]	Organochlorine	Aldrin	1,8,9,10,11,11-hexachlorotetracyclo [6.2.1.13,6.02,7] dodeca-4,9-diene	Insecticide	Highly toxic	2

[+] Pesticides prohibited by the International Pesticide Action Network (PAN). *Pesticides not registered in the Federal Commission for the Protection Against Sanitary Risk (COFEPRIS). WHO: World Health Organization.

Our results on the use of protective equipment during the application of pesticides showed that floriculturists use it partially, without observing the provisions of the aforementioned standard, which specifies the use of waterproof boots, hat and gloves, long-sleeved clothing, googles and mask. The absence of protective equipment in this area has been previously documented by Castillo-Cadena *et al.,* 2006, who studied 52 floriculturists from the town of Santa María Aransazú, and reported that only 3.8% of workers wear waterproof gloves and overalls during the application of pesticides. However, the floricultural zone of the State of México is not the only region in this country where studies of this nature have been carried out. Similar results have been reported in other regions, one of these was carried out by Blanco-Muñoz & Lacasaña 2011, where they studied 99 agricultural workers in central México and found that around 50% do not use protective equipment. While López-Martínez *et al.,* 2018, studied 126 agricultural workers from occident Mexico, of which 50% do not use protective equipment. In this same region, Herrera-Moreno *et al.,* 2018, studied 209 fumigators, and identified that 73.6% reported that they do not use protective equipment. In addition to the above, there are also reports in other countries such as Ghana, Greece, Australia and the USA, where studied groups of farmers have shown deficiencies in the correct use of protective equipment during the application of pesticides (Macfarlane *et al.,* 2008; Damalas-Christos & Hashemi-Seyyed, 2010; Arcury, Quandt, Rao & Russell, 2001; Okoffo, Mensah, Fosu-Mensah, 2016). The use of personal protective equipment is the most elementary action to reduce the risk to health before compounds that replace those currently used are available and subsequently eliminated. To this end, the authorities in charge of the proper use of pesticides must intervene.

With respect to hygiene habits, the Official Mexican Standard NOM-003-STPS-1999 establishes that workers must shower or wash exposed body areas at the end of each working day and wash or change their protective clothing or equipment daily. However, most of the floriculturists surveyed do not follow these recommendations. This increases the risk of exposure and consequently damage to health. Such as study conducted by McCauley *et al*., 2003, where found high levels of pesticides in the homes of workers who waited more than 2 hours before changing out of their work clothes, providing evidence that they were increasing the risk of pesticide exposure for themselves and other family members within the home. Behavior from bad hygiene habits, also was reported by López-Martínez *et al.,* 2018, who studied 20 Mexican farmers, of which only 20% change their clothes daily. In contrast, García *et al.,* 2002, studied 89

Spanish farmers and found that 71% shower at the end of the day. Mohanty *et al.,* 2013, studied 100 farmers in India and mentioned that 63% take a shower and wash the clothes used after the application of pesticides. It appears that agricultural workers in other countries show better hygienic practices, possibly because the work areas provide adequate facilities for cleaning workers; such conditions that do not regularly exist in the Mexican countryside.

With reference to the pesticides used in the study locality, compounds prohibited by the PAN were identified as highly toxic and with carcinogenic potential, these were Dichlorvos, Carbofuran, Iprodione, Chlorothalonil, Aldicarb and Aldrin. While COFEPRIS has no registration for Carbofuran, Aldicarb and Aldrin. However, these pesticides are still available in this region.

These findings are not exclusive to Santa Ana Ixtlahuatzingo, since in other investigations carried out in the neighboring municipality of Villa Guerrero, which is eminently floricultural, Martínez-Luna *et al.,* 2014, identified that the most widely used pesticides were Methomyl, Mancozeb, Carbofuran and Methamidophos. While Mejia-Sanchez *et al.*, 2017, reported Methomyl, Carbofuran, Captan, Methamidophos and Imidan as the most used. It is important to highlight that the compounds used in both locations are different despite being the same crop. The presence of Methamidophos stands out, which is a compound of restricted use. This shows that in Villa Guerrero pesticides prohibited by the PAN are also used.

About the application of pesticide mixtures, our results show that Dichlorvos and Captan make up the most frequent mixture. Oliva, Rodríguez & Silva, 2005, reported in their study in Bella Vista, a community in the same floricultural area, that the formulation of mixtures and their application is carried out with total ignorance of the impact that they could cause on human health. Our experience in this research leads us to consider with high probability that the same happens in this community.

The information obtained on the protection measures adopted during the application of pesticides in the town of Santa Ana Ixtlahuatzingo reflects that the training and education on the use, application and protection measures during the application was not carried out by qualified personnel, but inherited by the ancestors of floriculturists.

These results invite us to consider the need for continuous training of floriculturists. Such training should address the essential elements of protective equipment, its proper use, as well as the correct selection and application of pesticides in order to reduce risks to the health of workers and damage to the environment.

Conclusions

The conditions under which flower cultivation is carried out in Santa Ana Ixtlahuatzingo, municipality of Tenancingo, Estado de México in relation to the personal protective equipment and the pesticides used, are outside the established Mexican regulations. The results of this research contribute to generate a registry of pesticides applied in floriculture, particularly in the Estado de México, which will facilitate the regulation of their use.

It is recommended that the competent authority promote and supervise the use of pesticides and working conditions in accordance with current regulations.

Conflicts of interest

All authors have no conflicts of interest to declare.

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