

Evaluation of the use of glyphosate and legumes in valencia orange (*Citrus sinensis* L. Osbeck), in the north of Veracruz: case study.

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ABSTRACT

Evaluation of the use of glyphosate and legumes in valencia orange (*Citrus sinensis* L. Osbeck), in the north of Veracruz: case study. The objective of the case study was to contribute to the knowledge of herbicides (mainly glyphosate) and legumes of valencia orange producers in northern Veracruz. The study was carried out in the year 2021, with producers from three municipalities located in the north of Veracruz: Papantla, Álamo Temapache and Ixhuatlan de Madero. A total of 55 interviews were carried out. The interview that was conducted was structured around three sections: personal information of the interview respondent, information about herbicides, and information about legumes. The characteristics found in this study indicate that the majority of producers continue to use herbicides, 80% do not know the term glyphosate even though it turns out to be the main active ingredient of several of the herbicides that they apply and despite knowing that these can be very dangerous due to various reasons, they continue to use them without any protective equipment, due to how easy, fast and cheap their application is. However, regardless of everything, the producers are in the best disposition to know and cultivate leguminous plants in their plots to observe their characteristics, benefits and advantages in weed control.

Keywords: glyphosate, legumes, presidential decree, valencia orange, weeds.

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INTRODUCTION

Glyphosate is the name of the active ingredient of a total or non-selective herbicide, which means that it has the capacity to kill all types of plants, both of narrow leaf and of wide leaf; it is of foliar action, meaning that it is not absorbed by the roots, so its application is done post-emergence (Ramírez, 2021) [1] (p. 24).

It is the herbicide of greatest use in the world, its commercialization began in 1974 by the Monsanto company, with its most widely known formulation as ROUNDUP. The uses given to it are agricultural, livestock, urban, gardening and industrial, in addition to also being used as a disseminating agent, in crops such as sorghum or soy to dry the grain



and hasten the harvest, or in sugarcane as maturing agent to increase the degree of sucrose (Bejarano, 2017) [2] (p. 86) and is authorized in 32 agricultural crops, in addition to grasses, forest plantations and non-agricultural areas, with 96 different formulations (Ramírez *et al.*, 2017) [3] (pp. 59-72).

In Mexico, glyphosate is used in the cultivation of different species in the agricultural sector, among which its application in corn stands out, with 35% of the total national use, followed by citrus production with 14%, grasses 11%, and sorghum 10% (SEMARNAT, 2020) [4] (w/p). In this sense, in addition to citrus production being one of the most important activities in Mexico, it is also the second crop of highest use of glyphosate (Gómez *et al.*, 2021) [5] (pp. 5-6).

Although glyphosate and other herbicides are used to eradicate agrestal plants, herbs or weeds under the argument that they reduce the quality and the productivity of crops (between 13% and 30%) (Menalled, 2010) [6] (pp. 73-78), when competing for water, space, light and nutrient; the reality is that they are largely affecting the natural cycles: organic matter, microorganisms, minerals, fauna and human health, and can cause congenital malformations, alterations in the renal, hepatic, endocrine and gastrointestinal system, infertility and various types of cancer (non-Hodgkin's lymphoma), mutagenesis, encephalopathy, autism, Parkinson's, and damage to the liver, to intestinal bacteria and to the immune system (Watts *et al.*, 2016, cited by Bejarano, 2017) [2] (p. 87).

It is important to mention that in 2015 glyphosate was classified by the World Health Organization (WHO) as probable carcinogen in humans, which is why it is considered a highly dangerous pesticide (HDP) for health and this has been confirmed in 1,108 scientific articles (Rossi, 2020) [7] (p. 8).

Facing this situation and with the aim of decreasing the impact of glyphosate, president of Mexico issued a decree that went into force on December 31, 2020, which suggests, among other issues: “[...to establish the actions to gradually substitute the use, acquisition, distribution, promotion and import of the chemical substance denominated Glyphosate for sustainable and culturally adequate alternatives, which allow maintaining the production and which are safe for human health, biocultural diversity of the country, and the environment]” (DOF, 2020) [8] (p.1).

In addition to this, and with the aim of contributing to the national crusade, as well as in function of what the third article of the presidential decree mandates^[1], CONACYT agrees to carry out a project between regions; Yucatán-Campeche, Michoacán and the north of the state of Veracruz, key regions in the production of three agriculture and livestock products of utmost importance, corn, citrus and avocado, crops that together represent 53% of the total use of glyphosate in Mexico with 35, 14 and 4%, respectively. When it comes to the total national corn production, Michoacán occupies the 3rd place and Veracruz the 7th, with 7.52 and 4.71% respectively. Regarding orange production,

¹ **Article Three.** – The National Council of Science and Technology, in the scope of its competence, will coordinate, articulate, promote and support scientific research, technological development and innovations that allow sustaining and proposing to SADER and SEMARNAT alternatives to glyphosate.

which figures as one of the main crops in the north of Veracruz, this state is the 1st place and Yucatán the 7th with 51 and 3% of the total national production. Finally, regarding the avocado production, Michoacán occupies the 1st place, Yucatán the 10th and Veracruz the 11th place with 75.19, 0.42 and 0.31% of the total national production.

The project is titled: “MANAGEMENT OF PLANT COVER FOR THE CONTROL OF WEEDS IN MEXICO” (*MANEJO DE COBERTURAS VEGETALES PARA EL CONTROL DE ARVENSES EN MÉXICO*) and its main objective is to promote and disseminate the use of plant covers (legume and non-legume species) for the management of weeds that help substitute the use of herbicides in Mexico, through the systematization of successful experiences and a broad and intense effort of technology transfer and awareness, to be able to reach the goal of eliminating the use of herbicides based on glyphosate by January 2024.

In response to that project, a case study was conducted titled **Evaluation of the use of glyphosate and legumes in valencia orange (*Citrus sinensis* L. Osbeck), in the north of Veracruz**, to contribute to the knowledge that producers have with regards to glyphosate and legume plants.

The state of Veracruz was chosen because it is the main orange-producing state at the national level with 51% of total production, equivalent to 2,361,612.31 tons (SIACON, 2020) [9] (w/p).

The municipalities that were visited to carry out the interviews were found within the first 10 municipalities according to SIAP, 2020 [10] (w/p), that concentrated 96% of the total production with 2,263,526.05 tons and 95% of the total production value, equivalent to 6,075,138,545.83 pesos. Álamo Temapache was found as the main orange producer, in terms of tons and production value with 31 and 32%, Papantla was the third place with 17% and Ixhuatlán de Madero in ninth place with 2%. The last two municipalities with the same percentage compared to the total production value and the total of tons produced.

MATERIALS AND METHODS

Type of study

The study is a qualitative interpretation through 55 interviews where the degree of knowledge that producers have is analyzed, in their perception about herbicides and the use of legumes in the management of weeds in the north zone of Veracruz.

Study location

The interviews were carried out in three municipalities of Veracruz; the municipality of Álamo Temapache with coordinates 20° 55' latitude North, 97° 41' longitude West at an altitude of 40 masl; the municipality of Papantla with coordinates 20° 27' latitude North, 97° 19' longitude West at an altitude of 180 masl; and the municipality of Ixhuatlán de Madero with coordinates 20° 41' latitude North and 98° 01' of longitude West at an altitude of 260 masl (INEGI, 2022) [11] (w/p).

Structure of the interview

The interview conducted with producers is constituted by the following three sections:

1. General information. This section includes the most important data, such as: Name of the interview respondent, age, sex, number of hectares they have, as well as which crops they produce.
2. Information about knowledge of herbicides. In this section, the following questions were asked: Do you know, what are herbicides? Do you know what they are used for? Do you use herbicides? What herbicides do you use? How do you apply the herbicides? Do you use any type of protection? Do you know, what is glyphosate? Do you consider that herbicides are harmful to health?
3. Information about the knowledge of legumes. This section included the following questions: Do you know legumes? Do you grow or currently use legumes? Would you like to learn more about how legumes can help to control weeds in your plot without using herbicides? Would you be willing to test them in your plot?

RESULTS AND DISCUSSION

Next, the results obtained from the interviews applied are presented.

General information of interview respondents:

Of the producers interviewed, 80% are men, which indicates that the masculine sex is prevalent, although a significant increase of the participation of women in the field is increasingly reflected, in this case of 20%. Of the producers, 76% are 50 years or older.

Regarding the marital status, 78% of the producers are married or in civil union, and the remaining 22% are single or widows. Regarding schooling, 67% have basic education (preschool, primary or secondary), and the remaining 33% have high school or university education (bachelor's, master's or PhD).

Of the producers, 91% have less than 5 hectares, which indicate that they are mostly small-scale producers, which agrees with Gómez *et al.*, (2021) [12] (p. 114), regarding the variation of the surface in the majority group of producers of valencia orange in the north of the state of Veracruz, which is 3 to 7 hectares.

Of the producers, 69% have been citrus producers for more than 10 years, which indicates that they have experience in the trade, mainly in the production of valencia orange.

Knowledge of glyphosate among interview respondents:

All of the producers (100%) know what is the function of herbicides, although they are not familiar with the term herbicide, so producers refer to herbicides as “liquids”, “burners” or “weed killers”; therefore, it is fundamental to use the common terms that producers use in order to avoid biases in the results due to mistakenly describing the information. For example, in the sensitizing campaign carried out by the Ministry of the Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales*, SEMARNAT), Glyphosate is mentioned and not the terms that producers understand.

The producers who are currently using herbicides represent the largest part, with 94% of the total producers surveyed. Among the herbicides that are most often mentioned due to their generalized or extensive use, there are: faena, la fam and glifos (glyphosate);

dragocson, gramoxone (paraquat), and fitoamina (2,4D). It is fundamental to mention that producers use herbicides alternately; thus, for example, in their first application they can use glyphosate and for the next application they use the same or one of the others, such as paraquat or 2,4D. In this sense, the herbicide that predominates the most is glyphosate, since 100% of the producers who apply herbicides use it, in contrast with the herbicides paraquat and fitoamina which are used by 75 and 45% of the producers, respectively. The season of application depends on the stage of growth of the weeds. Glyphosate, paraquat and 2,4-D are applied before sowing the crop and only glyphosate and paraquat after emergence of weeds and the crop (CEDRSSA, 2020) [13] (p. 10).

Glyphosate is a herbicide of total action, that is, it kills all types of plants; its application is post-emergence and systemic; it is transported internally from the point of contact in the plant towards some others of its parts (Ramírez, 2021) [1] (p. 11). According to the results, only 20% mentioned knowing what glyphosate is for, and they commonly refer to it as “glifos”.

Similar to glyphosate, within the group 2,4D there are herbicides of systemic action that move fast which combat weeds selectively and post-emergence, although they are only used to control weeds of broad leaf.

On the other hand, paraquat is another one of the relevant herbicides due to its use in citrus crops; it is of non-selective contact, functions for all types of weeds, and only acts on the green organs of the plants, by causing an immediate necrosis, withering and total dissecting after three days post-application (Martínez, 2017) [14] (p. 10).

Of the total producers who continue to use herbicides, only 8% uses some protection equipment when they carry out the application through a sprinkler backpack and the most common are boots and goggles. This shows that aside from being a small percentage, the equipment they use is not enough, since according to the PROJECT of the Norma Oficial Mexicana PROY-NOM-003-STPS-2016, Agricultural Activities-Safety and Health Conditions at Work, the personal protection equipment (PPE) that should be used during the application of agrichemicals (in this case herbicides) are: “[impermeable gloves, long-sleeve clothes, impermeable boots, facial protection, respiratory protection equipment, and impermeable wide-brimmed hat]” (STPS, 2006) [15] (w/p).

It is important to mention and highlight the fact that 100% of the producers consider that herbicides cause harm to health, although 94% continues to use them because of the low costs that they generate by not requiring too much labor and because they are of easy and fast to handle.

Table 1 shows three of the indicators already mentioned before: surface, age, sex, with the aim of showing in function of them and the parameters established the percentage of producers that apply herbicides.

Table 1 shows that both small-scale (<5) and medium and large scale producers (>10) incur in the use of herbicides, since they are not less than 75% of the producers. When it comes to age, the percentages are also high, since 95% of the producers with an age of 50 years or more use herbicides and the percentage in those who are less than 50 years is 92%. Finally, regarding the last indicator, 100% of the women producers apply herbicides and of the masculine sex the percentage is 92%.

Table 1. Percentage of producers who use herbicides per indicator of surface, age and sex.

Indicator	Parameter	Use of herbicides (%)
Surface (hectares)	>10	100
	5-10	75
	<5	96
Age (years)	≥50	95
	<50	92
Sex	Masculine	93
	Feminine	100

Source: Prepared by the authors.

Similarly, this indicates that from all the parameters established for each indicator, there is not a single one where producers do not use herbicides, but rather on the contrary: they do use it and the percentages are rather high.

Knowledge of legumes among interview respondents:

Of the producers, 60% identify legume plants, but only those plants that are common to the region, such as bean, peanut, northern bean, year-round bean, pea and lentil. The remaining 40% mentioned not being familiar with them.

Only 4% of the producers cultivate some type of legume, but they are not aware of their use in weed control.

The legumes grown by 4% of the producers are bean, broad bean and lentil, addressing self-supply for their families.

Of the producers, 96% who do not cultivate legumes are interested in cultivating them and in performing the trial on their plots, and likewise the remaining 4% since they are already sowing bean, broad bean or lentil, and they were very interested in knowing more types of legume plants and in sowing them in their orchards.

Table 2 maintains the same indicators from Table 1 with the objective of sustaining the essence of the characterization or typification of producers, although now it is with relation

Table 2. Percentage of producers who are interested in legumes by indicator of surface, age and sex.

Indicator	Parameter	Interest in legumes (%)
Surface (hectares)	>10	100
	5-10	
	<5	
Age (years)	≥50	100
	<50	
Sex	Masculine	100
	Femenine	

Source: Prepared by the authors.

to the interest there is over legume plants. As can be seen, 100% of the producers in the different parameters established are interested in these plants.

In addition to this, 100% of the producers mentioned that they would like to begin with the most recommendable legume plants in terms of their functionality with regards to the type of soil, climate and other important factors, so that in this sense they can observe the benefits they provide. Most of the interview respondents are unaware of most of these species: [Gandúl bean (*Cajanus cajan*), Fodder soy (*Neonotonia wightii*, *Glycine* sp.), Mucuna (*Mucuna pruriens* ó *Stizolobium deeringianum*), Canavalia (*Canavalia ensiformes*), Crotalaria (*Crotalaria juncea*)] and they are not aware of the benefits and different uses that they can provide.

However, legumes play a fundamental role by virtue of their qualities and the diversity of benefits they offer at the level of the dietary system (Voisin *et al.*, 2014) [16] (pp. 361-380); for human and animal consumption, as a source of plant protein and with growing importance in the improvement of human health (Tharanathan *et al.*, 2003) [17] (pp. 507-518); at the level of production system; with biological fixation of atmospheric nitrogen, the mitigation of Greenhouse Effect Gases (GEGs) such as carbon dioxide (CO₂) and nitrous oxide (N₂O) (Lemke *et al.*, 2007; Reckling *et al.*, 2014) [18] (pp. 1719-1725) [19] (pp. 54-55); the emission of GEGs of around 5 to 7 times less per area unit compared to other crops (Jeuffroy *et al.*, 2013) [20] (pp. 1787-1797); improvements in the structure and organic matter of the soil (Hernanz *et al.*, 2009) [21] (pp.114-122); the mobilization of phosphorus (Shen *et al.*, 2011) [22] (pp. 997-1005); and the retention and availability of water in the soil (Angus *et al.*, 2015) [23] (pp. 523-552); and at the level of cultivation system as diversification crops in agroecosystems based on few principal species, breaking the pest cycles, and reducing the pressure from diseases and bad weeds (Robson *et al.*, 2002) [24] (pp. 369-427).

Among the most important criteria for the adoption of legumes in agricultural systems according to the analysis in 140 distinctive agricultural systems, which involve 41 species, there is the fact that the crop must have an additional use for the producer and not only weed control or green manure; in particular for human or animal diet (for example, gandúl bean, ayocote bean, year-round bean), the installation costs should not be high (being important that the same farmer grow his own seed); and the demand for work should be low (Bunch, 2004) [25] (pp. 11-12).

Some desirable characteristics in a legume would be: easy establishment, vigorous growth, capacity of covering weeds quickly, and also of fixing nitrogen or concentrating phosphorus, being resistant to insects, diseases, resistant to drought, having multiple uses, and producing viable seed for its future cultivation (Bunch, 2004) [25] (p. 13).

CONCLUSIONS

Although the sample that was considered for the study is small, it provides a representation of the knowledge and use of herbicides and legumes that producers have in three municipalities in the north of Veracruz, characterized mainly by belonging to the first ten most important producing municipalities of valencia orange.

It should be highlighted that citrus producers from the north of Veracruz, and probably producers from the country in general, do not know the terms glyphosate and legumes, and any official decree, research, specific action, etc., that is undertaken should use the words and concepts that are comprehensible for the people with whom they will work, interview or sensitize, so that there can be an impact or comply in the best way with the actions taken.

Likewise, it is important to clarify that from the agroecological point of view, the producers that are using herbicides (from small, medium, large scale, older and younger than 50 years old, and feminine and masculine) are not really aware of the damage that these cause to health and biodiversity, since they only center their attention on the results that are obtained in the short term, but not in the long term, where it has been proven that herbicides are affecting largely and strongly the natural cycles, from microorganisms, fauna and flora to human health. This confirms that the actions of the Presidential Decree from December 31, 2020, are correct, directed towards eradicating the use of glyphosate in Mexico in a transition period that ends on January 31, 2024.

Finally, it is necessary to emphasize that regardless of the number of hectares, of the age or of whether they are men or women, all the producers are interested in knowing and using legume plants and in this sense, it is fundamental to direct strategies that allow transferring the knowledge there is regarding these plants for the management of weeds by substituting the use of herbicides.

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