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RESEARCH ON WEED CONTROL IN ONION AND GARLIC CROPS

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Abstract

Onion and garlic crops are weeded by a wide range of weed species, including annual and perennial monocotyledonous and dicotyledonous. The application of herbicides is an economical, rapid measure, which allows the cultivation of large areas and the achievement of high production yields and increased economic efficiency. Three active substances with pre-emergence application (metolachlor, pendimethalin and oxyfluorfen) and various concentrations of oxyfluorfen with post-emergence application were tested. The results showed good control of annual monocotyledons with metolachlor and good control of annual dicotyledons with small seeds, with oxyfluorfen and pendimethalin. The post-emergence application of oxyfluorfen with various concentrations controlled annual cotyledons with large seeds (Xanthium sp. *and Abutilon theophrasti) but did not control perennial dicotyledonous species.*

Key words*: onion crop, garlic crop, herbicides.*

INTRODUCTION

In 2022, Romania was the 9th largest onion producer in the European Union and 62nd globally, with an area of 1,5670 hectares allocated to this crop, 6th in the European Union, after the Netherlands, Spain, Poland, France and Germany, and 42nd in the world. Productivity in Romania was 9,283.3 kg/ha, 24th in the European Union and 119th worldwide, half the global average of 18,536.5 kg/ha.(https://ro.wikipedia.org/wiki/Lista_țărilor_producătoare_de_ceapă).

In 2022, Romania cultivated garlic on an area of 5,200 hectares, the 2nd largest in the European Union, after Spain, and the 22nd in the world, being the 3rd producer in the European Union, after Spain and Italy, and the 33rd globally. Productivity in Romania was 4,326.9 kg/ha, 13th in the European Union and 81st worldwide, almost a quarter of the global average of 17,534.7 kg/ha. (https://ro.wikipedia.org/wiki/Lista_țărilor_producătoare_de_usturoi).

The herbicidal active ingredient of commercial herbicides and its transformations

All herbicide active ingredients contain an acidic group. In this state, the herbicide has an effect on the plant. When formulating the commercial substance, the herbicide that we buy, the active substance is chemically transformed by the manufacturer into an esterified form or in the form of a salt, by neutralizing the acidic group with an alcohol or a base. Depending on the resulting molecule, smaller or larger, the concentration of the active substance differs. When two commercial products with different active substances must be mixed in the machine tank, to be applied together, quantities of the active substance or quantities of the acidic part of the active substance are given. This substance is written on the product label with the chemical name or common name or both. The label also lists the chemically inert substance or substances present in the respective herbicide formulation. The acidic part of the active substance is the part of the molecule that is responsible for the herbicidal effect of the respective active substance. The molecule of the active substance formulated as an ester or salt penetrates the plant more easily, is more chemically stable and more easily crosses the waxy cuticle of the plant. This allows the herbicide to mix easily with water, with adjuvants, which increases the ability of the active substance to be absorbed and transported by the plant. Once inside the plant, the active substance loses the salt or ester, through enzymatic activity, the parent acidic part remains independent and manifests its herbicidal effect. So, after formulation as a salt or ester, the active substance will contain the parent acid moiety, responsible for the herbicidal effect, and the salt or ester added to the active substance for the benefits mentioned above. The mass of the active substance molecule can therefore vary depending on the salt or ester added. This does not improve the performance of the active substance because, after the loss of the salt or ester, the same parent acid moiety will act as herbicide. This is called the acid equivalent of the active substance, i.e. the parent acid moiety, regardless of which molecule is added (Dobre M., 2019).

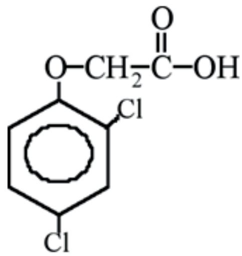

Figure 1. The parental acidic part of the active ingredient 2,4 dicolorophenoxiacid (Dobre M., 2019)

This can react with an alcohol, a base or ammonia, forming the commercial active substance, which is formulated as an ester, sodium salt or ammonium salt.

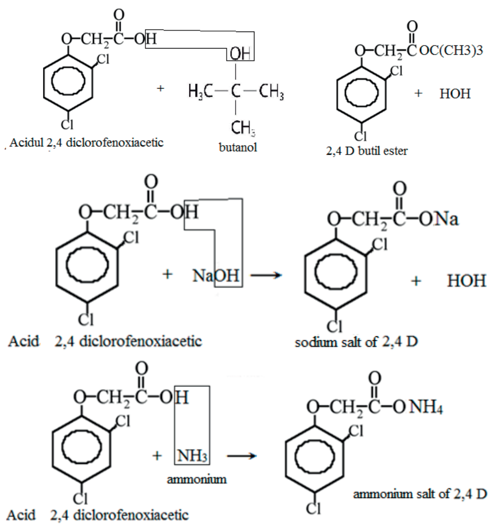

Figure 2. The active herbicidal ingredients after neutralization by an alcohol, base or ammonium (Dobre M., 2019)

Absorption of herbicides through leaves

Before exerting its herbicidal effect, any substance must first enter the leaf. To do this, it must penetrate the leaf cuticle, which is the skin that covers the leaves. This is a covering that is not made up of living cells but is composed of a layer of hydrophobic and lipophilic wax, cutin and pectin which are hydrophilic. The cuticle can be likened to a sponge where the ribs are made up of cutin and what is between them is wax. On the surface there is a layer of epicuticular wax. The cuticle differs greatly with the plant species. The absorption of herbicides in the plant is usually a passive phenomenon, based on diffusion, however, for certain active substances biochemically close to metabolic molecules, the absorption is done actively, with energy consumption, because the plant recognizes these substances as being close to those used in its metabolism. These substances are 2,4 D acid, recognized as an auxin, a growth hormone, glyphosate, recognized by the phosphate group (glyc comes from glycine, an amino acid, and phosate from phosphonate) and paraquat, recognized by putrescein, an amino acid derivative. Lipophilic herbicides are absorbed through the cuticular wax, passing easily through the wax with which the cuticle is impregnated, wax that is located between the cutin and pectin veins. Over time, the cuticle becomes more hydrophilic and the movement of lipophilic herbicides slows down. The initial absorption into the cuticular wax can represent a large percentage of the amount of lipophilic herbicide absorbed by the leaf. Furthermore, lipophilic herbicides may have difficulty passing through the cuticle into the epidermal cell layer of the leaf. A certain amount of these lipophilic herbicides can be retained by the cytoplasmic membrane (formed by two lipid layers with a double character, hydrophilic and lipophilic). For example, the herbicide Fusilade, formulated as an ester, is quickly absorbed by the cuticle. Once inside the plant, the active substance returns to its original components: the acid part, the true herbicidal component, and the alcohol. Formulating herbicides as esters is an advantage from this point of view, because they are absorbed more quickly through the wax layer of the cuticle.

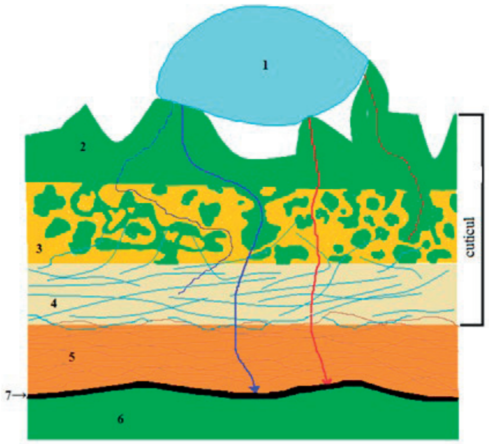

Figure 3. Differential penetration of hydrophilic (polar) and lipophilic (non-polar) herbicides through the leaf cuticle and cell wall, to the cytoplasmic membrane: 1 - spray droplet on the leaf; 2 - wax layer; 3 - cutin; 4 - pectin; 5 - cellulose cell wall; 6 - cell cytoplasm; 7 - cytoplasmic membrane

Hydrophilic herbicides, on the other hand, are more difficult to absorb through the cuticular layer, but their absorption can be improved by adding surfactants or liquid fertilizers to dissolve the wax on the leaf surface and to increase the time the spray droplet remains liquid on the leaf. Hydrophilic herbicides are absorbed through cutin and pectin, not through the cuticular wax. The absorption of these herbicides increases if they touch the pectin layer, hydrophilic, or the cell wall of the leaf epidermis. The next barrier, for some hydrophilic herbicides, can even be the cytoplasmic membrane due to its dual character, hydrophilic and lipophilic. In particular, herbicides that have the COOH group that gives the weak acidic character of the active substance, go from hydrophilic to lipophilic, and in this way, pass more easily through the cytoplasmic membrane. This phenomenon is called "ion capture" or "acid capture" and occurs depending on pH, especially in the case of weakly acidic active substances, which have a carboxylic group. The phenomenon occurs when UAN (ammonium nitrate mixed with urea – urea ammonium nitrate) or ammonium sulfate (AS) is added to the spray solution of hydrophilic herbicides, in solution form. Thus, the ammonium ion, NH4+, (which is actively absorbed, with energy consumption in the cell from the cell wall, through the cytoplasmic membrane) increases its concentration in the cytoplasm. Here, it separates into ammonia, NH3, and a hydrogen ion, H+. These ions lower the pH of the cytoplasm, but since it must remain between 7.5 and 8 units, the cell removes the excess hydrogen ions from the cytoplasm and pushes them into the cell wall, where the herbicide is. Under these conditions, the pH of the cell wall can even reach 4.5. Under conditions of high acidity, part of the herbicide passes from the hydrophilic to the lipophilic form, which we have shown above (http://www.ewrs.org/et/docs/herbicide_interaction.pdf)

An example of a hydrophilic herbicide is the well-known glyphosate which, although highly soluble in water, easily passes through the cuticle, being absorbed into the leaf up to 80%. This is possible, on the one hand, due to the hydrophilic paths of the cuticle and the use of surfactants. Also, environmental conditions can have a great impact on the absorption of hydrophilic herbicides, compared to lipophilic ones. The water content of the cuticle is lower in conditions of low relative air humidity or in drought conditions, which causes the waxy portions of the cuticle to be closer together, therefore, reducing the areas of cutin and pectin, which are hydrophilic. This determines a weaker absorption of hydrophilic herbicides (Dobre M., 2019).

The parameters pKa and lg Kow and their importance in the translocation of herbicides in the plant

The three barriers that herbicides applied to leaves must pass through are: the cuticle, the cell wall and the cytoplasmic membrane. After passing the cuticle barrier, the herbicide must enter the cytoplasm of the cell to have its effect. The state in which the active substance is in the cell wall, next to the cytoplasmic membrane is very important in the perspective of passing through it. In this position, the herbicide reaches the point where the polar (hydrophilic) and non-polar (lipophilic) forms reach equilibrium. This means that half of the molecules dissociate, giving rise to positive and negative ions and the other half remains undissociated, remaining in the lipophilic, non-polar state. This situation occurs at a certain pH, called pKa. If this pH point is within physiological limits, i.e. between 3.5 and 5.5, then translocation through living cells, the plant's phloem, occurs and is enhanced by the ion capture phenomenon described above. In summary, this phenomenon consists of increasing the acidity of the cytoplasm by migrating acid ions and "pumping" them back into the cell wall because the pH of the cytoplasm must remain alkaline, between 7.5 and 8.0. The more acidic environment produced in the cell wall, where the herbicide is found, determines the passage of a larger amount into the lipophilic, non-polar, non-ionic form, which more easily penetrates the cytoplasmic membrane. The alkaline environment of the cytoplasm transforms the active substance, again, into the acidic, hydrophilic form, the form in which it is metabolically active, manifesting its herbicidal effect. This phenomenon occurs, in particular, in the case of active substances with the carboxylic acid group, COOH, which determines a weaker acidity. Another approach to polar, hydrophilic and non-polar, lipophilic forms is through lg Kow. This parameter represents the ratio between these two forms, that is, between the octanol-soluble form and the water-soluble form, o comes from octanol and w from water. If the ratio between the lipophilic and hydrophilic forms is 10/1, it means that for every 10 lipophilic molecules there is only one hydrophilic one. To make the expression easier, the logarithm function was used. This represents the power to which the base must be raised to give the number from the logarithm. For example, the decimal log (lg) of 10/1 is 1, that is, the power to which the base (10) must be raised to give 10/1. In the same way, the log of 100/1 is equal to 2 and the log of 100,000/1=105, that is, it is equal to 5. If the hydrophilic form predominates, the ratio between them will be 1/10 and the log of 1/10 (10^{-1}) will be -1, and so on. If the two forms are in equilibrium, the ratio will be 1/1=1. The log of 1 is zero, that is, the power to which the base (10) must be raised to give 1 (any number to the power of zero is equal to 1, thus, 100=1). The lower this ratio, the more soluble in water the active substance is, therefore, the more hydrophilic. This influences the penetration of the cytoplasmic membrane, which is a lyophilic double layer on the inside. Active substances with a high lg Kow ratio are more lipophilic and penetrate the cytoplasmic membrane more easily, penetrating the cell more easily. This parameter varies between -1 and 5. Active substances with lg Kow between -1 and 1 are more hydrophilic and penetrate the cell more difficultly. Those with lg Kow between 1 and 3 penetrate more easily, those with lg Kow = 4 are more lipophilic and part of the active substance returns to the cell wall and those with lg Kow = 5 remain trapped inside the cytoplasmic membrane, between its internal lipophilic layers because they are very lipophilic, non-polar.

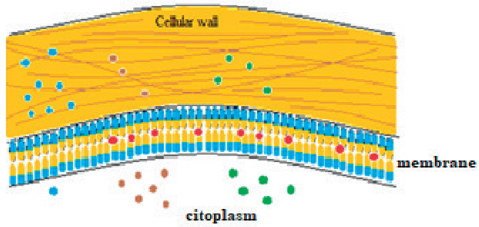

Figure 4. Penetration of herbicide active substances through the cytoplasmic membrane into the cell, depending on the lg Kow parameter

This is very important because active substances with high lg Kow, close to 5, remain trapped in the membrane, do not translocate and only affect the tissues where they entered.

Table 1. The lg Kow and pKa values for some herbicide active ingredients

Active ingredient	Lg Kow	pKa
Aminopiralid	- 2.87	2.56 (high acid)
Azimsulfuron	-1.40	3.6 (low acid)
Bentazon	-0.45	3.28 (low acid)
Bromoxinil	2.70	3.86 (low acid)
Cletodim	4.21	4.47 (low acid)
Clopiralid	-2.63	2.01 (high acid)
Dicamba	-1.88	1.77 (high acid)
Dimetenamid	2.20	Does not dissociate
Etofumesat	2.70	Does not dissociate
Flumioxazin	2.55	Does not dissociate
Fluroxipir	0.04	2.94 (strong acid)
Glifosat	-3.20	2.34 (strong acid)
Glufosinat	-3.96	2.0 (strong acid)
Imazamox	5.36	2.3 (strong acid)
Isoxaflutol	2.32	Does not dissociate
Linuron	3.00	Does not dissociate
MCPA (Mono Cloro Phenoxi Acid)	-0.81	3.73 (weak acid)
2,4 D	-0.82	3.40 (strong acid)
Metribuzin	1.65	0.99 (very strong acid)
Metolaclor	3.40	Does not dissociate
Napropamid	3.30	Does not dissociate
Nicosulfuron	0.61	4.78 (weak acid)
Oxifluorfen	4.86	Does not dissociate
Pendimetalin	5.20	2.80 (strong acid)
Rimsulfuron	-1.46	4.00 (weak acid)

MATERIALS AND METHODS

The presentation of experimental conditions and the experimental purpose

Onion and garlic crops are weeded by a wide range of weed species, including annual and perennial monocotyledons and dicotyledons. In general, the weeding work applied to combat them is costly and the labor force is expensive and increasingly scarce. The application of herbicides is an economical, fast measure, which allows the cultivation of large areas and the achievement of high production yields and increased economic efficiency. It is known that onions are resistant even to high doses of oxyfluorfen, however, the herbicide leaflet does not provide accurate information on the concentration of the herbicide in water when used on vegetation for direct-sown onions, in the first phases, nor for garlic, on vegetation. Being a contact herbicide, in high concentration it can affect young direct-sown onion plants or garlic plants. Therefore, the aim of the experiment was to find a suitable concentration that would destroy weeds in the early vegetation phase, cotyledon or the first true leaves, but would not affect the crop plants.

The experiment was located at the Botanical Garden of the University of Craiova, at the Economic Sector. Three treatments were applied for direct-sown onion, onion planted from bulbs and garlic in three replications:

- V1 - Dual Gold (metolachlor) 1.2 liters/ha in 300 liters of water applied to the sown onion;
- V2 - Pendisol 40 SC (pendimethalin) 6 liters/ha in 300 liters of water for the sown onion;
- V3 - Galigan 240 EC (oxyfluorfen) 1 liter/ha in 300 liters of water for the sown onion;
- V4 - Dual Gold (metolachlor) 1.2 liters/ha in 300 liters of water for the onion planted from bulbs;
- V5 - Pendisol 40 SC (pendimethalin) 6 liters/ha in 300 liters of water for onion planted from bulbs;
- V6 EC (oxyfluorfen) 2 liters/ha in 300 liters of water for onion planted from bulbs;
- V7 - Dual Gold (metolachlor) 1.2 liters/ha in 300 liters of water applied to garlic;
- V8 - Pendisol 40 SC (pendimethalin) 6 liters/ha in 300 liters of water applied to garlic;
- V9 - Galigan 240 EC(oxyfluorfen) 2 liters/ha in 300 liters of water applied to garlic;
- V10 - untreated control.

The experiment had 3 x 10 m long furrows that were cultivated with sown onion, planted onion and garlic. Each 10 m furrow was divided into 10 plots of 1 m length. 4 rows were sown per furrow, 25 cm apart between rows. The surface of an experimental plot was 1 m long and 1 m wide = 1 sq m. On each plot, the calculated amount of herbicide + water mixture was applied, i.e. 100 ml of solution, applied to the three plots. These substances were applied to the soil. After the emergence of crops and weeds, 4 different concentrations of Galigan 240 EC in water were applied perpendicular to the three furrows (replications).

V1 = 33 ml Galigan 240 EC in 5 liters of water (2,000 ml in 300 liters of water/ha or 0.6%);
V2 = 7 ml Galigan 240 EC in 5 liters of water (420 ml in 300 liters of water/ha or 0.14%);
V3 = 5 ml Galigan 240 EC in 5 liters of water (300 ml in 300 liters of water/ha or 0.1%);
V4 = 5 ml Galigan 240 EC in 7 liters of water (215 ml in 300 liters of water/ha or 0.07%);
V5 = untreated control.

In order to control *Sorghum halepense* and *Cynodon dactylon*, Agil 1.2 l/ha (propaquizafop) was subsequently applied when these weeds reached approximately 15 cm in height, after these species had resumed growth, following treatment with oxyfluorfen which partially necrotized them.

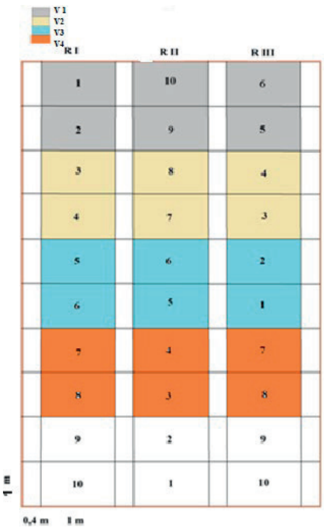

Figure 5. The experiment sketch

RESULTS AND DISCUSSIONS

a. **In the case of herbicides applied to the soil**

The results of the efficacy of the herbicides Dual Gold (metolachlor), Pendisol 40 SC (pendimethalin) and Galigan 240 EC (oxyfluorfen) as well as the phytotoxicity on sown onion, chive and garlic crops, assessed by EWRS scores are presented in the Table 2.

From these results we draw the following conclusions:

- The herbicide Dual Gold controls very well the annual monocotyledonous weeds, *Setaria glauca* and *Digitaria sanguinalis*, as well as the annual dicotyledons *Stellaria media*, *Amaranthus retroflexus* and *Galinsoga parviflora*. It controls approx. 80% on *Chenopodium album* (EWRS score 2) and does not control the annual dicotyledons with large seeds: *Xanthium strumarium*, *Xanthium spinosum*, *Abutilon theophrasti* and *Ambrosia artemisiifolia*. It does not control perennial weeds and does not have any effect on their inhibition;
- The herbicide Pendisol 40 SC has a similar effect to Dual Gold yet, in addition, it controls *Chenopodium album* and *Ambrosia artemisiifolia*;
- The herbicide Galigan 240 EC, at a dose of 1 l/ha, controls very well the annual dicotyledons with small seeds but has a weaker effect on the annual monocotyledons *Setaria glauca* and *Digitaria sanguinalis*. At a dose of 2 l/ha it has a radical effect. However, it does not control large-seeded dicotyledons either;
- No crop showed phytotoxicity phenomena with the applied herbicides and doses.

Oxyfluorfen, metolachlor and pendimethalin are also recommended by other research conducted in our country and abroad for controlling weeds in sown onion crops, onion planted from bulbs or garlic (https://content.ces.ncsu.edu/weed-management-in-onions
https://ipm.ucanr.edu/agriculture/onion-and-garlic/integrated-weed-management/#gsc.tab=0
https://www.canr.msu.edu/news/onion-weed-control-for-2019
https://www.dhanuka.com/blogs/post-emergence-herbicides-for-onion-crop
https://agrointel.ro/261308/ebicid-ceapa-cand-cu-ce-stropim
https://agro-bucuresti.ro/wp-content/uploads/2022/08/Agrotehnica_2001.pdf
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https://acad.ro/sectii2002/proceedingsChemistry/doc2014-1/art07Gidea.pdf; Rădoi V. et. al., 1995).

b. **In the case of the herbicide Galigan 240 EC applied in post-emergence in different concentrations**

The results are presented in the Table 3.

From these results we draw the following conclusions:

- The concentration of 33 ml Galigan 240 EC in 5 liters of water can only be applied to sown onions when they grow large leaves, like onion planted from bulbs that are covered with wax. Although the herbicide leaflet does not specify not to apply to sown onions, in young stages, we observed obvious phytotoxicity phenomena, namely the total necrosis of the seedlings.
- The concentration of 33 ml Galigan 240 EC in 5 liters of water cannot be applied to garlic, in any growth phase, because garlic does not have wax on its leaves, as onion, it has less wax and for this reason it cannot withstand this concentration;
- The other concentrations, of 7 ml in 5 liters of water, 5 ml in 5 liters of water and 5 ml in 7 liters of water can be applied to sown onion and garlic, in cotyledons phase of the weeds;
- The resistant weeds to all concentrations were those with hairs on the leaves, with velvety or waxy leaves, such as purslane, velvetleaf and ragweed which do not allow the herbicide to enter the leaf;
- Perennial weeds as *Cirsium*, *Convolvulus*, *Sorghum* and *Cynodon* recover after approx. 2 weeks while the onion or garlic grows and can withstand another herbicide. Perennial monocots are controlled by specific herbicides: Agil, Fusilade, etc.
- If the treatment with Galigan is done on mature weeds, over 15 cm high, even at a concentration of 33 ml in 5 l of water, they recover after approx. 10 days.

Table 2. Efficacy and selectivity of herbicides applied to sown onion, planted onion from chive and garlic crops, expressed by EWRS scores

Weed Bayer Code	Biological category	V1	V2	V3	V4	V5	V6	V7	V8	V9
CIRAR	p.d.	9	9	9	9	9	9	9	9	9
CONAR	p.d.	9	9	9	9	9	9	9	9	9
CHEAL	a.d.	2	1	1	2	1	0	2	1	0
STEME	a.d.	1	1	1	1	1	0	1	1	0
AMARE	a.d.	1	1	1	1	1	0	1	1	0
POROL	a.d.	1	1	1	1	1	0	1	1	0
GASPA	a.d.	1	1	1	1	1	0	1	1	0
ABUTH	a.d.	9	9	9	9	9	9	9	9	9
AMBEL	a.d.	9	2	1	9	2	1	9	2	1
XANST	a.d.	9	9	9	9	9	9	9	9	9
XANSP	a.d.	9	9	9	9	9	9	9	9	9
SORHA	p.m.	9	9	9	9	9	9	9	9	9
CYNDA	p.m.	9	9	9	9	9	9	9	9	9
SETLU	a.m.	0	0	3	0	0	2	0	0	2
DIGSA	a.m.	0	0	3	0	0	2	0	0	2
Phytotoxicity		0	0	1	0	0	0	0	0	0

Legend: p.d. - perennial dicot; a.d. - annual dicot; p.m. - perennial monocot; a.m. - annual monocot. CIRAR - *Cirsium arvense*; CONAR - *Convolvulus arvensis*; CHEAL - *Chenopodium album*; STEME - *Stellaria media*; AMARE - *Amaranthus retroflexus*; POROL - *Portulaca oleracaea*; GASPA - *Galinsoga parviflora*; ABUTH - *Abutilon theophrasti*; AMBEL - *Ambrozia artemisiifolia*; XANST - *Xanthium strumarium*; XANSP - *Xanthium spinosum*; SORHA - *Sorghum halepnse*; CYNDA - *Cynodon dactylon*; SETLU - *Setaria glauca*; DIGSA - *Digitaria sanguinalis*.
EWRS scale for herbicide efficacy: (0-2 = control accepted as efficacy; 2-10, control not accepted as efficacy). For phytotoxicity on the crop: 0-2 low damage accepted; 2-10 strong damage, not accepted.

Table 3. Efficacy and selectivity of the herbicide Galigan 240 EC applied in 4 concentrations, on sown onion, onion planted from bulbs and garlic crops, expressed by EWRS scores

Weed Bayer Code	Biological category	V1		V2		V3		V4	
		3-4 leaves of the crop	8-10 leaves of the crop	3-4 leaves of the crop	8-10 leaves of the crop	3-4 leaves of the crop	8-10 leaves of the crop	3-4 leaves of the crop	8-10 leaves of the crop
CIRAR	p.d.	1	1	1	1	1	2	1	2
CONAR	p.d.	1	1	1	1	1	2	1	2
CHEAL	a.d.	1	1	1	1	1	2	1	2
STEME	a.d.	1	1	1	1	1	2	1	2
AMARE	a.d.	1	1	1	1	1	2	1	2
POROL	a.d.	3	5	4	6	4	6	6	7
GASPA	a.d.	1	1	1	1	1	2	1	2
ABUTH	a.d.	3	5	4	6	4	6	6	7
AMBEL	a.d.	1	1	1	1	1	2	1	2
XANST	a.d.	1	1	1	1	1	2	1	2
XANSP	a.d.	1	1	1	1	1	2	1	2
SORHA	p.m.	1	1	1	1	1	2	1	2
CYNDA	p.m.	3	5	4	6	4	6	6	7
SETLU	a.m.	1	1	1	1	1	2	1	2
DIGSA	a.m.	1	1	1	1	1	2	1	2
Phytotoxicity on sown onion		9	7	3	4	2	2	1	1
Phytotoxicity on onion planted from bulbs		3	2	1	1	1	1	1	1
Phytotoxicity on garlic		7	5	2	2	1	1	1	1

Legend: p.d. - perennial dicot; a.d. - annual dicot; p.m. - perennial monocot; a.m. - annual monocot. CIRAR - *Cirsium arvense*; CONAR - *Convolvulus arvensis*; CHEAL - *Chenopodium album*; STEME - *Stellaria media*; AMARE - *Amaranthus retroflexus*; POROL - *Portulaca oleracaea*; GASPA - *Galinsoga parviflora*; ABUTH - *Abutilon theophrasti*; AMBEL - *Ambrozia artemisiifolia*; XANST - Xanthium strumarium; XANSP - *Xanthium spinosum*; SORHA - *Sorghum halepnse*; CYNDA - *Cynodon dactylon*; SETLU - *Setaria glauca*; DIGSA - *Digitaria sanguinalis*.
EWRS scale for herbicide efficacy: (0-2 = control accepted as efficacy; 2-10, control not accepted as efficacy). For phytotoxicity on the crop: 0-2 low damage accepted; 2-10 strong damage, not accepted.

CONCLUSIONS

Onion and garlic cultivation requires weed control with herbicides to ensure economic efficiency. Three herbicide active ingredients were tested with pre-emergence application and four concentrations of oxyfluorfen in post-emergence. The herbicides tested after sowing or planting onion and garlic were: Dual Gold (metolachlor), Pendisol 40 SC (pendimethalin) and Galigan 240 EC (oxyfluorfen).

Regarding the application of the three herbicides to the three crops, it was observed that the herbicides Dual Gold and Pendisol 40 SC control very well annual monocotyledonous and annual dicotyledonous weeds with small seeds, such as *Setaria glauca*, *Stellaria media*, *Amaranthus retroflexus*, *Galinsoga parviflora* or *Portulaca oleracaea*. Weeds with large seeds, such as *Abutilon theophrasti*, *Xanthium strumarium* and *Ambrosia artemisiifolia* are not controlled by the Dual Gold and Galigan 240 EC treatments, but the herbicide Pendisol 40 SC controls the species *Ambrosia artemisiifolia* as well as *Chenopodium album*, compared to the Dual Gold herbicide. The herbicide Galigan 240 EC does not control annual monocotyledonous weeds. No herbicide applied to the soil controls perennial monocotyledonous or dicotyledonous weeds.

Regarding post-emergence treatments, it was observed that both sown onion and garlic do not tolerate the application of a concentration of 33 ml Galigan 240 EC in 5 liters of water (0.6%) or 2 liters of herbicide in 300 liters of water per hectare. This is not mentioned in the leaflet info of this herbicide.

The other oxyfluorfen concentration treatments must be applied when the weeds are young, small, otherwise they will regenerate their leaves in about 10 days.

The resistant weeds to all concentrations were those with hairs on the leaves, with velvety or waxy leaves, such as purslane, velvetleaf and ragweed which do not allow the herbicide to enter the leaf.

Perennial weeds as *Cirsium*, *Convolvulus*, *Sorghum* and *Cynodon* recover after approx. 2 weeks while the onion or garlic grows and can withstand another herbicide. Perennial monocots are controlled by specific herbicides: Agil, Fusilade, etc.

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