Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

# THE CONTROL OF WEEDS IN MAIZE USING NEW HERBICIDES FORMULATIONS

**Călin SĂLCEANU[1], Mirela PARASCHIVU[1], Mihaela CERGAN[2], Elena PARTAL[2], Aurel Liviu OLARU[1], Otilia COTUNA[3]**

[1]University of Craiova, Faculty of Agronomy, 19 Libertăţii Street, Craiova, Dolj, Romania,
[2]National Agricultural Research and Development Institute Fundulea,
1 Nicolae Titulescu Street, 915200, Fundulea, Călăraşi, Romania
[3]University of Life Sciences "King Mihai I" from Timişoara,
119 Calea Aradului Street, Timişoara, Romania

Corresponding author email: paraschivumirela@yahoo.com

***Abstract***

*Worldwide grain yield in maize may be severely impacted by competition with weeds. To evaluate the efficacy of novel herbicide formulations for weed control in maize, a randomized complete block design trial comprising three replications and seven treatments was carried out at the experimental field of the Agricultural and Research Station Caracal in 2023 year. All of the treatments, which were made up of separate and related herbicides, were considered to be selective in maize after emergence (POST). Their effectiveness was evaluated at 7, 14, 21, and 28 days after each treatment targeting the most common weeds, such as HIBTR, DIGSA, SOLNI, ATRPL, AMARE, CONAR, POROL, XANTIST, CIRAR. The findings indicated that of the herbicidal treatments, the best efficacy was recorded by Click Trio (2 L/ha) with efficacy between 80-100% even at 7 days after treatment for most of the targeted weeds. Also, a good control of targeted weeds from maize crop was done by Pyxides WG 562.5 g/kg + Adigor ADJ and the combination SAE 0.53 H/01+ Baracuda controlled weeds 100% especially at 14, 21 and 28 days after treatment, excepting Convolvulus arvensis (CONAR), Hibiscus trionum (HIBTR).*

***Key words**: weeds, new herbicides, Zea mays L., efficacy, control.*

## INTRODUCTION

Worldwide, climate changes directly affect the production of food and natural vegetation features, having costs consequences (Feng et al., 2020; Li et al., 2011; Păunescu et al., 2022; Răduţoiu and Băloniu, 2021; Răduţoiu, 2022; Răduţoiu and Stan, 2022; Răduţoiu and Ștefănescu, 2022; Răduţoiu, 2023; Velea et al., 2021; Wolf and Van Diepen, 1995).
As the global population explosion progresses, more food, energy and goods are needed (Bonciu, 2023). Today, maize is considered one of the most important crops for food, fodder, and industry, therefore it is cropped for grain, seeds, green feed, silage and biofuel (ethanol) (Millet et al., 2019; Smith et al., 2004; Veljković et al., 2018). Moreover, maize is so versatile cereal crops that can adapt widely to a variety of agroclimatic conditions (Borleanu et al., 2012; Fun et al., 2007; Kumar et al., 2018; Partal et al., 2012a, 2012b). Despite its versatility, the biotic and abiotic stress factors suppress the growth and performance of maize reducing yield and crop productivity. Thus, the main goal of agricultural research is to produce more food with less resources using breeding and bioengineering by including genes for resistance to herbicides, diseases, drought, etc. in plants genome, aside to alternative cropping methods that could increase the yield and quality of agricultural products (Alkan et al., 2022; Bonciu et al., 2021; De Souza and Bonciu, 2022; Lipianu et al., 2023; Paraschivu et al., 2022; Partal and Paraschivu, 2020; Păunescu et al., 2021; Sălceanu et al., 2022).
Globally, weeds are considered one of the most important biotic constrainers due to their competition for light, water and nutrients in maize fields (Gharde et al., 2018). Various studies have previously emphasized the negative effects of annual and perennial weed species on maize yield in the field, with global losses ranging from 28 to 100% of total maize production worldwide, depending on the composition of geographic locations, the weed

composition and each specie density and intensity and the stage of maize crop development (Brankov et al., 2021; Idziak et al., 2022; Imoloame and Omolaiye, 2016; Jagadish et al., 2016; Mhlanga et al., 2016; Samant et al., 2015; Sharma and Rayamajhi, 2022; Soare et al., 2010a; Tesfay et al., 2014; Zhang et al., 2013).

Worldwide, the main obstacle to increasing maize yield has to do with managing and controlling weed development. Because of their quick outcomes, easy application, low cost, and reduced labor requirements, herbicides are absolutely essentially as a necessary component of maize technology (Idziak et al., 2022; Qu et al., 2021; Sharma & Rayamajhi, 2022).

In practice, farmers heavily apply herbicides both before and after the emergence of maize fields. Pre-emergence herbicides have a 40-50 day half-life in the soil, however post-emergence foliar spray is necessary to control secondary weed infestation (Delchev, 2021). To acquire the targeted results from herbicides application, the proper herbicide must be used at the right time and dosage. However, weeds will be more affected when pre-emergence and post-emergence herbicides are used in tandem to target both annual and perennial weeds (Idziak et al., 2022).

As part of an integrated weed management approach, herbicides will continue to be considered a valuable tool in agriculture for weed control in the future.

The current study's goal was to assess the efficacy and selectivity of new herbicide formulations for managing weeds in maize using various bioactive components under natural settings from ARDS Caracal, Romania.

## MATERIALS AND METHODS

In 2023 year, an experimental trail was conducted at the University of Craiova, Romania's Agricultural Research Station Caracal (ARDS) (44°11'N and 24°37'E) to assess the relative effectiveness on weed control in maize of new herbicide formulations combined with various bioactive ingredients. Split plots with three replicates were used for the trial, which was set up in a randomized full block (RCBD-Fisher model). Every trial plot was 25 m² in size. Standard recommended cultural methods were used, including two disc harrowings and two cultivations procedures prior to sowing, as well as fertilization with 250 kg ha-1 NPK 15:15:15 and spring top-coat fertilization with 200 kilogram/ha NH4NO3.

All of the treatments, which consisted of separate and related herbicides, were considered to be selective when applied to maize by post-emergence (POST) moments.

The following treatments were used in the experiment:

V1. Untreated - control;

V2. Principal Forte WG 606 g/kg (62.475 g nicosulfuron + 31.25 g rimsulfuron + 510.42 g dicamba + 31.25 g Isoxadifen) – 0.48 kg/ha;

V3. Click Trio EC 490 g/l (75 g mesotrione + 375 g terbutilazin + 40 g clomazona) – 2 kg/ha;

V4. Click Pro EC 376 g/l (50 g mesotrione + 326 g terbutilazin) – 2.3 kg/ha;

V5.Pyxides WG 562.5 g/kg + Adigor ADJ (312.5 g dicamba + 150 g mesotrione + 100 g nicosulfuron + 47% rapeseed methylate oil ) – 0.4 kg/ha + 1 l/ha;

V6. SAE 053 H/01 + Nico 40 OD (80 mesotrione +30 nicosulfuron + 40 nicosulfuron) – 1.2 l/ha + 0.5 l/ha;

V7. SAE 053 H/01 + Baracuda (80 mesotrione +30 nicosulfuron + 100 g mesotrione) – 1.2 l/ha + 0.5 l/ha;

According with the recommendations the herbicides Click Pro and Click Trio were sprayed post-emergent in BBCH 12-14, when maize had 2-4 leaves, while the herbicides Principal Forte, Pyxides+ Adigor, SAE 053 H/01 + Nico 40 OD, SAE 053 H/01 + Baracuda were applied post-emergent in BBCH 14-16 when maize had 4-6 leaves. There were used 400 l/ha solution applied using a back sprayer equipped with fan nozzles, a gasoline engine, and a 25 L tank. Weed species and densities were assessed before the trials were set up. The weed species, development stages, and quantity of each weed species in the covered area ($m^2$) were realized using a 1 $m^2$ frame in the trial area randomly replaced.

Therefore, prior to spraying, the following species were the focus of the initial assessment of the weed spectrum: *Hibiscus trionum* (HIBTR), *Digitaria sanguinalis* (DIGSA), *Solanum nigrum* (SOLNI), *Atriplex patula* (ATRPL), *Convolvulus arvensis* (CONAR), *Portulaca oleracea* (POROL), *Xantium strumarium* (XANTIST), and *Amaranthus retroflexus* (AMARE), *Cirsium arvense* (CIRAR).

The critical period of crop-weed competition is determined by the density and periodicity of weed population emergence. Consequently, the following formula was used to determine each species' densities:

$$\text{Density (plants/m}^2\text{)} = B/m,$$

where "m" stands for the total number of meters and "B" for the total number of individual plants in the samples (Odum and Barrett, 1971).

Additionally, the species density was calculated using the scale proposed by Üstüner and Güncan (2002) (Table 1).

Table 1. The scale used for assess weeds density

| Scale | Density level | Density (plants/m$^2$) |
|---|---|---|
| A | High dense | 10+ |
| B | Dense | 1-10 |
| C | Middle dense | 0.1-1 |
| D | Low dense | 0.01-1 |
| E | Rare | Less than 0.01 |

At four regular intervals of on the 7$^{th}$, 14$^{th}$, 21$^{th}$ and on the 28$^{th}$ day after spraying was made the assessment of herbicides efficacy on weed population and weed species. For each assessment was calculated the percentage decrease in the weed population by comparing the treated plots with the weedy control plot. The phenology of the weeds and their impacts are detailed in each evaluation.

The impacts on weeds at the species level and the effects on all weeds were calculated using the Abbott formula (Snedecor et al., 1967):

$$HPE = (CWN - TWN) \times 100/CWN$$

Where: "HPE" indicates Herbicide Percentage Effect, "CWN" indicates Number of Weeds in Control, "TWN" indicates Number of Weeds in Treatments.

The 9-score EWRS scale, as outlined by Zhelyazkov et al. (2017), was used to assess the herbicides' selectivity (score 0 indicates there are not damages on the crop, and score 9 indicates the crop is fully damaged). ANOVA and the mathematical features of Microsoft Office Excel 2013 were used to conduct a statistical analysis of the data that was gathered. Also, the Newman-Keuls complementary test for multiple comparisons was used for significant statistical differences ($p<0.05$).

## RESULTS AND DISCUSSIONS

All over the world weeds have been showed their unfavorable impact on maize plants development in terms of their competition for light, water and nutrients with negative consequences on grain yield (Acharya et al., 2022; Reddy et al., 2022; Sharma and Rayamajhi, 2022). Therefore, a good strategy to reduce the negative consequences of weeds on maize output is to combine all mechanical, chemical, and cultural control strategies into a Weeds Integrated Management System.

The expected effect of the herbicides sprayed throughout the trial was different depending on the weed species and the herbicide's active components. A large amount of weeds will be damaged when pre-emergence and post-emergence herbicides are used together to target both annual and perennial weeds. Furthermore, the efficacy of herbicides differed depending on the evaluation periods. Also, the effectiveness and selectivity of herbicides in maize have been the subject of numerous prior research (Alptekin et al., 2023; Brankov et al., 2021; Grzanka et al., 2022; Iqbal et al., 2020; Jagła et al., 2020; Sairam et al., 2023; Sălceanu et al., 2024; Soare et al, 2010b).

However, weeds may develop a resistance problem if a single herbicide or herbicides with the same mechanism of action are used continuously. As a result, new herbicides are required to manage the mixed weed flora in maize. Thus, the use of these new realised dual purposes herbicides offers the opportunity for a new mode of action for weed management in maize, especially on grasses, broadleaved weeds and rhizomatous perennial temperate weeds (Kakade et al., 2020; Şerban et al., 2021). They initially impact meristemic tissues, whose growth stops shortly after spraying, quickly developing chlorosis and necrosis and it takes an additional three to four weeks for the mature plant portions to dieback. One of the most important advantages of these new dual purposes herbicides is that they act at very low dose reducing the environmental concern, which is a very important issue currently. The most common weed species in maize crops are: monocotyledons (*Setaria* sp., *Echinochloa crusgalli*, , *Elymus repens*, *Sorghum halepense* (seed and rhizomes), *Eriochloa villosa* and dicotyledons: *Amaranthus retroflexus*, *Solanum nigrum*, *Raphanus raphanistrum*, *Thlaspi arvensis*, *Datura stramonium*, *Cirsium arvense*, *Convolvulus arvensis*, *Chenopodium album*, *Sinapis arvensis*, *Stellaria media*, *Hibiscus trionum*, *Abutilon theophrasti*, *Sonchus arvensis* (Popescu et al, 2009).With a mono-to-dicotyledonous weed ratio of 6:94, the complex weed structure in the maize field trail at ARDS Caracal resulted in a 97% infestation degree.

The assessment results showed that depending on the previous crop and pedo-climatic conditions, the highest percentage of the weeds were dicotyledonous plants either annual or perennial. Among annual monocotyledonous only *Digitaria sanguinalis* (DIGSA) (6%) was present, while no perennial monocotyledonous was noticed. Among annual dicotyledonous different percentages were assessed depending on weed species, such as *Solanum nigrum* (SOLNI) – 49%, *Atriplex patula* (ATRPL) – 22%, *Portulaca oleracea* (POROL) – 16%, *Hibiscus trionum* (HIBTR) – 3%, *Xantium strumarium* (XANTIST) – 1%, *Amaranthus retroflexus* (AMARE) – 0%, while among perennial dicotyledonous only *Convolvulus arvensis* (CONAR) recorded 4% and *Cirsium arvense* (CIRAR) 0% (Figure 1).

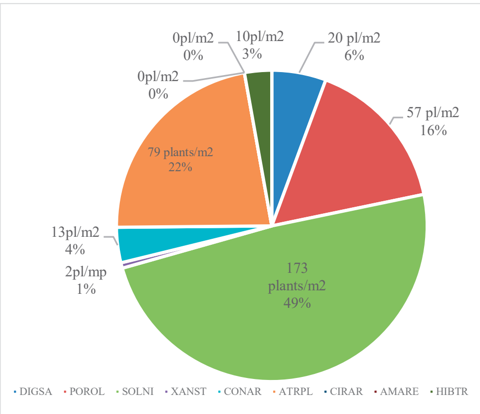


Figure 1. The weed species assessed in maize crop in 2023 year in ARDS Caracal

The highest density of weed species were found as *Solanum nigrum* (SOLNI) (49%), *Atriplex patula* (ATRPL) (22%) and *Portulaca oleracea* (POROL) (16%). Using the scale proposed by Üstüner and Güncan (2002) in the weeds evaluation it was noticed that weed density (weeds/m$^2$) varied between Dense (B) and High-Dense (A).

It was noticed that excepting the variant 3 (Click Trio Ec 490 g/l (75 g mesotrione + 375 g terbutilazin + 40 g clomazona – 2 kg/ha - B), targeted weeds density was high (A) for all variants at 7 days after treatments application. When the herbicides Click Trio Ec 490 g/l (75 g mesotrione + 375 g terbutilazin + 40 g clomazona – 2 kg/ha), Click Pro Ec 376 g/l (50 g mesotrione + 326 g terbutilazin – 2.3 kg/ha), Pyxides WG 562.5 g/kg + Adigor ADJ (312.5 g dicamba + 150 g mesotrione + 100 g nicosulfuron + 47% rapeseed methylate oil –0.4 kg/ha + 1l/ha) and SAE 053 H/01 + Nico 40 OD (80 mesotrione +30 nicosulfuron + 40 nicosulfuron – 1.2 l/ha + 0.5 l/ha) were applied it was noticed a lower weeds density (B) at 14 days after treatments. When the herbicide Principal Forte WG 606 g/kg (62.475 g nicosulfuron + 31.25 g rimsulfuron + 510.42 g dicamba + 31.25 g Isoxadifen – 0.48 g/ha) was applied it was observed that at 21 days after treatment weeds density was diminished for all targeted weeds, but still high for variant 2, comparatively with the control (V1).

At 28 days after treatments the weeds density decreased for all treated variants (B) and all herbicides formulations showed high efficacy comparatively with the untreated control variant for both annual and perennial weed species (Figure 2).

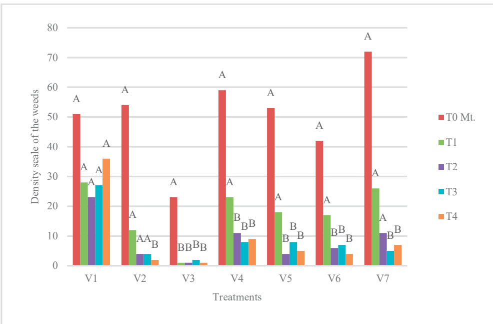


Figure 2. The impact of herbicides on weeds density at 7, 14, 21 and 28 days after treatment

In accordance with selectivity, application and evaluation timing, weed stage, infestation level, and climate, the herbicides' efficacy (HPE, or Herbicide Percentage Effect) varied from 0% to 100%.
Figure 3 shows the average efficacy results (%) noticed in weeds density after the application of Principal Forte WG 606 g/kg (62.475 g nicosulfuron + 31.25 g rimsulfuron + 510.42 g dicamba + 31.25 g Isoxadifen) – 0.48 g/ha (V2).

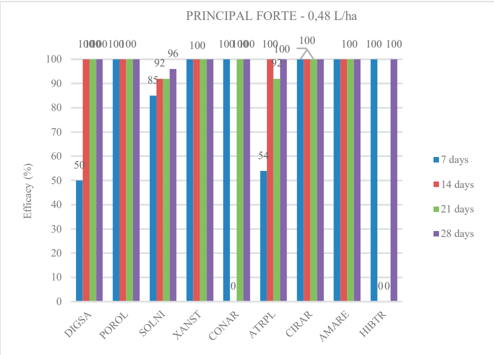


Figure 3. The Efficacy (%) at 7, 14, 21, 28 days after treatment with Principal Forte WG 606 postemergently applied at the stage BBCH 14-16

It was noticed a good efficacy of 85-100% at 14, 21 and 21 days after treatments in controlling annual dicotyledons (*Portulaca oleracea* (POROL), *Xantium strumarium* (XANTIST), *Amaranthus retroflexus* (AMARE), *Solanum nigrum* (SOLNI), *Atriplex patula* (ATRPL) and perennial dicotyledons *Cirsium arvense* (CIRAR), while the lowest efficacy (50%) was observed in the annual monocotyledons *Digitaria sanguinalis* (DIGSA).
The best effect in controlling weeds (100%) at 7 days after treatment was noticed when the herbicide Click Trio EC 490 g/l (75 g mesotrione + 375 g terbutilazin + 40 g clomazona) – 2 kg/ha was applied, excepting the annual monocotyledons *Digitaria sanguinalis* (DIGSA) in which case the herbicide efficacy was 67% at 7 and 14 days after spraying. Even al 14 days after treatment the herbicide efficacy Was 100% for all weeds targeted, excepting annual dicotyledons (*Portulaca oleracea* (POROL), in which case was of 80%.
At 21 and 28 days after treatment the herbicide efficacy was 100% excepting *Convolvulus arvensis* (CONAR – 50% efficacy) (Figure 4). Click Trio EC 490 g/l it contains three active substances (mesotrione + 375 g terbutilazin + 40 g clomazona) that have systemic and residual action high selectivity due to the controlled release of clomazone.


Figure 4. The Efficacy (%) at 7, 14, 21, 28 days after treatment with Click Trio EC 490 g/l postemergently applied at the stage BBCH 12-14

The results emphasized that efficacy ranged between 0% to 100% when the herbicide Click Pro EC 376 g/l (50 g mesotrione + 326 g terbutilazin) – 2.3 kg/ha was applied (Figure 5) depending on the assessment moment. Thus, at 7 and 28 days after treatment the control of *Convolvulus arvensis* (CONAR) and *Hibiscus trionum* (HIBTR) was 0%.

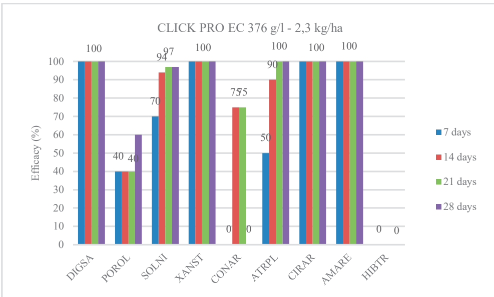


Figure 5. The Efficacy (%) at 7, 14, 21, 28 days after treatment with Click Pro EC 376 g/l applied postemergently at the stage BBCH 12-14

Among all targeted weeds only *Hibiscus trionum* (HIBTR) had no response to Click Pro EC 376 treatment, while for controlling *Convolvulus arvensis* (CONAR) it was noticed an efficacy of 75% at 14 and 21 days after treatment. In case of the annual dicotyledons (*Portulaca oleracea* (POROL) it was noticed an efficacy of 40% after 7, 14 and 21 days after treatment and 60% after 28 days after treatment.

A good efficiency was observed in controlling the aannual dicotyledonous *Solanum nigrum* (SOLNI) of 70% at 7 days after treatment and over 94% at 14, 21 and 28 days after spraying. The greatest efficacy 100% of Click Pro EC 376 with observed in controlling the annual monocotyledons *Digitaria sanguinalis* (DIGSA), annual dicotyledonous *Amaranthus retroflexus* (AMARE) and *Xantium strumarium* (XANTIST) and perennial dicotyledonous *Cirsium arvense* (CIRAR).

Adigor is a blend of surfactant and methylated canola oil for use with a wide range of crop protection products to improve the reliability of weed control, being one of the most effective adjuvant to enhance the efficacy of dual purposes herbicides respectively. Additionally, it lessens the negative effects of abiotic constraints, like vigor losses from herbicide treatments and a quicker recovery of vegetative growth. The average effectiveness outcomes of the herbicide combination Pyxides WG 562.5 g/kg + Adigor ADJ (312.5 g dicamba + 150 g mesotrione + 100 g nicosulfuron + 47% rapeseed methylate oil ) –0.4 kg/ha + 1 l/ha was observed especially at 14, 21 and 28 days after treatments, when ranged between 70-100%. Thus, all the targeted weeds showed a high degrees of control that ranged between75% to 100%, excepting the annual dicotyledons *Hibiscus trionum* (HIBTR) that was 100% controlled only after 7 days after treatment. The efficacy of the herbicide Pyxides WG 562,5 g/kg + Adigor ADJ ranged between 60-70% at 7 days after treatment in case of the annual dicotyledons (*Portulaca oleracea* (POROL) and annual dicotyledons *Atriplex patula* (ATRPL) and *Solanum nigrum* (SOLNI) (Figure 6).

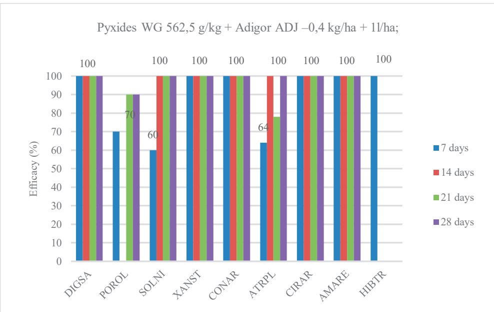


Figure 6. The Efficacy (%) at 7, 14, 21, 28 days after treatment with Pyxides WG 562.5 g/kg + Adigor ADJ applied postemergently at the stage BBCH 14-16

The herbicide Pyxides WG 562.5 g/kg + Adigor ADJ emphasized 100% efficacy in controlling *Cirsium arvense* (CIRAR), *Xanthium strumarium* (XANST), *Digitaria sanguinalis* (DIGSA), *Convolvulus arvensis* (CONAR) and *Amaranthus retroflexus* (AMARE) at 7, 14, 21 and 28 days after treatment. The highest efficacy degree 100% was noticed also when the herbicide SAE 053 H/01 – 1.2 l/ha was mixed with + Nico 40 OD – 0.5 l/ha in controlling weeds such as *Digitaria sanguinalis* (DIGSA), *Amaranthus retroflexus* (AMARE) and *Cirsium arvense* (CIRAR) at 7, 14, 21 and 28 days after treatment. In case of *Atriplex patula* (ATRPL) and *Solanum nigrum* (SOLNI) this combination showed lower efficacy that ranged of 55% to 76% at 7 days after treatment. No efficacy was noticed in *Convolvulus arvensis* (CONAR) at 14, 21 and 28 days after treatment, but a complete control (100%) was noticed at 7 days after treatment.

In case of *Portulaca oleracea* (POROL), *Atriplex patula* (ATRPL) and *Solanum nigrum* (SOLNI), the efficacy of the the herbicide formulation SAE 053 H/01 + Nico 40 OD applied postemergently (BBCH 14-16) at 7 days of treatment ranged between 55-80%, but it was 100% at 14, 21 and 28 days after treatment. This herbicide combination had no efficacy *Hibiscus trionum* (HIBTR) (Figure 7).

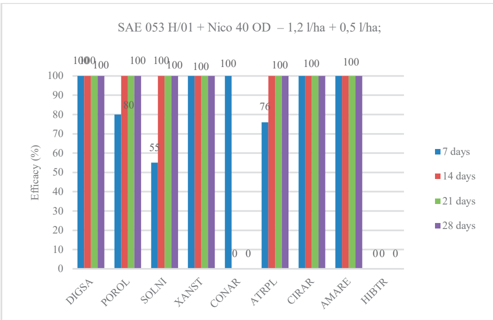


Figure 7. The Efficacy (%) at 7, 14, 21, 28 days after treatment with SAE 053 H/01 + Nico 40 OD applied postemergently at the stage BBCH 14-16

The mixture between the herbicides SAE 053 H/01 and Baracuda showed an efficacy that ranged from 13% to 100% at 7 days after treatment. This mix efficacy increased significantly over 95% at 14, 21 and 28 days after treatment in controlling weeds such as

*Digitaria sanguinalis* (DIGSA), *Solanum nigrum* SOLNI), *Xanthium strumarium* (XANST), *Atriplex patula* (ATRPL), (*Cirsium arvense* (CIRAR), *Amaranthus retroflexus* (AMARE), *Portulaca oleracea* (POROL). The lowest efficacy of this herbicides mixture was observed in *Hibiscus trionum* (HIBTR) and *Convolvulus arvensis* (CONAR) (Figure 8).

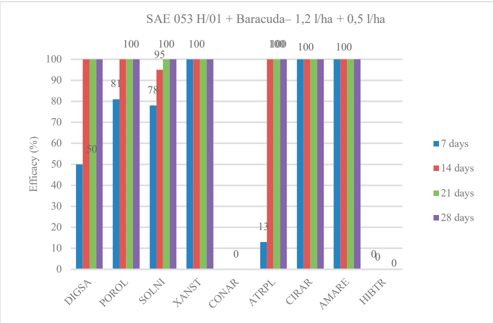


Figure 8. The Efficacy (%) at 7, 14, 21, 28 days after treatment with SAE 053 H/01 + Baracuda applied postemergently at the stage BBCH 14-16

All herbicides treatments tested in the trial showed no phytotoxic effects (EWRS scale = 0) (Table 2).

Table 2. The selectivity (%) of herbicide treatments applied at the maize crop 2023

| Var. | Treatments | Dose | Time * | Selectivity % | | | |
|---|---|---|---|---|---|---|---|
| | | | | 7 | 14 | 21 | 28 |
| 1 | Untreated – control | - | - | No phytotoxic effects** | | | |
| 2 | Principal Forte | 0.48 kg/ha | P-EM | | | | |
| 3 | Click Trio EC | 2 kg/ha | P-EM | | | | |
| 4 | Click Pro EC | 2.3 kg/ha | P-EM | | | | |
| 5 | Pyxides WG + Adigor ADJ | 0.4 kg/ha + 1 l/ha | P-EM | | | | |
| 6 | SAE 053 H/01 + Nico 40 OD | 1.2 l/ha + 0.5 l/ha | P-EM | | | | |
| 7 | SAE 053 H/01 + Baracuda | 1.2 l/ha + 0.5 l/ha | P-EM | | | | |

*P-EM = Post-Emergent in BBCH 14-16, when maize had 4-6 leaves
** (EWRS scale = 0, where 0 means not damages on the crop, and score 9 means the crop is fully damaged).

The experiment's findings demonstrated that by keeping weeds below the threshold level, herbicides provide an economical and effective way to manage weed populations before crop-weed conflict arises.

## CONCLUSIONS

Today, high-yielding agriculture heavily depends on herbicides, as they constitute a vital and integral component of weed management practices. Therefore, using herbicides to reduce weeds before, during, and after emergence will be the most cost-effective and efficient way to manage weeds in maize.

All of the herbicide treatments that were utilized in the experiment showed no phytotoxic effects and had good selectivity for the maize plant.

The experiment's findings showed that all weed control treatments had a substantial impact on weed density at 21 and 28 days after sowing (DAS), excepting V4 (Click Pro EC 376 g/l (50 g mesotrione + 326 g terbutilazin) – 2.3 kg/ha) that showed low control of the annual dicotyledons (*Portulaca oleracea* (POROL), the herbicide efficacy ranging between 40% to 60%.

Among all assessed weeds the most difficult to control were *Hibiscus trionum* (HIBTR) and *Convolvulus arvensis* (CONAR). Despite of this, the best control of *Convolvulus arvensis* (CONAR) was done by Pyxides WG 562.5 g/kg + Adigor ADJ –0.4 kg/ha + 1l/ha, while the best control of *Hibiscus trionum* (HIBTR) was done by Click Trio EC 490 g/l– 2 kg/ha, at 7, 14, 21 and 28 days after treatment.

All herbicides formulations showed 100% efficacy in controlling *Xanthium strumarium* (XANST), *Amaranthus retroflexus* (AMARE) and (*Cirsium arvense* (CIRAR) for all assessed moments. Among all tested herbicide formulations Click Trio EC 490 g/l (75 g mesotrione + 375 g terbutilazin + 40 g clomazona) – 2 kg/ha emphasized 100% efficacy in controlling of all targeted weeds to 7 days after treatment, excepting (*Digitaria sanguinalis* (DIGSA) when the efficacy was only 67%.

The best control of targeted weeds from maize crop was assured by the new herbicides formulations Click Trio EC 490 g/l– 2 kg/ha and Pyxides WG 562.5 g/kg + Adigor ADJ–0.4 kg/ha + 1l/ha. Also, the combination SAE 0.53 H/01+ Baracuda (1.2 l/ha + 0.5 L/ha) proved 100% efficacy in controlling targeted weeds, especially at 14, 21 and 28 days after treatment, excepting *Hibiscus trionum* (HIBTR) and *Convolvulus arvensis* (CONAR).

## AKNOWLEDGEMENTS

This study was funded by a private corporation and conducted in 2023 with assistance from the Agricultural and Development Research Station Caracal of University from Craiova, Romania.

## REFERENCES


Acharya, R., Karki, T. B., Adhikari, B. (2022). Effect of various weed management practices on weed dynamics and crop yields under maize-wheat cropping system of western hills. *Agronomy Journal of Nepal*, 153-161.

Alkan, H., Ciğerci, İ.H., Ali, M.M., Hazman, O., Liman, R., Colă, F., Bonciu, E. (2022). Cytotoxic and Genotoxic Evaluation of Biosynthesized Silver Nanoparticles Using *Moringa oleifera* on MCF-7 and HUVEC Cell Lines. *Plants*, *11*(10):1293.

Alptekin, H., Ozkan, A., Gurbuz, R., & Kulak, M. (2023). Management of weeds in maize by sequential or individual applications of pre-and post-emergence herbicides. *Agriculture*, 13(2), 421.

Brankov, M., Simić, M., & Dragičević, V. (2021). The influence of maize–winter wheat rotation and pre-emergence herbicides on weeds and maize productivity. *Crop protection*, 143, 105558.

Bonciu, E., Liman, R., Cigerci, I.G. (2021). Genetic Bioengineering in agriculture-A model system for study of the mechanism of programmed cell death. *Scientific Papers: Management, Economic Engineering in Agriculture and Rural Development*, 21(4), 65-70.

Bonciu, E. (2023). Some sustainable depollution strategies applied in integrated environmental protection management in agriculture. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 23(3), 69-76.

Borleanu, I. C., Paraschivu, M., Tuță, C. E. (2012). Research on the evolution of main yield components of maize hybrids grown in different climatic conditions on luvosoil from Simnic area. *Annals of the University of Craiova, Agriculture, Montanology, Cadastre Series*, vol. 42 (2), p. 28-33.

Brankov, M., Simić, M., & Dragičević, V. (2021). The influence of maize–winter wheat rotation and pre-emergence herbicides on weeds and maize productivity. *Crop protection*, 143, 105558.

De Souza, C.P., Bonciu, E. (2022). Use of molecular markers in plant bioengineering. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22(1), 159-166.

Feng, Z., Hu, T., Tai, A. P., & Calatayud, V. (2020). Yield and economic losses in maize caused by ambient ozone in the North China Plain (2014–2017). *Science of the Total Environment*, 722, 137958.

Fan, X.M., Kang, M.S., Chen, H., Zhang, Y., Tan, J., Xu, C. (2007). Yield Stability of Maize Hybrids Evaluated in Multi-Environment Trials in Yunnan, China. *Agronomy Journal*, *99*, 220–228.

Gharde, Y., Singh, P.K., Dubey, R.P., Gupta, P.K. (2018). Assessment of yield and economic losses in agriculture due to weeds in India. *Crop Protection,* 107, 12–18.

Grzanka, M., Sobiech, Ł., Idziak, R., Skrzypczak, G. (2022). Effect of the time of herbicide application and the properties of the spray solution on the efficacy of weed control in maize (Zea mays L.) cultivation. *Agriculture*, 12(3), 353.

Idziak, R., Waligóra, H., Szuba, V. (2022). The influence of agronomical and chemical weed control on weeds of corn. *Journal of Plant Protection Research*, 62, 215–222.

Iqbal, S., Tahir, S., Dass, A., Bhat, M. A., Rashid, Z. (2020). Bio-efficacy of pre-emergent herbicides for weed control in maize: a review on weed dynamics evaluation. *Journal of Experimental Agriculture International*, 42(8), 13-23.

Imoloame, E.O., Omolalye, J,O. (2016). Impact of different periods of weed interference on the growth and yield of maize (Zea mays L.). *Agriculture*, 93(4), 245-257.

Jagła, M., Sobiech, Ł., Szulc, P., Nowosad, K., Bocianowski, J., Grzanka, M. (2020). Sensitivity assessment of varieties, effectiveness of weed control by selected herbicides, and infection of the fusarium in maize (Zea mays L.) cultivation. *Agronomy*, 10(8), 1115.

Jagadish, K., Shrinivas, C.S., Prashant, C. (2016). A review on weed management on maize (Zea mays L.). *Advances in Life Sciences*. 5 (9), 3448-3455.

Kakade, S. U., Deshmukh, J. P., Thakare, S. S., & Solanke, M. S. (2020). Efficacy of pre-and post-emergence herbicides in maize. *Indian Journal of Weed Science*, 52(2), 143-146.

Kumar, A., Behera, U.K., Dhar, S., Shukla, L., Bhatiya, A., Meena, M.C., Gupta, G., Singh, R.K. (2018). Effect of tillage, crop residues and phosphorus management practices on the productivity and profitability of maize cultivation under Inceptsols of IGPs. *Indian Journal of Agricultural Sciences,* 85(2), 182–188.

Li, X., Takahashi, T., Suzuki, N., & Kaiser, H. M. (2011). The impact of climate change on maize yields in the United States and China. *Agricultural Systems*, 104(4), 348-353.

Lipianu, S., Zală, C.R., Istrate, R., Manole M-S., Ciontu, C. (2023). Research on the protection of rapeseed crop against diseases, weeds and pests. *Scientific Papers. Series A. Agronomy*, Vol. LXVI (1), 399-405.

Mhlanga, B., Chauhan, B.S., Thierfelder, C. (2016). Weed management in maize using crop competition: A review. *Crop Protection*, 88, 28–36.

Millet, E.J., Kruijer, W., Coupel-Ledru, A., Alvarez Prado, S., Cabrera-Bosquet, L., Lacube, S., Charcosset, A., Welcker, C., van Eeuwijk, F., Tardieu, F. (2019). Genomic Prediction of Maize Yield across European Environmental Conditions. *Nature Genetics,* 51, 952–956.

Odum, E. P., & Barrett, G. W. (1971). Fundamentals of ecology. W.B. Saunders Company: Philadelphia, PA, USA, 574 pp.

Paraschivu, M., Matei, Gh., Draghici, R., Paraschivu, M., Cotuna, O., Popa, L.D. (2022). Genetic and chemical approaches to manage rye leaf rust (Puccinia recondita f.sp. secalis) in natural conditions from marginal areas. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series* 52 (2), 122-133.

Partal, E., Paraschivu, M., Oltenacu, C. V., Paraschivu, M. (2012a). Productivity and profitability of maize and sorghum crops in natural conditions from south area. *Annals of the University of Craiova, Agriculture, Montanology, Cadastre Series*,vol. 42 (2), p.214-219.

Partal, E., Paraschivu, M., Oltenacu, C.V., Paraschivu, M. (2012b). Productivity and quality of maize and sorghum crops in climatic conditions of Ialomita County. *Annals of the University of Craiova, Agriculture, Montanology, Cadastre Series*, vol. 42 (2), p.208-213.

Partal, E., Paraschivu, M. (2020). Results regarding the effect of crop rotation and fertilization on the yield and qualities at wheat and maize in South of Romania. *Scientific Papers. Series A. Agronomy*, LXIII (2), 184-189.

Păunescu, R.A., Bonciu, E., Rosculete, E., Paunescu, G., Rosculete, C.A., Babeanu, C. (2021). The Variability for the Biochemical Indicators at the Winter Wheat Assortment and Identifying the Sources with a High Antioxidant Activity. *Plants*, *10*(11): 2443.

Păunescu, G., Paraschivu, M., Păunescu, R.A., Roșculete, C.A. (2022). The relationship between yield and pathogens attacks on the advanced breeding winter wheat lines assessed for adult plant resistance. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22 (1), 493-501.

Popescu A., Bodescu F., Ciobanu C., Bârlea V., Păunescu G., Fritea T. (2009). Noi erbicide combinate în combaterea buruienilor anuale din cultura porumbului. *Analele INCDA Fundulea*, 77, 137-146. (In Romanian).

Qu, R.Y., He, B., Yang, J.F., Lin, H.Y., Yang, W.C., Wu, Q.Y., Li, Q.X. Yang, G.F., (2021). Where are the new herbicides?. *Pest Management Science*, 77(6), 2620-2625.

Răduţoiu, D. & Băloniu, L. (2021). Invasive and potentially invasive alogen plants in the agricultural crops of Oltenia. *Scientific Papers. Series B, Horticulture.* LXV, 1, 782-787.

Răduţoiu, D. (2022). The economic importance of the spontaneous flora within Oltenia Plain, Romania. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development* 22 (1), 561-568.Răduţoiu, D. & Stan, I. (2022). Vegetation damage to agricultural crops in Oltenia, Romania. *Scientific Papers. Series B, Horticulture*. LXVI, 885-892.

Răduțoiu, D. & Ștefănescu, D.M. (2022). Invasive native plants in anthropogenic ecosystems from Oltenia, Romania. *Scientific Papers. Series B, Horticulture*. Vol. LXVI, 878-884.

Răduțoiu, D. (2023). The economic importance of the spontaneous flora in the area of the Piedmont and Subcarpathian Hills of Oltenia, Romania. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, Vol. 23(3), 768-775.

Reddy, M. B., Elankavi, S., Baradhan, G., & Muthuselvam, K. (2022). Evaluation of weed management practices on weed dynamics and yield of maize (Zea mays L.). *Crop Research*, 57(5and6), 330-334.

Sairam, G., Jha, A. K., Verma, B., Porwal, M., Sahu, M. P., & Meshram, R. K. (2023). Effect of pre and post-emergence herbicides on weed flora of maize. *International Journal of Plant & Soil Science*, 35(11), 68-76.

Samant, T.K., Dhir, B.C., Mohanty, B. (2015). Weed growth, yield components, productivity, economics and nutrient uptake of maize (Zea mays L.) as influenced by various herbicide applications under rainfed condition. *Indian Journal of Weed Science*, 2, 79–83.

Sălceanu, C., Paraschivu, M., Cotuna, O., Sărățeanu, V., Prioteasa, M.A., Flondor, I.S. (2022). Global pesticide market: size, trends, forecasts. *Analele Universității din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series)*, 52 (2), 146-157.

Sălceanu, C., Paraschivu, M., Popescu, C.V., Olaru, A.L. (2024). The management of weeds using new generation herbicides in maize. *Scientific Papers. Series A. Agronomy,* Vol. LXVII, No. 2, 369-379.

Șerban, M., Măturaru, G., Lazăr, C., Grădilă, M., & Ciontu, C. (2021). Research on the selectivity and the efficacy of herbicides in controlling weeds for the maize crop. *Romanian Agricultural Research*, 38, 271-279.

Sharma, N., & Rayamajhi, M. (2022). Different aspects of weed management in maize (Zea mays L.): A brief review. *Advances in Agriculture*, Volume 2022, Article ID 7960175, 10 pages https://doi.org/10.1155/2022/7960175

Soare, B., Paraschivu, M., Păunescu, G. (2010a). The influence of weeding degree control and weed green total mass to the maize yield on black earth (chernozem) from Mărculești. *Annals of the University of Craiova, Agriculture, Montanology, Cadastre series*, vol. 40/1, p.215-220.

Soare, B., Păunescu, G., Paraschivu, M. (2010b). The efficiency study of the herbicides used to control weed from maize crop on the black earth (chernozem) from Mărculești. *Annals of the University of Craiova, Agriculture, Montanology, Cadastre series*, vol. 40/1, p.221-229.

Smith, C.W., Betrán, J., Runge, E.C. (2004). (Eds.) Corn: Origin, History, Technology, and Production; John Wiley & Sons: Hoboken, NJ, USA, 2004; Volume 4. [Google Scholar]

Tesfay, A., Amin, M., Mulugeta, N. (2014). Management of weeds in maize (Zea mays L.) through various pre and post emergency herbicides. *Advances in Crop Science and Technology*, 2, 151–155.

Üstüner, T. and Güncan, A. (2002). Niğde ve yöresi patates tarlalarında sorun olan yabancı otların yoğunluğu ve önemi ile topluluk oluşturmaları üzerine araştırmalar. *Türkiye Herboloji Derg, 5*, 30–42.

Veljković, V.B., Biberdžić, M.O., Banković-Ilić, I.B., Djalović, I.G., Tasić, M.B., Nježić, Z.B., Stamenković, O.S. (2018). Biodiesel production from corn oil: A review. *Renew. Sustain. Energy Rev.* 2018, 91, 531–548.

Velea, L., Bojariu, R., Burada, C., Udristioiu, M.T., Paraschivu, M., Burce, R.D. (2021). Characteristics of extreme temperatures relevant for agriculture in the near future (2021-2040) in Romania. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*. X, p.70-75.

Wolf, J., & Van Diepen, C. A. (1995). Effects of climate change on grain maize yield potential in the European Community. *Climatic change*, *29*(3), 299-331.

Zhang, J., Zheng, L., Jäck, O., Yan, D., Zhang, Z., Gerhards, R., Ni, H. (2013). Efficacy of four post-emergence herbicides applied at reduced doses on weeds in summer maize (Zea mays L.) fields in North China Plain. *Crop Protection*, 52, 26–32.

Zhelyazkov, I., Mitkov, A., Stoychev, D. (2017). *A Guidebook for Exercises on Herbology*. Academic Publisher of the Agricultural University of Plovdiv, 188 pp.