Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE MANAGEMENT OF WEEDS USING NEW GENERATION HERBICIDES IN MAIZE

Călin SĂLCEANU[1], Mirela PARASCHIVU[1], Veronica SĂRĂȚEANU[1], Otilia COTUNA[2], Aurel Liviu OLARU[1]

[1]University of Craiova, 19 Libertatii Street, Craiova, Dolj, Romania
[2]University of Life Sciences "King Mihai I" from Timisoara, 119 Calea Aradului Street, Timisoara, Romania

Corresponding author email: liviu.olaru.dtas@gmail.com

Abstract

Maize (Zea mays L.) is one of the most versatile multi-purpose crop used as feed and food crop beside other no-food uses. During 2023 year a field experiment in a randomized complete block design with three replications and fourteen treatments was carried out in the Agricultural and Research Station Caracal with the aim of evaluation of weed control in maize, using new generation herbicides. The treatments were composed of isolated and associated herbicides and all were considered selective in maize via pre-emergence (PRE) and post-emergence (POST) applications. The efficacy evaluation was done at 7, 14, 21 and 28 days since each treatment targeting CHEAL, HIBTR, DATST, POLSS, CONAR, ECHCG, SETVI, SORHA, CYNDA, DIGSA, MATSS, AMBEL, GALPA, POROL, SOLNI. Results revealed that, among the herbicidal treatments, the best efficacy was recorded by SAE 053 H/01 + Baracuda doze p.c. 1.2 + 0.5; SAE 053 H/01 + Nico 40 OD doze p.c. 1.2 + 0.5; SAE 053 H/01 + Baracuda +Nico 40 OD doze p.c. 1.2 + 0.5 + 0.5.

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

INTRODUCTION

Since its domestication some 9,000 years ago, maize (*Zea mays* L., also commonly known as corn) has played an increasing and diverse role in global agri-food systems (Awika, 2011; Kennett et al. 2020).

Nowadays, multiple roles and uses of maize (*Zea mays* L.) is still explored, due to its genetic diversity and economical importance, primarily as a feed globally and also as a food crop, besides other non-food uses.

In terms of production volume, maize is currently the most popular cereal and is expected to overtake all other crops as the most frequently grown and traded commodity in the next ten years, being so versatile in a wide range of climates and soils (Borleanu et al., 2012; Dragomir et al., 2022; Guzzon et al., 2021; Lamichhane et al., 2023; Partal et al., 2012a; Partal et al., 2012b; Partal and Paraschivu, 2020).

According to previous studies, over the next 30 years, the earth's average surface temperature will rise at a rate of about 0.2 degrees Celsius every decade having a significant impact on the growth and health of natural plant species and crops and their interactions with abiotic (changes in temperatures, warmer than long-term means or unseasonal frosts and precipitation including snow, hail or extreme intensity, variable humidity, drought, salinity, heat, etc.) and biotic (invasive species, weeds, pests, pathogens) constrainers, leading even at new reports about them in different world areas (Elad and Pertot, 2014; Solomon, 2007; Bernstein et al., 2008; Paraschivu et al., 2019; Răduțoiu and Băloniu, 2021; Răduțoiu et al., 2023; Soare et al., 2010a; Soare et al., 2010b; Velea et al., 2021; Zală, 2021; Zală et al. 2023a). Moreover, by 2080, global temperature is anticipated to increase by 4,5-degree Celsius declining by 6% in productivity per each degree Celsius (Asseng et al., 2015). All these constrainers impact directly natural vegetation features and crops production with economic consequences (Eschen et al., 2021; Feng et al., 2020; Hedlund et al., 2020; Păunescu et al., 2022; Răduţoiu, 2022; Răduţoiu and Stan, 2022; Răduțoiu, 2023; Sawicka and Egbuna, 2020; Tripathi et al., 2016).

There are several possible strategies including breeding, technical progress and improving fertilizer and pesticides efficiency to increase crops production (Lipianu et al., 2023; Paraschivu et al., 2022; Sălceanu et al., 2022; Ză1ă et al., 2023b).

Current problems related to the consequences caused by using pesticides along with those caused by agricultural pollution (Bonciu et al, 2020; Bonciu, 2023b, 2023c; Torrens & Castellano, 2014) require essential changes in plant breeding technologies (Bonciu, 2023a). One of the most modern such technologies is agricultural biotechnology and genomics (De Souza and Bonciu, 2022a, 2022b), which is able to ensure the creation of varieties and forms of plants with targeted performances: increased productivity and quality, resistance to biotic constrainers and tolerance to unfavourable climatic factors.

Among the biotic factors, weeds are one of the critical factors. The negative effects of annual and perennial weed species on maize yield have been documented in many studies previously (Absy, 2019; Idziak et al., 2022; Mhlanga et al., 2016; Samant et al., 2015; Tesfay et al., 2014; Zhang et al., 2013).

Reports have estimated around a 37% global loss in total maize production due to weeds (Oerke & Dehne, 2004; Sharma and Rayamajhi, 2022). It's possible that the maize plants won't be able to grow enough roots in weedy fields, but the main obstacle to increased maize yields is related to managing and controlling weed growth (Güncan & Karaca, 2014).

The amount of the loss depends on the weed flora's composition, when the weeds arise in relation to the crop, their density and intensity, and the crop's developmental stage in relation to the competition period (Singh et al., 2016). Since this is the phase when the components relevant to grain yield are established, competition with maize at the stage of five fully grown leaves has the greatest detrimental effect on the crop (Duarte et al, 2002).

Other studies showed than when weeds interference in maize from 36 weeks after sowing (WAS) significantly depressed the growth parameters and grain yield of maize, leading to 28-100% yield losses (Imoloame & Omolaiye, 2016; Jagadish et al., 2016). Moreover, hand weeding and hoeing methods were effective in coping with the annual weeds, but they were not effective in controlling perennial weeds (Idziak et al., 2022).

Therefore, the use of pre-emergence and post-emergence herbicides can be an effective way to manage weeds in maize, due to their fast results, easy application and low cost (Idziak et al., 2022). Also, compared to other methods, the chemical control method is quicker, more efficient, and requires less labour (Kakade et al., 2020; Qu et al., 2021; Sharma & Rayamajhi, 2022).

In practical, farmers use both pre-emergence and post-emergence herbicides intensively in maize fields. The effect of pre-emergence herbicides applied to the soil lasts about 40–50 days, but the secondary weed infestation, requires post-emergence foliar application (Delchev, 2021). However, when the combined use of pre-emergence and post-emergence herbicides targets both annual and perennial weeds, it will have more effects on weeds. In the future, herbicides will still be a useful tool in agriculture for controlling weeds as part of an integrated weed management strategy.

The aim of current study was to evaluate the selectivity and efficacy of combined effects of new generation herbicides for weeds management in maize with the different bioactive ingredients in natural conditions from ARDS Caracal, Romania.

MATERIALS AND METHODS

A field investigation was carried out in the field of the Agricultural Research Station Caracal (ARDS) of the University of Craiova, Romania (44°11'N and 24°37'E) during 2023 year to study the relative efficacy of new generation of herbicides on weed control in maize combined with different bioactive ingredients.

The trial was conducted in a split–split-plot design with the main plots arranged in a randomized complete block (RCBD – Fisher model) with three replicates. The size of each plot was 25 m^2.

All recommended cultural practices (i.e. fertilization with 250 kg ha-1 NPK 15:15:15 and spring dressing with 200 kg/ha NH4NO3 was performed, etc.) and other management (two times disc harrowing and two times cultivation before sowing) were applied.

The treatments were composed of isolated and associated herbicides and all were considered selective in maize via post-emergence (POST) applications.

The experiment included the following treatments:

V1. Untreated – control;

V2. SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha;

V3. SAE 053 H/01 + Kaishi (80 g/l mesotrione + 30 g/l nicosulfuron + aminoacides) – 1.2 l/ha + 2 l/ha;

V4. SAE 053 H/01 + Improve 5 in 1 (80 g/l mesotrione + 40 g/l nicosulfuron + citric acid + aminoethanol) – 1.2 l/ha + 100 ml/100 l solution;

V5.Elumis OD (75 g/l mesotrione + 30 g/l nicosulfuron) – 1,2 l/ha;

V6. Elumis OD + Kaishi (75 g/l mesotrione + 30 g/l nicosulfuron + aminoacides) – 1.2 l/ha + 2 l/ha;

V7.Crew Ace OD + Baracuda (40 g/l nicosulfuron + 100 g/l mesotrione) – 1 l/ha + 1l/ha.

The herbicide products were applied post-emergent in BBCH 14-16, when maize had 4-6 leaves. The volume of the spraying solution was 400 l/ha. In the study, a back sprayer with a 25 L tank capacity, gasoline engine, and fan nozzles was used for herbicide application. Prior to the establishment of the trials, weed species and their densities were noted. In this regard, a 1 m^2 frame was used in the trial area, randomly replaced, and the weed species, growth stages, and the number of each weed species in the covered area or m^2 were recorded. Thus, the first evaluation of weeds spectrum was done before spraying targeting the following species: *Hibiscus trionum* (HIBTR), *Convolvulus arvensis* (CONAR), *Digitaria sanguinalis* (DIGSA), *Portulaca oleracea* (POROL), *Solanum nigrum* (SOLNI), *Xantium strumarium* (XANTIST), *Atriplex patula* (ATRPL), *Cirsium arvense* (CIRAR), and *Amaranthus retroflexus* (AMARE). The density and periodicity of weed population emergence determine the critical period of crop – weed competition. Thus, the densities of each species were calculated according the following equation:

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

where, “B” indicates the total number of individual plants in the samples and “m” represents the total number of meters (Odum & Barrett, 1971).

In addition, the scale suggested by Üstüner and Güncan (2002) was used to determine the density of the species (Table 1).

Table 1. Density scale of the weeds

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

The efficacy of the studied herbicides on weed population and weed species, changes in weed population and species were observed four times at regular intervals after herbicide treatments on the 7th, 14th, 21th and on the 28th day after application.

The percentage of reduction in weed population was determined by comparing the treated plots with the weedy control plots. Each assessment specifies the phenology of the weeds and the effects on the weeds. The Abbott formula was used for determination of the effect on weeds at the species level and the effects on all weeds (Snedecor et al., 1967):

$$HPE = (CWN – TWN) X 100/CWN$$

where, “HPE” indicates Herbicide Percentage Effect, “CWN” indicates Number of Weeds in Control, “TWN” indicates Number of Weeds in Treatments.

The selectivity of the herbicides was evaluated by the 9 score scale of EWRS as described by Zhelyazkov et al. (2017) (at score 0 there are not damages on the crop, and at score 9 the crop is completely destroyed).

Statistical analysis of collected data was performed by using ANOVA and mathematical functions of MS Office Excel 2013 facilities. For relevant statistical differences ($p<0.05$) was used complementary test for multiple comparations Newman-Keuls.

RESULTS AND DISCUSSIONS

Worldwide, the production of maize is severely affected by weeds, which lowers crop yields and reduces farmer earnings, due to their competition with maize plants for space, light, water, and nutrients (Gianessi, 2013; Acharya et al., 2022; Chauhan, 2020; Maqsood et al., 2020). In this context, minimizing the detrimental effects of weeds on maize yield requires efficient weed management.

Sutton et al. (2002) explained that, in contrast to costly labor for weed eradication, the chemical approach of weed management is stress-free, adaptable, and affordable.

During the experiment, the effect of the applied herbicides varied according to the active ingredients of the herbicide and the weed species. In addition, the effectiveness of herbicides varied according to the assessment times. Also, many previous studies have been done on the efficacy and selectivity of herbicides in maize (Delchev, 2021; Grzanka et al., 2022; Iqbal et al., 2020; Jagła et al., 2020).

However, factors such as locations, maize cultivar, bioactive compound of herbicides, mode of actions of the herbicides, as well as weed species and their densities, are also critical predictors in weed management.

In maize crop the most representative weed species are: monocotyledons (*Setaria* sp., *Echinochloa crusgalli*, *Sorghum halepense* (seed and rhizomes), *Elymus repens*, *Eriochloa villosa*) and dicotyledons: *Amaranthus retroflexus*, *Chenopodium album*, *Solanum nigrum*, *Sinapis arvensis*, *Raphanus raphanistrum*, *Stellaria media*, *Thlaspi arvensis*, *Hibiscus trionum*, *Datura stramonium*, *Abutilon theophrasti*, *Cirsium arvense*, *Convolvulus arvensis*, *Sonchus arvensis*) (Popescu et al, 2009).

In the maize field trail in ARDS Caracal the structure of weeds was diverse, leading to an 85% of infestation degree, with mono- and dicotyledonous weeds ratio of 6:94). Most of the weeds were annual and perennial dicotyledonous plants, depending on previous crop and pedo-climatic conditions, as follows:

-Annual monocotyledonous: *Digitaria sanguinalis* (DIGSA) (6%); no perennial monocotyledonous was present.

- Annual dicotyledonous: *Portulaca oleracea* (POROL) – 16%, *Solanum nigrum* (SOLNI) – 36%, *Xantium strumarium* (XANTIST) – 1%, *Atriplex patula* (ATRPL) – 30%, *Amaranthus retroflexus* (AMARE) – 1%, *Hibiscus trionum* (HIBTR) – 4%;

Perennial dicotyledonous: *Convolvulus arvensis* (CONAR) – 5%; Cirsium arvense (CIRAR) – 1% (Figure 1).

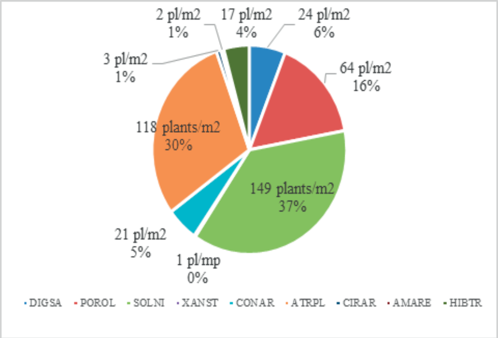

Figure 1. Weeds structure from maize crop on the experimental field

Amid the weeds observed, the highest density of weed species were found as *Atriplex patula* (ATRPL) (30%), *Solanum nigrum* (SOLNI) (37%), and *Portulaca oleracea* (POROL) (16%).

The assessment according with the scale suggested by Üstüner and Güncan (2002) showed that weeds density (weeds/m^2) ranged between Dense (B) and High-Dense (A). The results indicated that weeds density was high (A) for all weeds targeted species and all variants after 7 days from treatments application. At 14 days after treatments only in variants 4 (SAE 053 H/01 + Improve 5 in 1 (80 g/l mesotrione + 40 g/l nicosulfuron + citric acid + aminoethanol) – 1.2 l/ha + 100 ml/100 l solution), 5 (Elumis OD (75 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha) and 6 (Elumis OD + Kaishi (75 g/l mesotrione + 30 g/l nicosulfuron + aminoacides) – 1.2 l/ha + 2 l/ha) was noticed a lower weeds density (B).

At 21days after treatments application weeds density was diminished but still high for variants 2 (SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha) and 3 (SAE 053 H/01 + Kaishi (80 g/l mesotrione + 30 g/l nicosulfuron + aminoacides) – 1.2 l/ha + 2 l/ha).

At 28 days after treatments only in variant 2 (SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha) the weeds density was still high (A), while for all other treatments led to dense (B) (Figure 2).

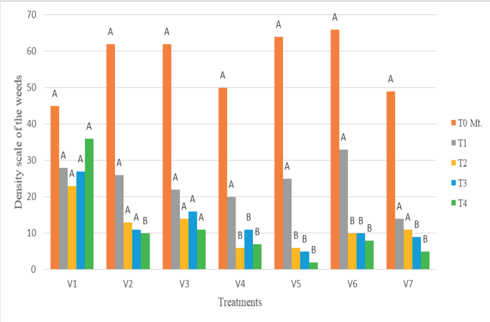

Figure 2. Weeds density according with the treatments applied and the assessment moments

According to the products utilized, the use of herbicide treatments had a substantial impact on the control of annual and perennial weed species in the treated version as compared to the untreated plot.

The herbicides efficacy (HPE - Herbicide Percentage Effect) ranged between 0 to 100% accordingly with selectivity, moment of application and assessment, the stage of weeds, the infestation degree and climatic conditions (Şerban et al., 2021).

Figure 3 shows the average efficacy results (%) obtained in the early post-emergence application of SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha (V2).

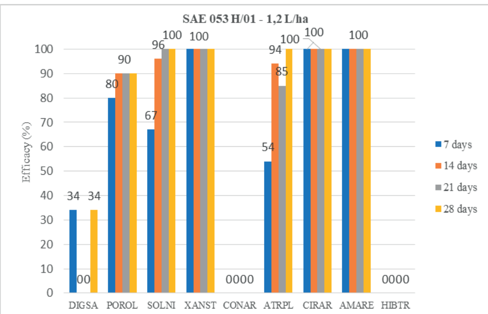

Figure 3. Efficacy (%) of SAE 053 H/01 postemergently applied in annual and perennial weeds controlling of maize crop, in 2023 (7, 14, 21, 28 days after treatment)

The results showed a control effect of 85-100% at 14, 21 and 21 days after treatments for annual dicotyledons (*Portulaca oleracea* (POROL), *Solanum nigrum* (SOLNI), *Xantium strumarium* (XANTIST), *Atriplex patula* (ATRPL), *Amaranthus retroflexus* (AMARE) and perennial dicotyledons *Cirsium arvense* (CIRAR). The annual monocotyledons *Digitaria sanguinalis* (DIGSA) was uncontrolled (34%).

Kaishi is a bio-stimulant of vegetal origin and enzymatic hydrolysis with role of increasing metabolism and boosting general growth of plants, but also improving absorption in plant tissues of fertilizers and plant protection products. Also, it decreases adverse effects generated by abiotic constrainers, such as vigour reductions caused by herbicide applications and a faster recovery of vegetative growth. The average efficacy results of the combination of herbicide SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – (1,2 L/ha) and Kaishi (aminoacides - 2 L/ha) showed a good degree of control to weed species, especially at 14, 21 and 28 days after treatments. Thus, this combined treatment efficacy ranged between 85-100% after 14, 21 and 28 days after treatment. Excepting the annual dicotyledons *Hibiscus trionum* (HIBTR), all assessed weeds showed a high degree of control. At 7 days after treatment only the annual monocotyledonous *Digitaria sanguinalis* (DIGSA) and annual dicotyledons *Solanum nigrum* (SOLNI), *Atriplex patula* (ATRPL) was not complete controlled, the efficacy of the herbicide SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – (1.2 l/ha) and Kaishi (aminoacides - 2 l/ha) ranging between 50-70% (Figure 4).

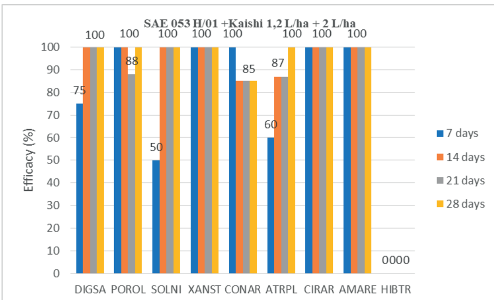

Figure 4. Efficacy (%) of SAE 053 H/01 + Kaishi postemergently applied in annual and perennial weeds controlling of maize crop, in 2023 (7, 14, 21, 28 days after treatment)

When the herbicide SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – (1.2 l/ha) was mixed with Improve 5 in 1 (80 g/l mesotrione + 40 g/l nicosulfuron + citric acid + aminoethanol) – (1.2 l/ha + 100 ml/100 l solution) (V4) The results show a control effect greater than 90% for the annual monocotyledons (*Digitaria sanguinalis* (DIGSA) and annual dicotyledons *Amaranthus retroflexus* (AMARE), *Solanum nigrum* SOLNI), *Xanthium strumarium* (XANST), *Portulaca oleracea* (POROL), *Atriplex patula* (ATRPL) and perennial dicotyledons (*Cirsium arvense* (CIRAR) at 14, 21 and 28 days. This combination proved low efficacy at 7 days for *Portulaca oleracea* (POROL), *Solanum nigrum* SOLNI) and *Atriplex patula* (ATRPL). The lowest efficacy was noticed in perennial dicotyledons Convolvulus arvensis (CONAR) that ranged between 65 to 82% (Figure 5).

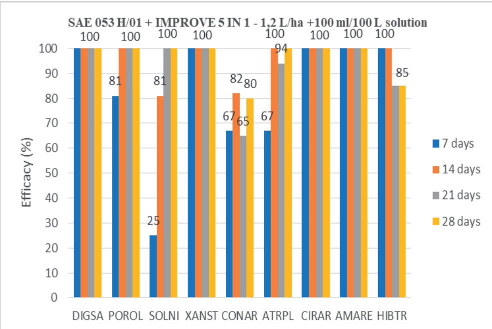

Figure 5. Efficacy (%) of SAE 053 H/01 + Improve 5 in 1 postemergently applied in annual and perennial weeds controlling of maize crop, in 2023 (7, 14, 21, 28 days after treatment)

Ones of the best results in controlling maize weeds were noticed when the herbicide Elumis OD (1.2 l/ha) was applied even after 7 days with efficacy between 93-100%.

In case of the annual monocotyledonous weed *Digitaria sanguinalis* (DIGSA) the herbicide Elumis OD showed lower efficacy (75%) after 7, 14 and 21 days after treatment, but proved 100% control at 28 days after treatment.

The best control with 100% efficacy was observed at all assessment moments after treatment for annual dicotyledons *Amaranthus retroflexus* (AMARE), *Xanthium strumarium* (XANST), *Portulaca oleracea* (POROL), *Hibiscus trionum* (HIBTR) and perennial dicotyledonous *Convolvulus arvensis* (CONAR), *Cirsium arvense* (CIRAR) (Figure 6). For the weeds *Digitaria sanguinalis* (DIGSA), *Solanum nigrum* (SOLNI), *Atriplex patula* (ATRPL) the herbicide efficacy was lower at 7 days after treatment (75%, 30%, respectively 81%).

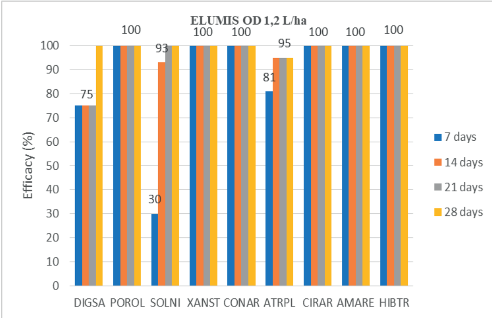

Figure 6. Efficacy (%) of ELUMIS OD post-emergently applied in annual and perennial weeds controlling of maize crop, in 2023 (7, 14, 21, 28 days after treatment)

When the herbicide Elumis OD was combined Kaishi the efficacy at 7 days ranged between 49% to 100%.

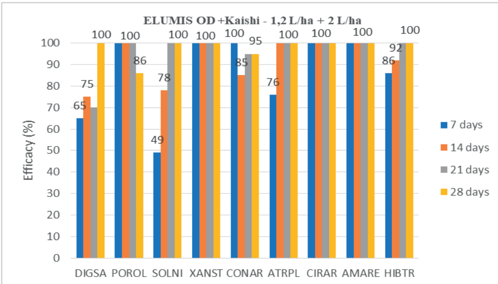

Figure 7. Efficacy (%) of ELUMIS OD + Kaishi post-emergently applied in annual and perennial weeds controlling of maize crop, in 2023 (7, 14, 21, 28 days after treatment)

The results showed a better control of weeds and a increased efficacy of Elumis OD at14 and 21 days after treatment when it was applied alone than in the variant when it was applied combined with Kaishi. A possible explanation might be the stimulant effect of Kaishi also on weeds not only maize plants, as slightly side effect. For the annual monocotyledons *Digitaria sanguinalis* (DIGSA), the annual dicotyledons *Xanthium strumarium* (XANST), *Amaranthus retroflexus* (AMARE), the

perennial dicotyledonous *Convolvulus arvensis* (CONAR), *Cirsium arvense* (CIRAR) the efficacy of ELUMIS OD + Kaishi was 100% after 7, 14, 21 and 28 days post-treatment.
When the combination Crew Ace OD + Baracuda (40 g/l nicosulfuron + 100 g/l mesotrione) – 1 l/ha + 1 l/ha was applied all assessed weeds were controlled 100% at 7, 14, 21 and 28 days after treatment, excepting *Portulaca oleracea* (POROL), *Solanum nigrum* (SOLNI), *Atriplex patula* (ATRPL) that showed good efficacy at 14, 21 and 28 days after treatment. The annual dicotyledons *Hibiscus trionum* (HIBTR) was uncontrolled (20-35%) (Figure 8).

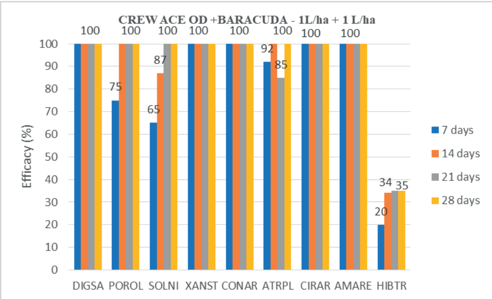

Figure 8. Efficacy (%) of CREW ACE OD +BARACUDA post-emergently applied in annual and perennial weeds controlling of maize crop, in 2023 (7, 14, 21, 28 days after treatment)

In the experimental field, the selectivity assessment for all herbicides variants had no phytotoxic effects (EWRS scale = 0) (Table 2).

Table 2. The selectivity (%) of herbicide treatments post-emergently applied at the maize crop 2023 (7- 14 - 21- 28 days after treatment)

Var.	Treatments	Dose	Time*	Selectivity %			
				7	14	21	28
1	Untreated – control	-	-	No phytotoxic effects**			
2	SAE 053 H/01	1,2 l/ha	P-EM				
3	SAE 053 H/01 + Kaishi	1,2 l/ha + 2 l/ha	P-EM				
4	SAE 053 H/01 + Improve 5 in 1	1,2 l/ha + 100 ml/100 l solution	P-EM				
5	Elumis OD	1,2 l/ha	P-EM				
6	Elumis OD + Kaishi	1,2 l/ha + 2 l/ha	P-EM				
7	Crew Ace OD + Baracuda	1 l/ha + 1l/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 completely destroyed).

The results of the experiment show that chemical control of the weed species existing in the maize crop is an important and necessary technological measure.

CONCLUSIONS

Managing weeds through pre-emergence, post-emergence and sequential use of herbicides will be an ideal means for controlling the weeds in the view of economics and effectiveness in maize.
All herbicide treatments used in the experiment had a good selectivity for maize plant without exhibiting phytotoxic effects. The results of the experiment revealed that weed density at 21 and 28 days after sowing (DAS) was significantly affected by all weed control treatments, excepting variants 2 (SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha) and 3 (SAE 053 H/01 + Kaishi (80 g/l mesotrione + 30 g/l nicosulfuron + aminoacides) – 1.2 l/ha + 2 l/ha).
The herbicide SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – 1.2 l/ha) showed a control effect of 85-100% at 14, 21 and 21 days after treatments for annual dicotyledons *Portulaca oleracea* (POROL), *Solanum nigrum* (SOLNI), *Xantium strumarium* (XANTIST), *Atriplex patula* (ATRPL), *Amaranthus retroflexus* (AMARE) and perennial dicotyledons *Cirsium arvense* (CIRAR). The average efficacy results of the combination of herbicide SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – (1.2 l/ha) and Kaishi (aminoacides - 2 L/ha) showed a good degree of control to weed species, especially at 14, 21 and 28 days after treatments. Thus, this combined treatment efficacy ranged between 85-100% after 14, 21 and 28 days after treatment. When the herbicide SAE 053 H/01 (80 g/l mesotrione + 30 g/l nicosulfuron) – (1.2 L/ha) was mixed with Improve 5 in 1 (80 g/l mesotrione + 40 g/l nicosulfuron + citric acid + aminoethanol) – (1.2 l/ha + 100 ml/100 l solution) (V4) The results show a control effect greater than 90% for the annual monocotyledons (*Digitaria sanguinalis* (DIGSA) and annual dicotyledons *Amaranthus retroflexus* (AMARE), *Solanum nigrum* SOLNI), *Xanthium strumarium* (XANST), *Portulaca oleracea* (POROL),

Atriplex patula (ATRPL) and perennial dicotyledons *Cirsium arvense* (CIRAR) at 14, 21 and 28 days.

Ones of the best results in controlling maize weeds were noticed when the herbicide Elumis OD (1,2 L/ha) was applied even after 7 days with efficacy between 93-100%. The results showed a better control of weeds and a increased efficacy of Elumis OD at 14 and 21 days after treatment when it was applied alone than in the variant when it was applied combined with Kaishi.

When the combination Crew Ace OD + Baracuda (40 g/l nicosulfuron + 100 g/l mesotrione) – 1 l/ha + 1 l/ha was applied all assessed weeds were controlled 100% at 7, 14, 21 and 28 days after treatment, excepting *Portulaca oleracea* (POROL), *Solanum nigrum* (SOLNI), *Atriplex patula* (ATRPL) that showed good efficacy at 14, 21 and 28 days after treatment.

AKNOWLEDGEMENTS

This research work was carried out in 2023 year with the support of the Agricultural and Development Research Station Caracal of University from Craiova, Romania and was financed by a private company.

REFERENCES

Absy, R. (2019). Weed Control Efficiency of some Pre- and Post-Emergence Herbicides in Maize. *Journal of Plant Production*, 10, 1037–1042.

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.

Asseng, S., Ewert, F., Martre, P., Rötter, R. P., Lobell, D., Cammarano, D., B.A. Kimball, M.J. Ottman, G.W. Wall, J.W. White, M.P. Reynolds, P.D. Alderman, P.V.V. Prasad, P.K. Aggarwal, J. Anothai, B. Basso, C. Biernath, A.J. Challinor, G. De Sanctis, J. Doltra, E. Fereres, M. Garcia-Vila, S. Gayler, G. Hoogenboom, L.A. Hunt, R.C. Izaurralde, M. Jabloun, C.D. Jones, K.C. Kersebaum, A-K. Koehler, C. Müller, S. Naresh Kumar, C. Nendel, G. O'Leary, J.E. Olesen, T. Palosuo, E. Priesack, E. Eyshi Rezaei, A.C. Ruane, M.A. Semenov, I. Shcherbak, C. Stockle, P. Stratonovitch, T. Streck, I. Supit, F. Tao, P.J. Thorburn, K. Waha, E. Wang, D. Wallach, J. Wolf, Z. Zhao, and Y. Zhu, 2015. Rising temperatures reduce global wheat production. *Nature Climate Change*, Vol. 59(2), 143–147.

Awika, J. (2011). Major cereal grains production and use around the world. In: Awika, J. M., Piironen, V., & Bean, S. (Eds.), *Advances in cereal science: implications to food processing and health promotion*. American Chemical Society Atlantic City, NJ, Washington DC, pp. 1–13. https://doi.org/10.1021/bk-2011-1089.ch001

Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., Riahi, K. IPCC (2008). *Climate Change 2007: Synthesis Report*; IPCC: Geneva, Switzerland, 2008.

Bonciu E., Rosculete E., Paraschivu M. (2020). The potential for environmental pollution of the Bromoxynil herbicide/Potențialul de poluarea mediului a erbicidului Bromoxynil. International Symposium, ISB-INMA TEH`2020, Agricultural and Mechanical Engineering, Bucharest, Romania, 30 october 2020, p. 134-137.

Bonciu, E. (2023a). Genetic transformation in agriculture: the real chance for ensuring worldwide sustainable food security. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, Vol. 23(1), 73-80.

Bonciu, E. (2023b). Clastogenic potential of some chemicals used in agriculture monitored through the allium assay. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, Vol. *23*(3), 63-68.

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

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.

Chauhan, B. S. (2020). Grand challenges in weed management. *Frontiers in Agronomy*, 1, 3.

De Souza, C.P., Bonciu, E., 2022a, Progress in genomics and biotechnology, the key to ensuring food security. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22(1), 149-157.

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

Delchev, G. (2021). *Efficacy and Selectivity of Some Herbicides in Five Field Crops*; Monograph, -LAP LAMBERT Academic Publishing: Saarbrücken, Germany, p. 225.

Dragomir, V., Ioan Sebastian, B., Alina, B., Victor, P., Tanasă, L., & Horhocea, D. (2022). An overview of global maize market compared to Romanian production. *Romanian Agriculture Research*, 39, 535-544.

Duarte N.F., Silva J.B., Souza I.F., (2002). Compatição de plantas daninhas com a cultura do milho no municipio de Ijaci. Mg. *Ciência e Agrotecnologia*, 26, 983-992.

Elad, Y. & Pertot, I. (2014). Climate Change Impacts on Plant Pathogens and Plant Diseases. *Journal of Crop Improvement*, 28(1), 99-139.

Eschen, R., Beale, T., Bonnin, J.M., Constantine, K.L., Duah, S., Finch, E.A., Makale, F., Nunda, W., Ogunmodede, A., Pratt, C.F. and Thompson, E., (2021). *Towards estimating the economic cost of invasive alien species to African crop and livestock production.* CABI Agriculture and Bioscience, 2, pp.1-18.

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.

Gianessi, L.P. (2013). The increasing importance of herbicides in worldwide crop production. *Pest Management Science*, 69, 1099–1105.

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.

Guzzon, F., Arandia Rios, L.W., Caviedes Cepeda, G.M., Céspedes Polo, M., Chavez Cabrera, A., Muriel Figueroa, J., Medina Hoyos, A.E., Jara Calvo, T.W., Molnar, T.L., Narro León, L.A. and Narro León, T.P., 2021. Conservation and use of Latin American maize diversity: Pillar of nutrition security and cultural heritage of humanity. *Agronomy*, 11(1), p.172.

Güncan, A., & Karaca, M. (2014). *Yabancı ot mücadelesi*. Selçuk Üniversitesi Yayınevi, Konya, 309.

Hedlund, J., Longo, S. B., York, R. (2020). Agriculture, pesticide use, and economic development: a global examination (1990–2014). *Rural Sociology*, *85*(2), 519-544.

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.

Kennett, D. J., Prufer, K. M., Culleton, B. J., George, R. J., Robinson, M., Trask, W. R., Buckley, G. M., Moes, E., Kate, E. J., Harper, T. K., O'Donnell, L., Ray, E. E., Hill, E. C., Alsgaard, A., Merriman, C., Meredith, C., Edgar, H. J. H., Awe, J. J., Gutierrez, S. M. (2020). Early isotopic evidence for maize as a staple grain in the Americas. *Science Advances,* 6, eaba3245.
https://doi.org/10.1126/sciadv.aba3245

Lamichhane, J.R., Alletto, L., Cong, W.F., Dayoub, E., Maury, P., Plaza-Bonilla, D., Reckling, M., Saia, S., Soltani, E., Tison, G. and Debaeke, P., (2023). Relay cropping for sustainable intensification of agriculture across temperate regions: Crop management challenges and future research priorities. *Field Crops Research*, 291, 108795.

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.

Maqsood, Q., Abbas, R. N., A Iqbal, M., A Serap, K., Iqbal, A., Sabagh, A. E. (2020). Overviewing of weed management practices to reduce weed seed bank and to increase maize yield. *Planta Daninha*, 38, e020199716.

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

Odum, E. P., & Barrett, G. W. (1971). *Fundamentals of ecology* (Vol. 3, p. 5). Philadelphia: Saunders.

Oerke, E.C., Dehne, H.W. (2004). Safeguarding production losses in major crops and the role of crop protection. *Crop Protection*, 23, 275–285.

Paraschivu, M., Cotuna, O., Paraschivu, M., Olaru, L. (2019). Effects of interaction between abiotic stress and pathogens in cereals in the context of climate change: an overview. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series* XLIX (2), 413-424.

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, 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.

Răduțoiu, D. & Stan, I. (2022). Vegetation damage to agricultural crops in Oltenia, Romania. *Scientific Papers. Series B, Horticulture*. LXVI, 885-892.

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.

Răduțoiu, D., Băloniu, L., Stan, I. (2023). Natura 2000 Habitats from Oltenia affected by invasive and potentially invasive species (I). *Scientific Papers. Series B. Horticulture*, Vol. LXVII, No. 1, 827-832.

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.

Sawicka, B., & Egbuna, C. (2020). *Pests of agricultural crops and control measures. In Natural remedies for pest, disease and weed control* (pp. 1-16). Academic Press.

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

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

Singh K., Kaur T., Bhullar M.S., Brar A.S., (2016). The critical period for weed control in spring maize in North-West India. *Maydica*, 61, 1-7.

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.

Solomon, S. (2007). *Climate Change 2007—The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the IPCC*; Cambridge University Press: Cambridge, UK, 2007; Volume 4.

Sutton, P., Richards, C., Buren, L., Glasgow, L., (2002). Activity of mesotrione on resistant weeds in maize, *Pest Management Science*, vol. 58, 9, 981–984.

Șerban, M., Măturaru, Gh., Lazăr, C., Grădilă, M., Cionut, C., (2021). Research on the selectivity and the efficacy of herbicides in controlling weeds for the maize crop. Romanian Agricultural Research, no. 38, 371-379.

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.

Torrens, F., Castellano, G. (2014). Molecular classification of pesticides including persistent organic pollutants, phenylurea and sulphonylurea herbicides. *Molecules*, 19, 7388–7414.

Tripathi, A., Tripathi, D.K., Chauhan, D., Kumar, N., Singh, G. (2016). Paradigms of climate change impacts on some major food sources of the world: A review on current knowledge and future prospects. *Agriculture, Ecosystems and Environment*, 216, 356–373.

Üstüner, T., & Güncan, A. (2002). Niğde ve yöresi patates tarlalarında sorun olan yabancı otların yoğunluğu ve önemi ile topluluk oluşturmaları üzerine araştırmalar. *Türkiye Herboloji Dergisi*, 5(2), 0-0.

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.

Zală, C.R. (2021). First report of loose smut-*Ustilago syntherismae* (Schweinitz) Peck on *Digitaria sanguinalis* (L.) Scop. in Bucharest-Romania. *Scientific Papers. Series A. Agronomy*, Vol. LXIV, No. 1, 632-640.

Zală, C.R., Manole, M.S., Istrate, R., Ciocoiu, E., Țurcan, D. (2023a). Preliminary research on soil microflora and macrofauna in the experimental field

Moara Domnească, *Scientific Papers*. *Series A. Agronomy*, Vol. LXVI, No. 1,190-196.
Zală, C.R., Cotuna, O., Paraschivu, M., Istrate, R., Mali-Sanda Manole, M.S. (2023b). Research on the effectiveness of some fungicides and insecticides in combating of some diseases and pests of rape in Cristian commune - Brașov County. *Romanian Agricultural Research*, 40, First Online: February, 2023. DII 2067-5720 RAR 2023-107.
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.