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INTEGRATED CONTROL OF *Echinochloa oryzoides*, *Echinochloa crus-galli* AND *Cyperus difformis* BASED ON PRE-SOWING HERBICIDE AND SOME HERBICIDE COMBINATIONS IN RICE

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Abstract: Cosmopolitan weeds are even constant elements where rice cultivation started just a century ago. There are few but important weed species with high adaptation in rice, which requires monoculture production systems and aquatic environment. Rotation difficulty resulted in the proliferation of highly competitive weed species strongly adapted to the aquatic environment. Constant use of herbicides with the same mechanisms of action leads to an evaluation of herbicide-resistant weed population and an increased number of herbicide-resistant populations in Türkiye. Chemical weed control and alternative integrated weed management strategies in rice production systems have significantly evolved throughout the years as well as rice herbicide traits and weed spectrum. The study was carried out in rice fields with resistance problems in two different locations, in the Black Sea and the Marmara Regions. The clamozone 480 EC, oxadiazon 200 CS, glyphosate potassium 441 g/l, glyphosate IPA 360 g/lt +carfentrazone-ethyl 5 g/l, cyhalofop-butyl 200 EC, penoxsulam 25.2 OD +bentazon-sodium 480 SL active ingredients and combinations' efficacy were investigated on ALS and ACCase inhibitor herbicides resistant *Cyperus difformis*, *Echinochloa oryzoides* and *Echinochloa crus-galli* populations. At the end of the study, it was determined that including pre-sowing herbicides such as clomazone and oxadiazon in the weed control program would help control the ALS and ACCase-resistant this species. Implementing integrated weed management strategies for managing existing herbicide-resistant weeds and reducing future development of herbicide resistance is one of our most influential and economical long-term strategies.

Keywords: Herbicide resistance, Pre-sowing herbicides, Rice, Weed

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1. Introduction

Weeds are very difficult to control in rice cultivation areas, and if not controlled, they cause more than 40% product loss (Busconi et al., 2012; Chauhan and Abugho, 2013). Because the rice production system is completely in an aquatic environment, we see that few but important weed species are adapted to this system. When we look at the weed species that are a problem in Asian, American and European countries where rice cultivation areas are dense, it is seen that the species of *Echinochloa, Cyperus* and *Alisma* genus cause significant problems and are difficult to control (Holm et al., 1977; Ruiz-Santaella et al., 2006; Talbert and Burgos, 2007; Mennan et al., 2012).

Weed competition is the primary pest for rice production, with yield reductions of more than 50% (Ziska et al., 2015). *Echinochloa crus-galli* (L.) P. Beauv. can cause more than 55% reduction in grain yield (Zhang et al., 2017), while competition with weedy rice can result in up to 72% reduction in the number of full grains (Martin and Tanzo, 2015). In addition to yield loss, rice weeds can reduce the land value (Ottis and Talbert, 2007), increase the soil seed bank (Bagavathiannan et al., 2011), and lead to price increases due to contaminated rice seeds. Rice growers worldwide rely heavily on herbicides for weed management (Rouse et al., 2018; Barber et al., 2022). However, chemical weed control and alternative integrated weed management strategies in rice production systems have evolved significantly over the years, along with rice herbicide properties and weed spectrum.

As in many developed countries, weed control in rice is carried out completely dependent on herbicides in Türkiye. It is seen that mainly ALS and ACCase inhibitor herbicides are used to control *Echinochloa* spp., *Cyperus difformis* L. and *Alisma plantago-aquatica* L. However, as a result of the use of this group of inhibitors in rice cultivation areas for a long time, resistance problems have emerged in different weed species belonging to these genera, and it has become impossible to control weeds at present (Itah et al., 1999; Park et al., 1999; Fischer et al., 2000). Mennan et al. (2012) investigated the populations of *Echinochloa oryzoides* L. and *E. crus-galli* resistant to ALS and ACCase inhibitor herbicides in the Marmara and Black Sea Regions rice cultivation areas. In recent years, the abandonment of some areas in rice cultivation due to herbicide resistance and leaving them after planting because they cannot be combated have reached dimensions that threaten agricultural production. In addition, studies have shown that the majority of resistant populations are metabolic; therefore, farmers try to dissolve the existing herbicides at 3-4 times the dose or by making many mixtures. As a result of the applications made, it is partially successful, but it also brings many problems with product safety.

Pre-emergence herbicide application is effective during the dry period for early weed emergence just before or after rice emergence (Singh et al., 2016; Mahajan and Chauhan, 2015), but a post-emergence herbicide application is required for the second spraying of weeds during the flood period (Jordan et al., 1998). A narrow time window (0 to 3 DAS (day after sowing)) requires highly effective pre-emergence herbicides (Mahajan and Chauhan, 2015) to provide season-long weed control (Helms et al., 1995).

The resistance to herbicides in weeds changes the spraying programs. In this case, to control populations resistant to ALS and ACCase inhibitor herbicides, developing and practising local integrated control techniques in our country and the rest of the world is necessary. From this point of view, it is essential to use herbicides effectively within the scope of integrated control, which is one of the issues that must be solved in order to prevent product loss in rice production. In Türkiye, two herbicides with active ingredients, clomazone and oxadiazon, are licensed as pre-sowing and early post-emergence. Although these two active ingredients have different properties, clomazone is more effective against *E. crus-galli* and oxadiazon is effective against *C. difformis*. However, it is not known what effect the combination of these two will have on *E. oryzoides*, which is one of the important problems. There is also apply of total herbicides before planting to break the resistance. In order to clarify this situation and to see a practical result, if any, considering the known ecological characteristics of these weeds, it is planned to develop an integrated control system with the application of glyphosate or glyphosate + carfentrazone at different times and in combination with other herbicides after emergence.

In this study, it was aimed to determine the chemical integrated control possibilities of *C. difformis*, *E. oryzoides* and *E. crus-galli* populations resistant to ALS and ACCase inhibitor herbicides, which were previously detected in rice cultivation areas of Marmara and Black Sea Regions, based on pre-sowing herbicide applications and some herbicide combinations.

2. Materials and Methods

The study was carried out in the rice fields with resistance problems in two different locations, in Samsun, representing the Black Sea Region, and in the center of Edirne, representing the Marmara Region, in the third week of May 2015 and 2016. Experiments were set up in a randomized block design with four replications, and the parcel sizes were set to 50 m^2 (10m x 5m). A safety strip of at least 2 m is left between the parcel and the blocks. The spray volume was 200 L ha^{-1} and applied using a compressed CO$_2$ sprayer system that had 8004 flat-fan nozzles with a pressure of three bars. A control parcel was also created. In addition to the control parcel, it was created in separate parcels where the producer's routine operations (3-4 herbicide applications) against the resistance problem will also occur. Thus, all applications had the chance to be compared.

Observations were made on different dates during the experiment depending on the application time. These were made 7 days after the first observation and 20 days after the second observation. In addition, checks were made every week to observe whether there were new exits.

The applications given below were carried out.

2.1. Clomazone and Oxadiazon Application

1. Clomazone 480 EC formulation was applied at 720-960 g a.iha^{-1} as a pre-sowing preparation dose, and then water was added to the pans by sowing within 1-2 days.
2. Oxadiazon 200 SC formulation was applied at 300-400 g a.iha^{-1} as a pre-sowing preparation dose, and then water was added to the pans by sowing within 1-2 days.
3. Clomazone 480 CS formulation and oxadiazon 200 SC were applied in a dose of 720+300 g a.i. ha^{-1} as a mixture before planting, and then water was added to the pans by sowing within 1-2 days.

2.2. Glyphosate (Glyphosate Potassium (441 g/l)) Application

4. 7 days before sowing (DBS), the pans were filled with water and kept in the pans, and the germination of weed seeds was encouraged. The water in the pans was drained, and a dose of 2205 g a.i. ha^{-1} glyphosate was applied as a preparation dose within 1-2 days.
5. 15 DBS, the pans were filled with water and kept in the pans, and the germination of weed seeds was encouraged. Afterwards, the water in the pans was drained, and then a dose of 2205 g a.i. ha^{-1} glyphosate was applied as a preparation dose within 1-2 days.
6. 21 DBS, the pans were filled with water and kept in the pans, and weed seeds germination was encouraged. Afterwards, the water in the pans was drained, and a dose of 2205 g a.i. ha^{-1} glyphosate was applied as a preparation dose within 1-2 days.

2.3. Glyphosate+Carfentrazone (Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l) Application

7. 7 DBS, the pans were filled with water and kept in the pans, and the germination of weed seeds was encouraged. Afterwards, the water in the pans was

drained, and a 720+10 g a.i. ha^{-1} dose of glyphosate+carfentrazon was applied as a preparation dose within 1-2 days.

8. 15 DBS, the pans were filled with water and kept in the pans, and weed seeds germination was encouraged. Afterwards, the water in the pans was drained, and a 720+10 g a.i. ha^{-1} dose of glyphosate+carfentrazon was applied as a preparation dose within 1-2 days.
9. 21 DBS, the pans were filled with water and kept in the pans, and weed seeds germination was encouraged. Afterwards, the water in the pans was drained, and a 720+10 g a.i. ha^{-1} dose of glyphosate+carfentrazon was applied as a preparation dose within 1-2 days.

The characters, doses and application periods used in the trials are given in Table 1.

Table 1. The characters, doses and application periods of herbicides used in the integrated control of *Echinochloa oryzoides, Echinochloa crus-galli* and *Cyperus difformis*.

No	Active ingredients and formulations	Dose (g a.i. ha^{-1})	Application periods (BBCH-scale)
1	Clomazone 480 EC	720	B 00
2	Clomazone 480 EC	960	B 00
3	Oxadiazon 200 CS	300	B 00
4	Oxadiazon 200 CS	400	B 00
5	Clomazone 480 EC+Oxadiazon 200 CS	720+300	B 00
6	Glyphosate potassium 441 g/l (7 DAT water apply)	2205	B 00
7	Glyphosate potassium 441 g/l (14 DAT water apply)	2205	B 00
8	Glyphosate potassium 441 g/l (21 DAT water apply)	2205	B 00
9	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (7 DAT water apply)	720+10	B 00
10	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (14 DAT water apply)	720+10	B 00
11	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (21 DAT water apply)	720+10	B 00
12	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC	720+300+700	B00 +B 12-14
13	Clomazone 480 EC+Oxadiazon 200 CS+Penoxsulam 25.2 OD	720+300+40,3	B 00 +B 12-14
14	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD	720+300+126	B 00 +B 12-14
15	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD +Bentazon-sodium 480 SL	720+300+126+720	B 00+B 12-14+ B 21-22
16	Control	-	

2.4. Statistical Analysis

The 0-100% scale specified by EWRS and WSSA was used to measure the activity levels of herbicides. Accordingly, 0% means no weed control, and 100% of weeds are completely controlled (Zandstra et al., 2003; Mennan et al., 2006). Arcsine transformation was applied to the obtained weed control percentage values to improve homogeneity before analysis of variance (ANOVA). The averages obtained in the experiment were separated by LSD (P<0.05) by applying Fisher's protected test, and then the results were grouped according to the Tukey test.

3. Results

Regarding herbicide applications in both regions (P<0.05), the interactions between regional and year were found to be insignificant, so the averages of both regions were combined. Considering the efficacy values obtained on the 7th day after the application, 1500+1500 cc ha^{-1} dose of the clamzone+oxadiazon mixture was found to be effective at an acceptable level against *E. oryzoides*, *E. crus-galli* and *C. difformis* (Table 2). When the efficacy values obtained on the 14th day from Table 3 are examined, results similar to the counts made on the 7th day were obtained. The clomazone + oxadiazon mixture gave excellent results in the control of three species. It is observed that there is a decrease in the effectiveness of glyphosate potassium application with quenching on the 7th day. Efficiency has decreased in these parcels with new exits. When we look at the glyphosate potassium application, no change was observed in the effectiveness of all three species as the number of days after the application increased (Table 2-3). Similar results were obtained in the application of glyphosate IPA + carfentrazone-ethyl, but the level of effectiveness was found to be higher. Clomazone + oxadiazon + cyhalofop-butyl (applied later) application showed an 85% efficiency as in the 5th application. Similar results were obtained in the applications numbered 13, 14 and 15 following this application (Table 1).

Considering the efficacy values obtained on the 14th day from Table 3, both doses of clomazone were successful, with an effect of over 90% on *E. oryzoides* and *E. crus-galli*. Similarly, both doses of oxadiazon were found to be effective against both *E. crus-galli* and *C. difformis*. No effect of this active substance on *E. oryzoides* was found. The clomazone + oxadiazon mixture gave an excellent result against all three species. In the application of glyphosate potassium, it is seen that there is a decrease in the effectiveness with quenching on the 7th day after the application. Efficiency has decreased in these parcels with new exits. On the other hand, the efficiency was found to be around 75% in the parcels where water was not given. Although similar results were obtained in the application of glyphosate IPA + carfentrazone-ethyl, the efficacy levels were found to be higher than glyphosate potassium (Table 3). Since the post-emergence applications to be made following clomazone + oxadiazon application have yet to be performed, the efficacy values obtained on the 14th day were found to be above 90%, as previously stated.

Considering the evaluations made on the 28th day, another counting period, from Table 4, the effectiveness of clomazone and oxadiazon applications was over 90%, as in the previous count. It is understood that very successful results were obtained in the parcels where these two active ingredients were applied together. Glyphosate potassium and glyphosate IPA + carfentrazone-ethyl applications decreased with quenching. Studies have shown us that these applications can be successful in the first weed emergence, but there is a need for post-emergence applications in the future. Post-emergence applications were also carried out in this counting period following the clomazone + oxadiazon application. However, these efficiencies above 90% come from pre-sowing applications. As it can be understood from here, the persistence and effectiveness of these active ingredients applied before planting continue on the 28th day.

A decrease in the efficacy of both doses of clomazone and oxadiazon started in the counts made on the 56th day after sowing. The activities decreased by 30-40% (Table 5). The effectiveness of glyphosate potassium and glyphosate IPA + carfentrazone-ethyl applications disappeared during these counting periods. Following the administration of clomazone + oxadiazon, the 3500 cc ha^{-1} dose of cyhalofop-butyl showed an efficiency of 75%. As can be seen from this, the dose of cyhalofop-butyl only contributed 10% in efficacy.

Table 2. Statistical grouping of herbicides used in the integrated control of *E. oryzoides*, *E. crus-galli* and *C. difformis* populations according to efficacy percentages on the 7th day after application in the biological efficacy trial of herbicides.

No	Active ingredients and formulations	Dose (g a.i. ha^{-1})	*E. oryzoides*	*E. crus-galli*	*C. difformis*
1	Clomazone 480 EC	720	85^{a}	85^{a}	0^{c}
2	Clomazone 480 EC	960	90^{a}	90^{a}	0^{c}
3	Oxadiazon 200 CS	300	20^{d}	65^{b}	95^{a}
4	Oxadiazon 200 CS	400	20^{d}	70^{b}	95^{a}
5	Clomazone 480 EC+Oxadiazon 200 CS	720+300	90^{a}	95^{a}	75^{b}
6	Glyphosate potassium 441 g/l (7 DAT water apply)	2205	50^{b}	55^{c}	65^{b}
7	Glyphosate potassium 441 g/l (14 DAT water apply)	2205	30^{cd}	30^{d}	60^{b}
8	Glyphosate potassium 441 g/l (21 DAT water apply)	2205	25^{cd}	30^{d}	60^{b}
9	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (7 DAT water apply)	720+10	55^{b}	55^{c}	70^{b}
10	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (14 DAT water apply)	720+10	50^{b}	50^{c}	70^{b}
11	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (21 DAT water apply)	720+10	40^{c}	50^{c}	75^{b}
12	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC	720+300+700	90^{a}	90^{a}	95^{a}
13	Clomazone 480 EC+Oxadiazon 200 CS+Penoxsulam 25.2 OD	720+300+40,3	90^{a}	95^{a}	95^{a}
14	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD	720+300+1126	90^{a}	100^{a}	95^{a}
15	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD +Bentazon-sodium 480 SL	720+300+1126+720	90^{a}	95^{a}	100^{a}
16	Control		0^{e}	0^{e}	0^{c}
	LSD (P<0.05)		7.88	9.56	8.53

*There is no difference at the level of (P<0.05) according to the Tukey test between the applications shown with the same letter in the columns.

Table 3. Statistical grouping of herbicides used in the integrated control of *E. oryzoides*, *E. crus-galli* and *C. difformis* populations according to efficacy percentages on the 14th day after application in the biological efficacy trial of herbicides.

No	Active ingredients and formulations	Dose (g a.i. ha^{-1})	*E. oryzoides*	*E. crus-galli*	*C. difformis*
1	Clomazone 480 EC	720	90^{a}	95^{a}	0^{d}
2	Clomazone 480 EC	960	95^{a}	100^{a}	0^{d}
3	Oxadiazon 200 CS	300	10^{e}	85^{ab}	95^{a}
4	Oxadiazon 200 CS	400	15^{e}	95^{a}	100^{a}
5	Clomazone 480 EC+Oxadiazon 200 CS	720+300	95^{a}	100^{a}	100^{a}
6	Glyphosate potassium 441 g/l (7 DAT water apply)	2205	40^{d}	50^{c}	45^{c}
7	Glyphosate potassium 441 g/l (14 DAT water apply)	2205	55^{c}	70^{b}	65^{b}
8	Glyphosate potassium 441 g/l (21 DAT water apply)	2205	55^{c}	75^{b}	65^{b}
9	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (7 DAT water apply)	720+10	60^{bc}	60^{b}	60^{bc}
10	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (14 DAT water apply)	720+10	65^{b}	75^{b}	75^{b}
11	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (21 DAT water apply)	720+10	70^{b}	70^{b}	80^{b}
12	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC	720+300+700	95^{a}	90^{a}	100^{a}
13	Clomazone 480 EC+Oxadiazon 200 CS+Penoxsulam 25.2 OD	720+300+40,3	95^{a}	95^{a}	100^{a}
14	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD	720+300+1126	95^{a}	100^{a}	100^{a}
15	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+ Penoxsulam 25.2 OD +Bentazon-sodium 480 SL	720+300+1126+720	100^{a}	100^{a}	100^{a}
16	Control		0^{e}	0^{d}	0^{d}
	LSD (P<0.05)		11.08	10.21	7.18

*There is no difference at the level of (P<0.05) according to the Tukey test between the applications shown with the same letter in the columns.

Table 4. Statistical grouping of herbicides used in the integrated control of *E. oryzoides*, *E. crus-galli* and *C. difformis* populations according to efficacy percentages on the 28th day after application in the biological efficacy trial of herbicides.

No	Active ingredients and formulations	Dose (g a.i. ha^{-1})	*E. oryzoides*	*E. crus-galli*	*C. difformis*
1	Clomazone 480 EC	720	90^{a}	95^{a}	0^{c}
2	Clomazone 480 EC	960	95^{a}	100^{a}	0^{c}
3	Oxadiazon 200 CS	300	0^{d}	85^{a}	95^{a}
4	Oxadiazon 200 CS	400	0^{d}	85^{a}	10^{bc}
5	Clomazone 480 EC+Oxadiazon 200 CS	720+300	95^{a}	100^{a}	100^{a}
6	Glyphosate potassium 441 g/l (7 DAT water apply)	2205	10^{d}	30^{c}	20^{bc}
7	Glyphosate potassium 441 g/l (14 DAT water apply)	2205	35^{c}	45^{c}	20^{bc}
8	Glyphosate potassium 441 g/l (21 DAT water apply)	2205	45^{bc}	45^{c}	20^{bc}
9	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (7 DAT water apply)	720+10	35^{c}	35^{c}	15^{bc}
10	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (14 DAT water apply)	720+10	55^{b}	45^{c}	20^{bc}
11	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (21 DAT water apply)	720+10	55^{b}	60^{b}	30^{b}
12	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC	720+300+700	95^{a}	95^{a}	95^{a}
13	Clomazone 480 EC+Oxadiazon 200 CS+Penoxsulam 25.2 OD	720+300+40.3	95^{a}	100^{a}	95^{a}
14	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD	720+300+1126	95^{a}	100^{a}	100^{a}
15	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+ Penoxsulam 25.2 OD +Bentazon-sodium 480 SL	720+300+1126 +720	95^{a}	95^{a}	100^{a}
16	Control				
	LSD (P<0.05)		10.69	12.14	8.41

*There is no difference at the level of (P<0.05) according to the Tukey test between the applications shown with the same letter in the columns.

Table 5. Statistical grouping of herbicides used in the integrated control of *E. oryzoides*, *E. crus-galli* and *C. difformis* populations according to efficacy percentages on the 56th day after application in the biological efficacy trial of herbicides.

No	Active ingredients and formulations	Dose (g a.i. ha^{-1})	*E. oryzoides*	*E. crus-galli*	*C. difformis*
1	Clomazone 480 EC	720	40 ^{c}	60 ^{c}	0 ^{c}
2	Clomazone 480 EC	960	50 ^{c}	65 ^{bc}	0 ^{c}
3	Oxadiazon 200 CS	300	0 ^{d}	40 ^{d}	65 ^{b}
4	Oxadiazon 200 CS	400	0 ^{d}	50 ^{cd}	70 ^{b}
5	Clomazone 480 EC+Oxadiazon 200 CS	720+300	55 ^{c}	70 ^{b}	70 ^{b}
6	Glyphosate potassium 441 g/l (7 DAT water apply)	2205	0 ^{d}	0 ^{e}	0 ^{c}
7	Glyphosate potassium 441 g/l (14 DAT water apply)	2205	0 ^{d}	0 ^{e}	0 ^{c}
8	Glyphosate potassium 441 g/l (21 DAT water apply)	2205	0 ^{d}	0 ^{e}	0 ^{c}
9	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (7 DAT water apply)	720+10	0 ^{d}	0 ^{e}	0 ^{c}
10	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (14 DAT water apply)	720+10	0 ^{d}	0 ^{e}	0 ^{c}
11	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (21 DAT water apply)	720+10	0 ^{d}	0 ^{e}	0 ^{c}
12	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC	720+300+700	60 ^{b}	70 ^{b}	95 ^{a}
13	Clomazone 480 EC+Oxadiazon 200 CS+Penoxsulam 25.2 OD	720+300+40.3	70 ^{b}	70 ^{b}	80 ^{b}
14	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD	720+300+1126	100 ^{a}	100 ^{a}	100 ^{a}
15	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+ Penoxsulam 25.2 OD +Bentazon-sodium 480 SL	720+300+1126+720	100 ^{a}	95 ^{a}	100 ^{a}
16	Control		0 ^{d}	0 ^{e}	0 ^{c}
	LSD (P<0.05)		8.44	10.52	11.36

*There is no difference at the level of (P<0.05) according to the Tukey test between the applications shown with the same letter in the columns.

Table 6. Statistical grouping of herbicides used in the integrated control of *E. oryzoides*, *E. crus-galli* and *C. difformis* populations, according to pre-harvest percentages activity in the biological activity trial.

No	Active ingredients and formulations	Dose (g a.i. ha^{-1})	*E. oryzoides*	*E. crus-galli*	*C. difformis*
1	Clomazone 480 EC	720	0 ^{c}	0 ^{c}	0 ^{c}
2	Clomazone 480 EC	960	0 ^{c}	0 ^{c}	0 ^{c}
3	Oxadiazon 200 CS	300	0 ^{c}	0 ^{c}	30 ^{b}
4	Oxadiazon 200 CS	400	0 ^{c}	0 ^{c}	30 ^{b}
5	Clomazone 480 EC+Oxadiazon 200 CS	720+300	0 ^{c}	20 ^{b}	30 ^{b}
6	Glyphosate potassium 441 g/l (7 DAT water apply)	2205	0 ^{c}	0 ^{c}	0 ^{c}
7	Glyphosate potassium 441 g/l (14 DAT water apply)	2205	0 ^{c}	0 ^{c}	0 ^{c}
8	Glyphosate potassium 441 g/l (21 DAT water apply)	2205	0 ^{c}	0 ^{c}	0 ^{c}
9	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (7 DAT water apply)	720+10	0 ^{c}	0 ^{c}	0 ^{c}
10	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (14 DAT water apply)	720+10	0 ^{c}	0 ^{c}	0 ^{c}
11	Glyphosate IPA 360 g/lt+Carfentrazone-ethyl 5 g/l (21 DAT water apply)	720+10	0 ^{c}	0 ^{c}	0 ^{c}
12	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC	720+300+700	25 ^{b}	20 ^{b}	35 ^{b}
13	Clomazone 480 EC+Oxadiazon 200 CS+Penoxsulam 25.2 OD	720+300+40.3	30 ^{b}	30 ^{b}	30 ^{b}
14	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+Penoxsulam 25.2 OD	720+300+1126	95 ^{a}	95 ^{a}	100 ^{a}
15	Clomazone 480 EC+Oxadiazon 200 CS+Cyhalofop-butyl 200 EC+ Penoxsulam 25.2 OD +Bentazon-sodium 480 SL	720+300+1126+720	95 ^{a}	95 ^{a}	100 ^{a}
16	Control		0 ^{c}	0 ^{c}	0 ^{c}
	LSD (P<0.05)		4.52	11.63	9.58

*There is no difference at the level of (P<0.05) according to the Tukey test between the applications shown with the same letter in the columns.

It shows the level of endurance. 1500 cc ha^{-1} dose of penoxsulam following clomazone + oxadiazon application created a 5-10% difference compared to cyhalofop-butyl application. In another application, 5000 cc ha-1 dose of cyhalofop-butyl + penoxsulam followed by clomazone + oxadiazon application, and cyhalofop-butyl + penoxsulam + bentazone-sodium applications following clomazone + oxadiazon application were found to be successful with an effect of over 90%.

In the last count made before harvest, 5000 cc ha^{-1} dose of cyhalofop-butyl + penoxsulam following clomazone + oxadiazon application and clomazone + oxadiazon application followed by cyhalofop-butyl + penoxsulam + bentazone-sodium applications, as can be seen in Figures 1 and 2 showed that 90% and a clean field before harvest (Table 5).

Figure 1. The view from cyhalofop-butyl penoxsulam parcels after pre-sowing clomazone + oxadiazon application.

Figure 2. The view from cyhalofop-butyl penoxsulam + bentazon-sodium parcels after pre-planting clomazone + oxadiazon application.

4. Discussion

Weed species that are a problem in rice cultivation areas also have adapted to this ecosystem (Holm et al., 1977). Rice is grown as a monoculture due to both the environment in which it is grown and its yield. The most natural result of years of monoculture production system and weed control in this product directly dependent on herbicides is the problem of resistance. As in many countries where rice is grown, Türkiye's herbicide resistance problem has peaked (Juliano et al., 2010; Mennan et al., 2011; Heap, 2012). Another critical problem in this regard is the prohibition of many herbicides within the European Union harmonisation laws. The lack of new herbicides with alternative mechanisms of action has made the situation more dramatic.

The development of integrated control systems that are less dependent on chemical control will make an important contribution to the control of weeds resistant to ALS and ACCase inhibitor herbicides (Itah et al., 1999; Fischer et al., 2000; Perron and Legere, 2000). The study's findings were supported by revealing that an integrated weed control approach, accompanied by an appropriate spraying program, provides efficacy in resistant weeds (Bajwa et al., 2015). It has been demonstrated that pre-sowing herbicides and combinations are highly effective, providing control over standard practices against *E. crus-galli*, *E. oryzoides,* and *C. difformis* resistant to ALS and ACCase inhibitor herbicides when supplemented with post-emergence herbicide treatment.

Implementing alternative integrated weed management practices is often more cumbersome and can increase emergency weed management costs. However, as the focus shifts from short-term to long-term economics and the potential for widespread, multi-domain resistance to nullify herbicides, the chemical costs of weed control will increase drastically (Davis and Frisvold, 2017). Implementing integrated weed management strategies for managing existing herbicide-resistant weeds and reducing future development of herbicide resistance is one of our most influential and economical long-term strategies. Educational campaigns are needed to increase adoption, emphasising the economic benefits of integrated weed management strategies (Llewellyn et al., 2004).

5. Conclusion

In studies on pre-planting herbicide applications and some herbicide combinations based on the pre-sowing herbicide applications of *C. difformis*, *E. oryzoides*, and *E. crus-galli* populations resistant to ALS and ACCase inhibitor herbicides, it was determined that pre-sowing applications such as clomazone and oxadiazon reduced weed pressure. The application of this herbicide mixture before sowing and after the emergence of cyhalofop-butyl + penoxsulam gave successful results in many cases.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	E.K.A.	H.M.
C	50	50
D	50	50
S	30	70
DCP	50	50
DAI	20	80
L	80	20
W	90	10
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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