NEW RESEARCH ON THE STUDY OF SELECTIVITY AND EFFICACY OF TREATMENTS ON WEED CONTROL FOR THE MAIZE CROP

Mihaela ŞERBAN[1], Gheorghe MĂTURARU[1], Cătălin LAZĂR[1]

e-mail: erbicide.incda@yahoo.com

Abstract

This paper present the results obtained at National Agricultural Research and Development Institute Fundulea, during 2019-2020, according to the new herbicide treatments: Diniro (prosulfuron 40 g/kg + dicamba 400 g/kg + nicosulfuron 100 g/kg) + Trend (adjuvant); Radial 40 (40 g/l nicosulfuron) + Dicopur Top (344 g/l acid 2,4 D from DMA salt and 120 g/l dicamba); Principal plus (50 g/kg dicamba + 92 g/kg nicosulfuron + 23 g/kg rimsulfuron) +Trend (adjuvant); Radial 60 (60 g/l nicosulfuron) + Hudson (fluroxypyr 200 gr/l), postemergently applied - BBCH 14-16, maize 4-6 leaves-, for the annual and perennial weeds controlling from the maize crop. The weather from the experimentation years is representative for the local trend for last decade. The differences (5.64 t/ha in average) between yields of control plots and the yields of treated plots were significant in all years, but the differences within the yields of treated plots were not significant. The herbicides must be correlated with the infestation degree of weed, the spectrum and dominance of weeds, the time of application, the technical potential for efficacy, the local climatic conditions.

Key words: weeds, herbicides, time of application, dose, selectivity and efficacy.

In general, the areas cultivated with corn show a strong degree of infestation (over 80%) with annual and perennial monocotyledonous and dicotyledonous weeds, extremely differentiated according to the zonal pedoclimatic conditions. The most representative weed species are: monocotyledons (*Setaria* sp., *Echinochloa crus-galli*, *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 A. *et al*, 2009).

In the field of weed control in field crops, the main objective is to permanently eliminate weed competition below the damage threshold throughout the growing season, in order to reduce water and nutrient consumption by them, so that plants continue to grow. culture to have a normal development, which will lead, in the end, to obtaining high yields, qualitative and at the level of the biological potential of the hybrids and cultivated varieties. (Popescu A., 2007)

Weeds have the greatest negative impact, around 37%, compared to insects (18%), fungi and bacteria (16%) and viruses (2%) (Oerke E.C., 2006).

The magnitude of the loss is related to the composition of the weed flora, weed emergence timing in relationship to the crop, weed density, intensity, and crop development stage in relation to the period of competition (Singh *et al*, 2016). The competition with maize in the stage of 5 fully expanded leaves has the most negative interference to the crop, since it is in this phase that the components related to grain yield are established (Duarte N.F. *et al*, 2002).

However, maize productivity is lower than that obtained in areas that adopt high technological levels or experimental areas, because it is affected by several factors. Weed competition is the primary factor limiting maize's full productive potential, therefore, there is an increase interest in weeds negative impacts on yield. (Safdar M.E. *et al*, 2015)

Herbicides will remain in future agriculture an efficient tool for control of weeds as part of an integrated weed control. The application of herbicides requires only a quarter of the fuel used than one passage over the same surface with a row crop cultivator (Gianessi L., 2013)

The aim of the research was to identify technological solutions to control the annual and perennial weeds present in the corn crop by using

[1] National Agricultural Research and Development Institute (NARDI), Fundulea, Romania

new herbicide treatments, aiming to broaden the control spectrum, synergism, persistence and without negative impact on the environment. The main objective of this paper focused on the study of selectivity and effectiveness of the application of herbicide treatments in the control of annual and perennial monocotyledonous and dicotyledonous weeds in maize.

Table 1

The herbicide treatments applied in the maize crop. Experimental variants

No var	Herbicides treatments	Active ingredient	Dose g,l /ha	Time of application
1	Untreated	-	-	-
2	Diniro + Trend (Adj.)	prosulfuron 40 g/kg + dicamba 400 g/kg + nicosulfuron 100 g/kg	500 g + 0.25 l	Postemergence BBCH 14-16 (maize 4-6 leaves)
3	Radial 40 + Dicopur Top	40 g/l nicosulfuron + 334 g acid 2.4 D from salt of DMA + 120 g/l dicamba	1.0 l + 1.0 l	
4	Principal plus + Trend (Adj.)	(50 g/kg dicamba + 92 g/kg nicosulfuron + 23 g/kg rimsulfuron)	440 g + 0.25 l	
5	Radial 60 + Hudson	60 g/l nicosulfuron + fluroxypyr 200 gr/l	0.7 l + 1.0 l	

Table 2

Monthly sum of precipitation (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
LTA (1968-2017)	32.2	31.9	37.0	46.4	60.9	76.5	74.3	53.5
2019	53.8	21.4	22.4	51.4	124.2	74.6	87.4	12.6
2020	2.0	16.6	29.8	14	58.0	68.4	34.2	5.4
2021	77.0	16.2	59.0	31	57.6	135.0	21.2	24.4
St. Dev. LTA	18.6	23.6	26.0	23.2	45.2	45.3	48.4	36.2

Table 3

Monthly average temperature (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
LTA (1968-2017)	-2.2	-0.4	5.0	11.2	17.1	20.8	22.8	22.3
2019	-1.2	3.8	9.3	11.2	17.2	23.6	23.0	24.7
2020	0.9	5.2	8.3	12.3	17.0	21.7	25.1	25.5
2021	1.6	3.2	5.1	9.7	17.2	21.1	25.3	24.2
St. Dev. LTA	2.4	3.4	2.4	1.6	1.5	1.4	1.6	1.7

MATERIAL AND METHOD

The research was carried out in the period 2019-2021, at the National Institute for Agricultural Research and Development - Fundulea, being studied the application of new herbicide treatments at the maize crop. The research was carried out in the experimental field, the experiment being located on a soil of cambic chernozem type (3.2% organic matter, 37% clay, 6.5 pH), using the Iezer corn hybrid created by the institute from Fundulea.

The Iezer hybrid is part of the FAO 401-500 group, with a vegetation period of 130-135 days. The plant is tall, vigorous, the average height is 270 - 280 cm, the insertion height of the cob is 100 - 110 cm. The stem has a medium thickness, elastic, with a very good resistance to breaking and falling. It is resistant to breaking and falling, resistant to drought and heat, resistant to common embers and fusariosis, resistant to *Ostrinia nubilalis* (Georgescu E. *et al*, 2013) and *Helicoverpa zeae*.

The organization of the experiment was done according to the method of randomized blocks, with a plot area of 25 m^2, in four replications, the amount of water used was 300 l/hectare. In this experiment, we observed the degree of selectivity of maize plants and the degree of control of annual and perennial monocotyledonous and dicotyledonous weeds by applying herbicide treatments (table 1): Diniro (prosulfuron 40 g / kg + dicamba 400 g / kg + nicosulfuron 100 g / kg) + Trend (adjuvant); Radial 40 (40 g / l nicosulfuron) + Dicopur Top (344 g / l 2.4 D acid from DMA salt and 120 g / l dicamba); Principal plus (50 g / kg dicamba + 92 g / kg nicosulfuron + 23 g / kg rimsulfuron) + Trend (adjuvant); Radial 60 (60 g / l nicosulfuron) + Hudson (fluroxypyr 200 gr / l).

The herbicide treatments were applied in the post-emergence (growth and development stage of maize cultivation: BBCH 14-16, 4-6 leaves) and weed development stage (monocotyledons: BBCH 11-14 and dicotyledons: BBCH 12-15). After the application of herbicide treatments, observations of selectivity (%) of maize plants were made at different intervals (7 - 14 - 21 days after the application of treatments) and the degree of control (%) of weeds at different intervals 14 - 21 days from the application of treatments).

The mean air temperature for March-August was 1.6°C above the long-term average in 2019, with 1.8°C in 2020 and 0.6 in the last year of the experience. Only the two months were cooler than LTA (May 2020 with – 0.1°C and April 2021 with - 1.5 °C). August was hotter than usual +1.9 to +3.6 C in all three years, but the largest difference was recorded in March 2019 (+ 4.3 C). The season 2019 may be considered as slightly wetter than usual (+24 mm more than LTA) with some good rains in May, season 2020 was very dry (-139 mm bellow LTA) and 2021 was slightly drier than usual (- 20 mm less than LTA).

Several R libraries like "*tidyverse*", "*ggpubr*", "*emmeans*" and "*rstatix*" were used for yield data visualization and group comparison (Kassambara A., 2019).

RESULTS AND DISCUSSIONS

The experience of maize realized in the experimental field showed an infestation degree of 74% (with monocotyledonous and dicotyledonous weeds - ratio of 60/40), in the culture being present the monocotyledonous and dicotyledonous annual and perennial weeds extremely diversified, depending on: the pre-emergent plant, the local pedo-climatic conditions. The most representative weed species were monocotyledons: *Setaria viridis*, *Echinochloa crus-galli*, *Sorghum halepense* and annual dicotyledonous *Chenopodium album*, *Xanthium strumarium*, and perennial: *Cirsium arvense* (*Figure 1*).

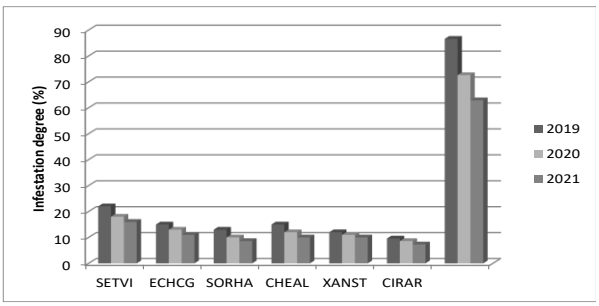

Figure 1 **The infestation degree (%) with annual and perennial weeds from the untreated maize plots**

In the experimental field, all the selectivity observations made for the cultivated hybrid- Iezer, not recorded phytotoxic phenomena (EWRS scale = 0).

In the corn crop, the herbicide treatments applied post-emergence (BBCH 14-16, corn 4-6 leaves) had a good control effect, highlighting their effectiveness through a single application. By applying the new treatments with herbicides, good results were obtained regarding the effect of combating annual and perennial weeds, depending on: the climatic conditions, the degree of infestation, the spectrum and the dominance of the species present in this crop.

Figure 2 shows the average effectiveness results recorded after the post-emergence application of the treatment with Diniro (500 g/ha) + Trend (0.25 l/ha - Adjuvant). The activity of the product is based on two different modes of action: prosulfuron and nicosulfuron are sulphonylurea herbicides whose activity is based on blocking cell division in the growth tips, while dicamba is a growth regulator. Due to the application of this herbicide, a high degree of control was obtained for the following species: *Setaria viridis* - 97%, *Sorghum halepense* - 98% and *Echinochloa crus-galli* -95%. Regarding the annual dicot species *Chenopodium album*, control was very good, over 99%. On the other hand, in the plots under this treatment the weed species *Xanthium strumarium* (annual dicotyledon) and *Cirsium arvense* (perennial dicotyledon), the average effectiveness was 95% and 96%, respectively.

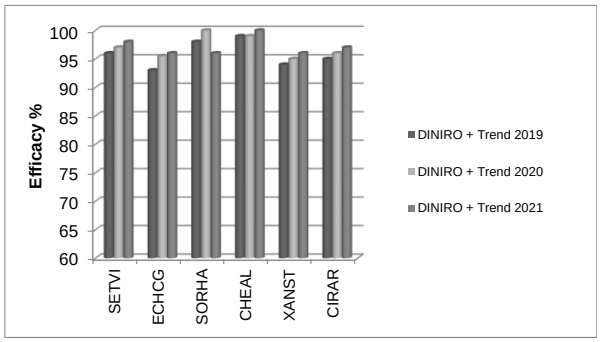

Figure 2 **The efficacy (%) of the herbicides Diniro (500 g/ha) + Trend (0.25 l/ha) on annual and perennial weeds control from the maize crop (Fundulea, 2019-2021)**

The next variant treated was with the combination of Radial 40 (1.0 l/ha) and Dicopur top herbicides (1.0 l/ha). Radial 40 is applied only post-emergence and is quickly absorbed especially by the leaves, but also by the roots of the weeds. The weeds stop growing, then after they turn red, etiolate and necroses appear. Dicopur top is a combination of two active substances, it is a selective and systemic herbicide that acts on weeds through absorption, both at the level of the leaves and at the root level. Following the application of this treatment, a good control effect of 93% was recorded for the weed species *Setaria viridis* and *Echinochloa crus-galli*. On the species *Sorghum halepense* it showed a very good control effect of 97%.

In the plots where this treatment was applied, a good control effect of 96% was obtained for the annual dicotyledon - *Chenopodium album*. For the other species *Xanthium strumarium* - annual dicotyledon and *Cirsium arvense* - perennial dicotyledon, the control effect was 92% (*Figure 3*).

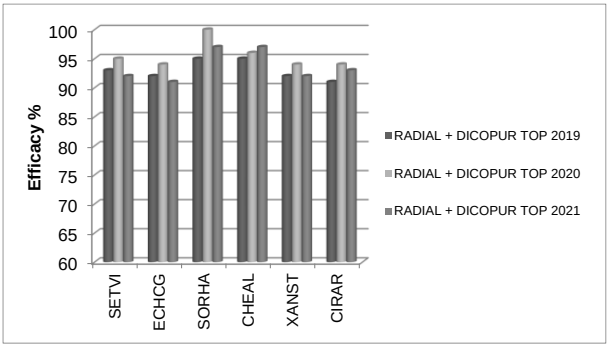

Figure 3 **The efficacy (%) of the herbicides Radial 40 (1.0 l/ha) + Dicopur Top (1.0 l/ha) on annual and perennial weeds control from the maize crop (Fundulea, 2019-2021)**

Figure 4 shows the average efficacy results (%) recorded after the post-emergence application of the treatment with Principal plus (440 g/ha) + Trend (0.25 l/ha). This herbicide is absorbed through the leaves and is quickly systemically distributed in all the organs of the plant and is specially designed to combat monocotyledonous and dicotyledonous weeds in corn culture.

In the three years of research, the results obtained show a good control effect (95 - 97%) for annual monocotyledons: *Setaria viridis* (SETVI), *Echinochloa crus-galli* (ECHCG). The species *Sorghum halepense* (SORHA) has been completely combated. Following this treatment for the annual dicotyledonous species, a good degree of control was obtained, respectively *Chenopodium album* (CHEAL) - 99% and *Xanthium strumarium* (XANST) - 96%. In contrast, the perennial dicotyledonous species, *Cirsium arvense* (CIRAR) showed a good efficacy of 95%.

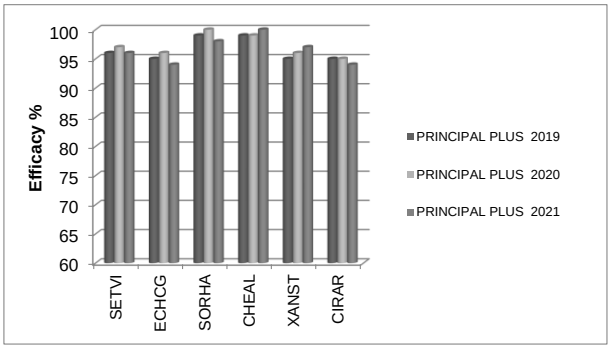

Figure 4 **The efficacy (%) of the herbicides Principal plus (440 g/ha) + Trend (0.25 l/ha) on annual and perennial weeds control from the maize crop (Fundulea, 2019-2021)**

Figure 5 shows the average efficacy results recorded after postemergence (BBCH 14-16, stage of growth and development of maize 4-6 leaves) applications of the herbicide combination Radial 60 (0.7 l/ha) + Hudson (1.0 l/ha). Hudson is absorbed in plants through the leaves and is quickly translocated throughout the plant. Sensitive weeds stop growing, discolor and die).

The results obtained show a superior control effect (99 - 97%) for the monocotyledonous species *Setaria viridis* (SETVI), *Echinochloa crus-galli* (ECHCG) and *Sorghum halepense* (SORHA) - 100%.

Following this treatment for the annual dicotyledonous species: *Xanthium strumarium* (XANST) - 94% and *Chenopodium album* (CHEAL) - 99%, a higher degree of control was obtained. This herbicide combination had a moderate efficacy of 72% on *Cirsium arvense* (CIRAR). This perennial dicotyledonous weed shows a certain degree of resistance to this herbicide combination (*Figure 5*).

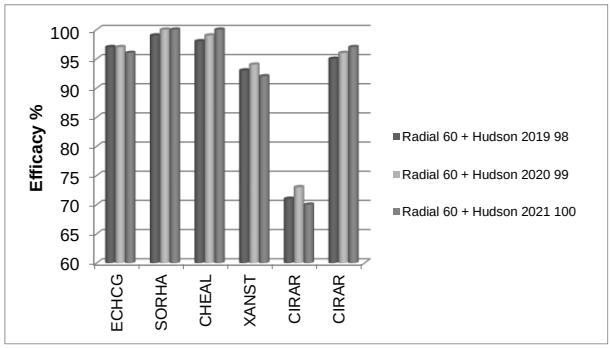

Figure 5 **The efficacy (%) of the herbicides Radial 60 (0.7 l/ha) + Hudson (1.0 l/ha) on annual and perennial weeds control from the maize crop (Fundulea, 2019-2021)**

The Shapiro-Wilk's tests and the visual inspection of the quantile-quantile plots suggest that data for maize yields within each treatment may have a normal distribution (*Figure 6*). For Radial + Hudson applications (treatment 5) one point appear as outlier, but it is not an extreme point its distance from the first quartile (Q1) is smaller than 1.5 interquartile range (IQR).

The p-value Levene's test ($p = 0.647$) indicated that there are no significant differences between the variances of yields obtained under different treatments. If the yields from all the treatments are examined across the three experimental years, the data points from the control treatments are placed clearly bellow the confidence interval (*Figure 7*).

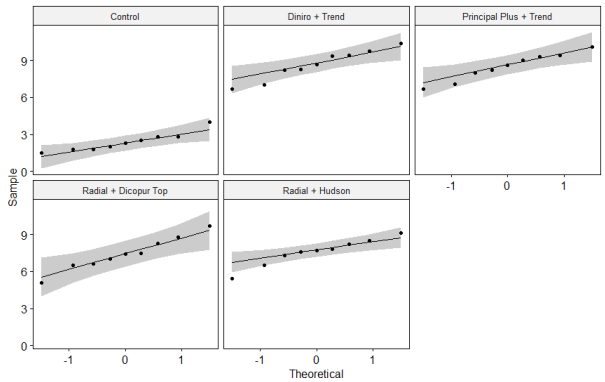

Figure 6 **The quartile -quartile (Q-Q) plot for maize yield under the five treatments for weed control**

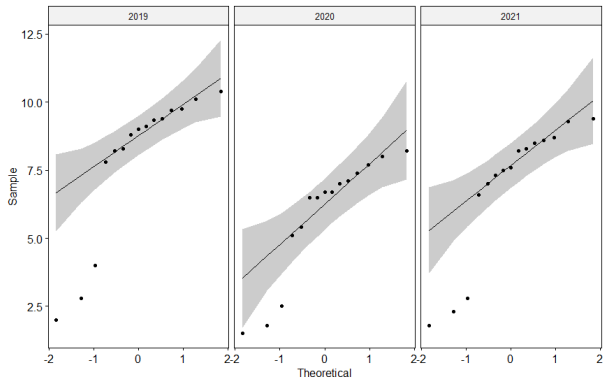

Figure 7 **The quartile - quartile (Q-Q) plot for maize yield in the three years of experimentation**

The Tuckey's HSD test used for the examinations of the differences between treatments (pooling the values from all three years) suggested that there are significant differences between control and each treatment but no significant differences within the treatments based on the tested herbicides (*Figure 8*).

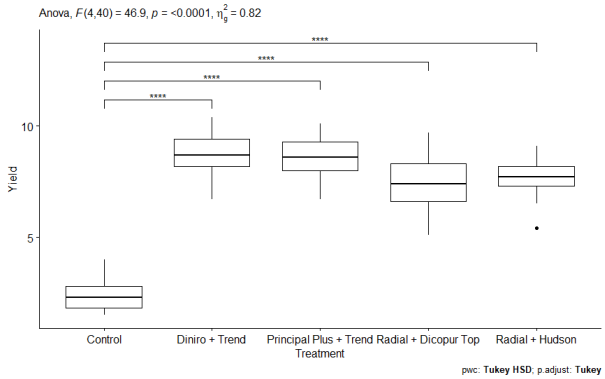

Figure 8 **The maize yields (t/ha) under the five experimental treatments (data pooled from the three experimental years).**

The averages yield (3 years) for Control was 3.7 t/ha, meanwhile the plots treated with Radial + Dicopur Top, Radial + Hudson, Principal Plus + Trend and Diniro + Trend, achieved average yields of 7.4, 7.7, 8.5 and respective 8.6 t/ha.

The chemical control of the weed species existing in the maize culture, on the type of cambic chernozem soil from Fundulea, represents an especially important and necessary technological measure.

In our country, special attention is paid to the control of annual and perennial monocotyledonous and dicotyledonous weed species by using and applying new herbicide treatments due to the degree of weeding, dominant and diversified spectrum of annual and perennial weeds present in the corn crop.

CONCLUSIONS

The maize crop showed a high degree of weeding and diversified with characteristic monocotyledonous weed species: *Setaria viridis*, *Echinochloa crus- galli*, *Sorghum halepense* and annual and perennial dicotyledons: *Chenopodium album*, *Xanthium strumarium*, *Cirsium arvense*.

Treatments with post-emergence herbicides applied (BBCH 14-16, stage of growth and development of corn 4-6 leaves) did not register phytotoxic phenomena for the cultivated corn hybrid - Iezer.

In the 2019-2021 research years, the use and application of new treatments with post-emergent applied herbicides (BBCH 14-16, stage of growth and development of corn 4-6 leaves) had a good control effect, highlighting their effectiveness through a single application.

The degree of control of herbicide treatments depends on the level of infestation, dominance, weed spectrum, applied dose and climatic conditions.

The differences (5.64 t/ha in average) between yields of control plots and the yields of treated plots were significant in all years, but the differences within the yields of treated plots were not significant.

The application of treatments with post-emergent herbicides is an advantageous technological link because controls a wide and diversified spectrum of annual and perennial weeds

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