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WEEDS MANAGEMENT ON A PREMIUM WHEAT CROP (JOSEF VARIETY) IN MONOCULTURE AND IN A 4 YEARS CROP SYSTEM, IN BURNAS PLAIN (ROMANIA)

Mihai BERCA[1], Valentina-Ofelia ROBESCU[2], Roxana HOROIAȘ[3]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania, Email: prof.mihai.berca@gmail.com
[2]Valahia University of Targoviste, 2 Regele Carol I Blvd., 130024, Targoviste City, Romania, Email: robescu_ofelia@yahoo.com
[3]Probstdorfer Saatzucht Romania SRL, 20 Siriului Street, 014354, District 1, Bucharest, Romania, Email: roxana.horoias@gmail.com

Corresponding author: prof.mihai.berca@gmail.com

Abstract

In a trifactorial experiment, crop rotation x years x treatments, performed in the south of Romania, on the leached chernozem soil from the Burnas Plain, some concrete results have been obtained. There is a negative correlation between the degree of crop weeding and the level of Josef wheat yield. In monoculture, after 10 years of experimentation, about 40 t weeds biomass/ha have been registered (5 → 40). Over the same period, yield decreased from 62 q/ha to about 23 q/ha (–39 q/ha). Carrying out two herbicide treatments (autumn and spring) reduced the weeds quantity to 15 t/ha, ie three times lower, and the yield from 62 to 35 q/ha (–27 q/ha) at the end of the research period. Herbicide treatments performed on the farm model have been ineffective in wheat monoculture. In crop rotation, decreases in yields without treatments, after 10 years, are significant, but without exceeding 10 q/ha. Under treatment conditions, in the 4-years crop rotation (peas-wheat-rape-wheat = P-W-R-W) the harvest level remains uniform or slightly increases, from 61 to 63 q/ha (insignificant). The lack of herbicides reduces yields twice as much in monoculture, compared to crop rotation. Monoculture also reduces the effect of herbicide treatments. In addition to the accumulation of a much larger biomass of weeds, there are also hard-to-fight species, such as Cirsium, Convolvulus, Matricaria. *The density of annual and even perennial grasses (*Avena fatua, Setaria glauca *and* Sorghum halepense*) also increases.*

Key words**:** *: wheat, monoculture, crop rotation, weed biomass, Burnas Plain*

INTRODUCTION

Wheat is the second largest crop in the world and is the main food of mankind, the product being demanded for consumption in increasing quantities, due to the exponential growth of the world's population (Berca et al., 2012; Lyon & Medlin, 2010) [4, 12]. Currently, there is a tendency to reduce the land areas allocated to wheat and other crops. At least in developed countries, genetics has also reached its limits (van Frank et al., 2020) [17], the possibilities for increasing the production of varieties being extremely close to the species' limits (Balfourier et al., 2019) [3]. Under these conditions, Romanian and international agriculture has only one solution, namely searching on the technological chains of the links that, through optimization, still allow an increase in yield's quantity and quality (Adkhamovich et al., 2020; Liebman & Dyck, 1993) [1, 11]. One of these links is weed management in wheat crop, formulated by more and more authors (Gaweda & Kwiatkowki, 2012; Legere and Stevenson, 2002; Shahzad et al., 2016; Weiner et al., 2001) [7, 10, 16, 18]. In the perspective of the cited authors, in monoculture weed control becomes problematic due to the continuous use of the same herbicide, which led to the emergence of resistance and/or to changes in the spectrum of species.

Many studies are also showing that the need for herbicides application in crop rotations is much lower than in monoculture, easily observed in agricultural practice. Are mostly recommend three-year crop rotations, with a legume (Khan et al., 2013) [9] or, alternatively, with rape (Naeem et al., 2012) [14]. In this case, the estimated costs are up to

35% lower for herbicides and nitrogen, 26% for primary energy, while the net margin is 12% higher (ARVALIS, 2018) [2].

In a long-term study (29 years) performed by Wozniak A. (2019) [19] in southern Poland, a cereal monoculture was compared with a pea – wheat/triticale rotation, concluding that the number and weight of weeds were higher by 57.1% and 75%, respectively, and the yield was 32% lower in monoculture, compared to the used crop rotation system.

In the Romanian space, Bogdan et al. (2007), Ionescu (2011), Petcu & Ioniță (1998) [6, 8, 15] demonstrated that the reduction of weeds in wheat are positively correlated with the 3-4 years crop rotation and with the specific works applied to the soil (MacLaren et al., 2021) [13].

In this context, the purpose of the paper was to analyze weeds management on a Premium wheat crop (Josef variety) based on a trifactorial experiment, crop rotation x years x treatments, performed in the South of Romania, on the leached chernozem soil from the Burnas Plain. The research work is a continuation of the experiments made in the previous years (Berca et al, 2020) [5].

MATERIALS AND METHODS

In the present paper, in a 10-year experience, the evolution of weeding and of wheat yield in monoculture, compared to a four-year crop rotation with peas - wheat - rapeseed - wheat (P-W-R-W) has been followed.

Starting from the practical needs in Southern Romania, the following parameters have been studied, measured and calculated:

(i)the extent to which the long-term wheat monoculture (10 years) influences the dynamics of the weeding incidence, as well as the change of their componence;

(ii)the effect of a rotation that includes an ameliorating plant (pea) and of a crop rotation type P-W-R-W on the degree of weeding and on the yields level;

(iii)the correlation between the weeding dynamics and the evolution of yields for the Josef premium wheat variety.

The objectives of the research topic were achieved by placing in the field, in the Burnas Plain, an important agricultural area from south Romania, an experience in conditions of production. The result was a multifactorial experience consists of: crop rotation x treatments x years of experimentation, which was statistically processed by dispersion analysis and correlation analysis in 2D and 3D.

Performed calculations were first collected in tables, then presented in the form of graphs and focused on two directions – the yield dynamics and the correlations between weeding degree and yields, depending on the other factors that enter into the equation (herbicide, years of experimentation).

It should be noted that the climatic conditions weren't taken into account, being very different from one year to another and with a very significant influence, in most cases. The comparison was only made concerning the used agrotechnics in the case of wheat cultivation. Because it's well-known in the area, Josef premium wheat variety was used, with which other experiments on nutrition and crop rotation were carried out in the past years. Weighing the weeds in their natural state (weed biomass) was performed every year when the wheat was ripe, in four repetitions, according to the same method used for measuring the production.

RESULTS AND DISCUSSIONS

The determinations carried out showed that in wheat crop, both in monoculture and in crop rotation, the following weeds are present: *Veronica hederifolia*, *Polygonum aviculare*, *Galium aparine* and Avena *fatua*. These species occupy over 65% of the weeding quantity in wheat crop, with the specification that the ratio between species is continually changing, especially in the direction of advancing monoculture from the third to the tenth year. In monoculture, especially after the fifth year, species that are characteristic of other crops appeared, such as *Stellaria media*, *Setaria glauca*, *Polygonum convolvulus*, *Chenopodium album*, *Matricaria* sp. and even the perrenials *Sorghum halepense* and *Cirsium arvense* (Photo 1).

Photo 1. Field cultivated with wheat in monoculture (7 years), treated with herbicides, full of weeds, especially *Sorghum halepense* și *Matricaria* sp. (2010, Alexandria)
Source: Original.

These weeds have also emerged considering the thinning of the wheat crop due to the phenomenon of soil fatigue. It was found, for example, that the *Amaranthus aritis* specie, which usually appears in the late wheat monoculture, in April, it disappears towards the end of May, without fruiting. Instead, perennial species increase their territory in clusters.
Dynamic comparisons regarding the effects of monoculture and P-W-R-W crop rotation system on wheat yield are shown in Figure 1 and Figure 2.

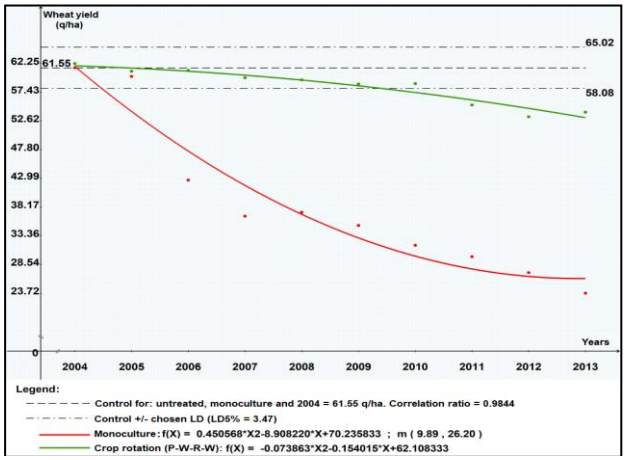

Fig. 1. Dynamics of wheat yield in monoculture and crop rotation, without herbicide treatment
Source: Own results.

Figure 1 is valid for the situation in which no herbicide treatments have been performed. In monoculture, the yield decreases after a quadratic polynomial function, from 61.55 q/ha to 23.72 q/ha, i.e. a very significant decrease of 37.83 q/ha. Relatively, it was a loss of 61.4%.
Under the conditions of crop rotation with ameliorating plant (peas) there is a decrease in yield which, however, remains within the confidence interval for P = 95% until 2010, after which the losses (–6.25 to –8.22 q/ha) become significant. It is necessary to emphasize this aspect because the crop rotation with ameliorating plants maintains the yield level for 5 years, without significant losses.
The herbicide treatment appears to be very necessary after the fifth year of its non-performance, even in the case of P-W-R-W crop rotation (Figure 2). Crop losses in the last three years of cultivation don't exceed 13%.
In monoculture, however, the treatment no longer has the same effect as in crop rotation. After 10 years, the yield loss is 21.5 q/ha, i.e. 34.7%. Herbicide treatment has reduced to half the loss, but it remains far too high, especially in the last 5 years. Prolonged wheat monoculture reduces the yield far too much, making it unacceptable in practice.

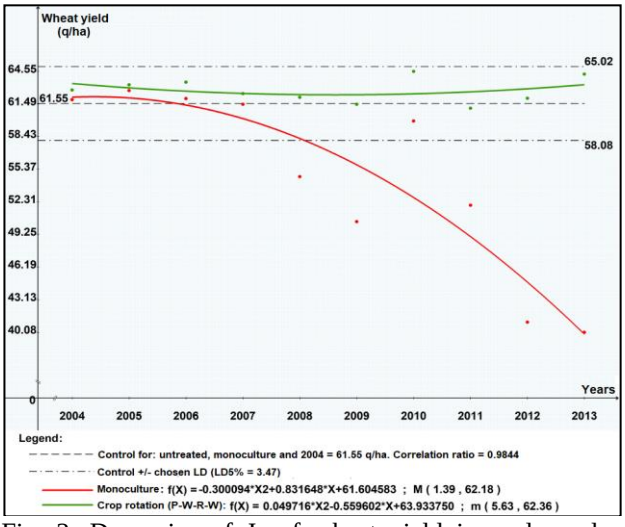

Fig. 2. Dynamics of Josef wheat yield in prolonged monoculture and crop rotation, with herbicide treatment
Source: Own results.

Under a 10-year average, the comparison between the type of crop rotation and herbicide treatment is shown in Figure 3. It follows that the difference between treated and untreated, in crop rotation, is insignificant, so that both options can be used

in agricultural practice. In monoculture, the difference between untreated and treated is close to the ratio of 1/2.

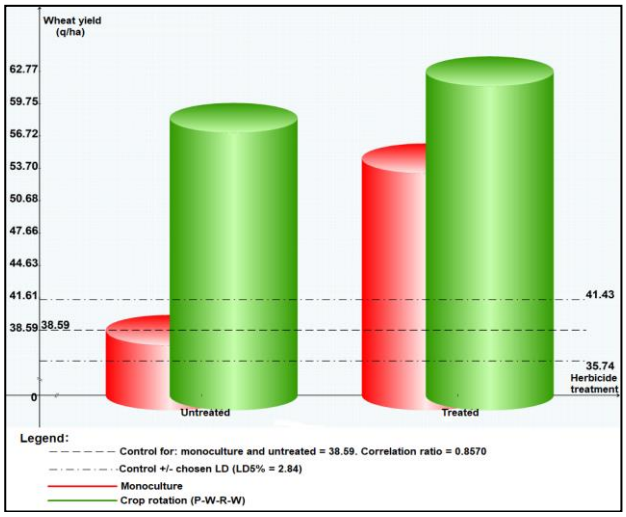

Fig. 3. 10-year average, comparison between monoculture and crop rotation, with and without herbicide treatment
Source: Own results.

Monoculture needs to be abandoned and replaced with ameliorating crops, such as peas, in the presented example – the combination of wheat, peas and rapeseed, which brings benefits on several levels (leaving a large amount of nitrogen in the soil, for wheat). The same can be seen in the dynamics in Figure 4.

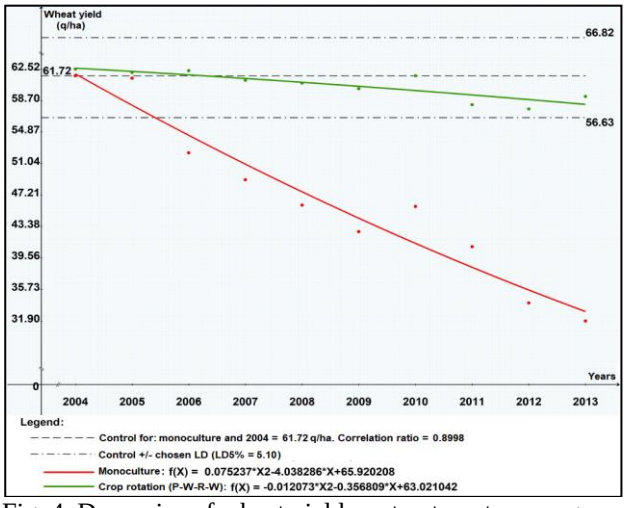

Fig. 4. Dynamics of wheat yield, on treatments average, for monoculture and 4-year crop rotation
Source: Own results.

It's once again emphasized the weeds power and how they destabilize wheat yield, hence the urgent need to give up monoculture. Equally useful is the calculation that shows to what extent the degree of weeding has been correlated with the achievement of the harvest or, better said, with its decrease.

In the case of P-W-R-W crop rotation, both the yields variation and the variation of the weeds were reduced, the correlations being small and insignificant. In contrast, in monoculture the large variation of weeding over the years and the much lower effectiveness of treatments allowed the establishment of correlative parameters presented in Figure 5 and Figure 6.

Figure 5(a) shows, in 2D, a correlation obtained from a 3D variability between the actual weeding (without treatments) and the Josef variety yield in monoculture for 10 years. The starting parameters are: 5 t/ha of raw weeds and about 64 q/ha of wheat yield.

In real conditions, the function looks like this:

$$y = \frac{65.04 - 10.29x + 0.52x^2 - 0.0068x^3}{1 - 0.15x + 0.007x^2 - 5.45x^3}$$

For the next 10 years the function is a NL fraction type polynomial, supported by a correlation ratio $r^2 = 0.99 = 99\%$, very close to determination, proving that the function can be easily reproduced under similar research conditions. The function shows a sudden decrease in yield over the weeding interval 10-15 t/ha and then a relatively constant decrease for the interval 15-40 t weeds/ha.

On average over the entire period the yield loss due to weeding (untreated) is of 62 – 20 = 44 q/ha, i.e. 44 ÷ 40 = 1.1 q wheat/t of green weeds, with variations from 2.9 q wheat/t weeds in the first phase, to 0.6 q wheat/t weeds in the second phase, when yields were low and losses correlated with them.

Figure 5(b), which has been processed in 3D, completes the overall analysis, offering the evolution in dynamics of the wheat crop degree of weeding (t/ha), on herbicidal and non-herbicidal background, being especially emphasized the growing differences year after year. If in the case of herbicide treatment, the degree of weeding stops before reaching the threshold of 15 t/ha, when untreated it reaches up to almost 40 t/ha, so an almost triple value.

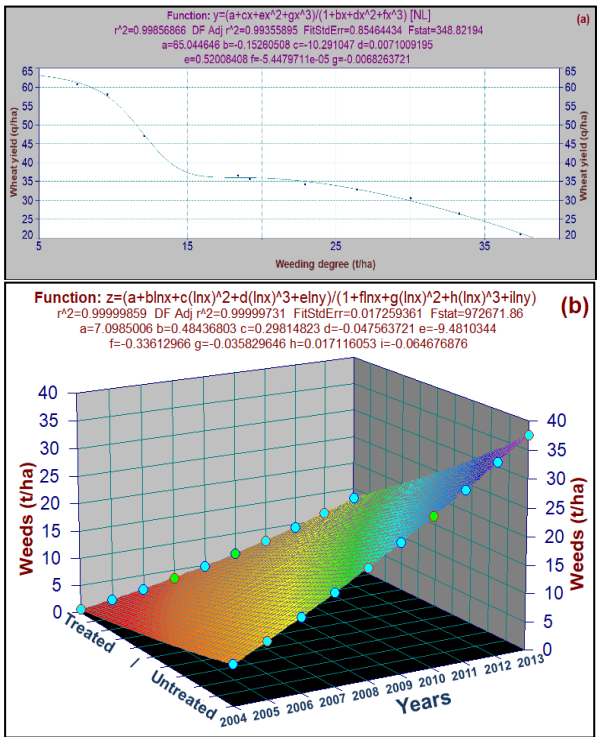

Fig. 5. Correlation between (a) the actual weeding (without herbicide treatment) and wheat yield and (b) the 10-year weeding dynamic, with and without herbicide, both in monoculture
Source: Own results.

Figure 6 shows the correlation between residual weeding (i.e. that remaining after herbicide treatment, as presented in the methodology) and yield loss generated by a low efficacy of treatment in monoculture. The representation function is a complicated, logarithmic one, which looks like below:

$$y = 75.74 + 120.49x - 343.54x^{0,5}lnx + 239.41(lnx)^2 - \frac{137.43}{x^2}$$

The function is ensured by a correlation ratio $r^2 = 0.987 = 98.7\%$ probability of repetition, very significant ratio and close to determination. The appearance of the curve is more uniform, but, as before, yield losses are less pronounced in the area of 2.2-5 t weeds/ha (about 2.1 q wheat/1 t weeds) and higher in the range 5-15 t/ha.
Throughout the experimentation period, the average yield loss, caused by residual weeding is 30 ÷ 15 = 2 q wheat/1 t weeds, difficult to sustain on long term.
Regardless of whether the herbicide treatment was performed or not, the weighted average losses vary around 21.5 q/ha.

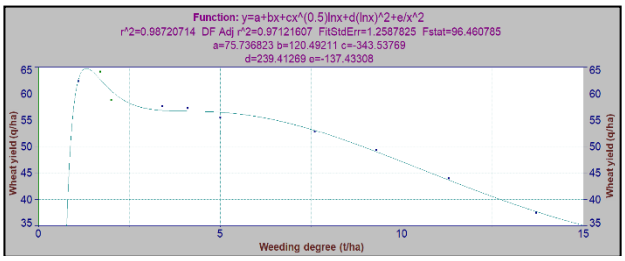

Fig. 6. Correlation between residual weeding (after herbicide treatment) and wheat yield, in monoculture
Source: Own results.

CONCLUSIONS

At the beginning of the experiment, there were four dominant weed species in wheat crop: *Veronica hederifolia*, *Polygonum aviculare*, *Galium aparine* and *Avena fatua*. The spectrum has diversified into monoculture with new species, such as *Stellaria media*, *Setaria glauca*, *Polygonum convolvulus*, *Chenopodium album*, *Matricaria* sp. and perennials *Sorghum halepense* and *Cirsium arvense*. In crop rotation, the change in weed structure was insignificant during the 10 years of research. There is a very close correlation between increasing weeding and reducing yield. About 2 q wheat/ha are lost for each ton of green weeds (biomass).
The loss of wheat yield (Josef variety), determined by monoculture and lack of herbicide, is 38 q/ha after 10 years of research (61.4%). Under crop rotation conditions, even if not treated with herbicides, the losses become significant, but they reach a maximum rating of 8.2 q/ha, i.e. 4.6 times lower. Applying herbicide treatment doesn't preserve yield during the research period, the loss being of 21.5 q/ha (34.7%). The application of herbicides only saves half of the loss caused by long-term monoculture. In the crop rotation with the ameliorating plant (P-W-R-W) the application of the herbicide treatment places the crop on a sustainable curve, with slight increases towards the end of the interval. It is recommended to avoid long monoculture and use the four-year crop with ameliorating plant (peas).

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