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Influence of Soil Tillage Systems on the Yield and Weeds Infestation in the Soybean Crop

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Abstract: Soybean is an important crop due to its multiple uses but also due to its agronomic advantages. Regardless of the agrotechnical system practiced, in the success of the crop, a very important role is represented by weed control. Soybeans are sensitive to infestation with weeds both at the early stages of growing season until the plants cover the soil, but also to maturity after the leaves fall. A soil tillage system applied, through its effect on the soil and on weed control, influences the soybean crop. This paper presents the evolution of soybean crop weeds and soybean yield under the influence of soil tillage systems (conventional, minimum tillage and no tillage) and climatic conditions from 2017 to 2021. The soil's mobilization by plowing significantly reduces the infestation with weeds, especially the perennial ones. Reducing the intensity of the soil tillage system and the depth of tillage causes an increase in the amount of weeding and, especially, perennial weeds. This determines a lower production of soybean crop by 23–243 kg ha^{-1} in the minimum tillage system and by 675 kg ha^{-1} in the no-tillage system, compared to the conventional system. Differentiation of the weed control strategy is required depending on the soil tillage system.

Keywords: climatic conditions; soybean; soil tillage system; weeds; yield

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1. Introduction

By excessive processing of agricultural land by ploughing and overturning the soil furrow [1], some of the diseases and pests are controlled [2,3], but there are also negative effects through a greater loss of water [4], weaker mineralization of plant residues (deeply incorporated) [5], favoring hardpan formations, breaking the continuity of capillarity (drainage) [6], and, if plowing on sloping land is performed along the line of the greatest slope, it will favor soil erosion [7].

Outdated, energy-consuming technologies are an initiating factor for soil degradation; worldwide, 35% of degradation is due to human activity and 28% to other forms of improper land management [8].

Increases in air temperature and the uneven distribution of precipitation recorded during the soybean vegetation period [9] in recent years requires the adoption of new tillage options [10–12]. A system with minimum tillage includes the basic tillage without turning the furrow, using [13,14]: disc harrow, chisel, rotary harrow, milling cutters and a paraplow and keeping plant residues on the soil surface or superficially incorporated that fulfill the role of mulch. In the case of a no-tillage system, the presence of plant residues or cover crops is essential for the success of the crop [5,6,12].

The importance of soybean as an agricultural plant derives from its multiple uses [15]: in human and animal food, in industry and as a plant improving the physical properties of the soil and improving the soil in nitrogen (the symbiosis between the root system and *Bradyrhizobium japonicum* bacteria [16,17]). Regional agro-ecological conditions specific to the Transylvanian Plain are favorable for soybean cultivation [12], but microclimate changes related to global warming require agrotechnical adaptation measures in order to maintain the level of soybean yield [13,14,18]. Regardless of the cultivation system practiced, to obtain superior productions from a quantitative and qualitative point of view, weed management has a particularly important role along the technological chain [19–21]. Soybean is sensitive to weeds [22], both in the first phases of vegetation until the plants cover the ground, but also towards maturity [23,24]. Successful control of weeds in a soybean crop, applying different tillage systems, is difficult to achieve through a single and identical strategy [25–27] because the degree of weeding can be influenced by the size and growth rate of the soybean crop which, in turn, is influenced due to other causes [20,22,28]: the soil tillage system practiced, infestation of the land with perennial species, quality of the biological material used, climatic conditions, soil type, etc.

Regardless of the soil tillage system practiced, for effective weed control, an important role is played by crop rotation [29,30], the quality of the work performed within the chosen soil tillage system, as well as a preventive and curative weed control strategy and knowing the particularities of infestation of specific weeds [31]. Herbicide treatments applied during the preparation of the seed bed, supplemented with treatments during the vegetation period, can ensure a weed-free culture. Knowledge of the weed spectrum in order to take effective and efficient control measures as early as possible is an important requirement [32–34]. When choosing herbicides, one must take into account their selectivity, the weed specific spectrum characteristic for the reference area, the recommended dose and the period of application with accurate and even administration [23,35,36].

Starting from the research hypothesis that the tillage system influences the weeding of the soybean crop, affecting the production, we defined the purpose and objectives of the research in the experimental field. The aim of this study is to evaluate the evolution of crop weeds' infestation and soybean yield, in the period of 2017–2021, under the influence of soil tillage systems and pedoclimatic conditions specific to the hilly area of the Transylvanian Plain.

2. Materials and Methods

2.1. Biological Materials

The research was carried out in the period from 2017 to 2021 at the Agricultural Research and Development Station Turda (ARDS Turda, Coordinates: 46.5803° N, 23.7876° E), located in the Transylvanian Plain, Romania.

The Felix soybean variety, created at ARDS Turda, was used as the biological material. Felix, an early variety, was obtained through individually repeated selection of hybrid population accomplished by crossing the North American cultivars Maple Presto and Merit; it is characterized by tall size (100 cm), high insertion of the basal pods (16 cm), a high resistance to bacterial leaf blight, very high resistance to downy mildew, high yielding potential (4100 kg ha^{-1}) as compared to the maturity group to which it belongs and a very high resistance to lodging and shattering, which, corroborated with the high insertion of the basal pods, ensures suitable conditions for mechanized harvest [37]. Based on recent studies, the soybean variety Felix achieved a protein content of 38% and oil content of 21.5% [38].

2.2. Research Method

The experimental soil was covered in a three-year crop rotation: maize–soybean–winter wheat. The study was set up on a Chernozem soil. Before the start of the experiment, the soil in the experimental field was cultivated in the same rotation and the conventional soil tillage with the plow was applied. The properties of the soil from the experimental site, at a depth of 0–20 cm, are as follows: clay content (<0.002 mm) 56.07%, fine silt (0.002–0.05 mm) 19.15%, silt (0.05–0.02 mm) 9.15%, fine sand (0.02–0.2 mm) 14.9%, coarse sand (0.2–2.0 mm) 0.73%, clay texture and soil organic matter content 3.73% and pH of 6.81, bulk density 1.13 g cm^{-3}, total porosity 58%, total nitrogen content 2050 mg kg^{-1}, mobile phosphorus 35 mg kg^{-1} and mobile potassium 320 mg kg^{-1}. Texture was determined by the Stokes sedimentation method, the Walkley–Black method was used for soil organic matter and the potentiometric method was used to establish pH; total nitrogen was established using the Kjeldhal method; phosphorous and the content of potassium were established through the Egner–Riehm–Domingo extraction method. Soil samples were analyzed as the average sample of 25 partial samples (collected according to the diagonal method) collected from the experimental field at the beginning of the experiment.

The experiment was based on an Ax Bx $C - R$: 5x 4x $2 - 2$ trifactorial type, according to the method of subdivided plots. The size of the experimental plots is 48 m^2 (4 m width $\times$ 12 m length), and the total experimental surface is 2756 m^2.

The experiment included three factors, as follows:

A—Experimental year (climatic conditions): a_1 2017; a_2 2018; a_3 2019; a_4 2020; a_5 2021.

B—Soil tillage system:

b_1 Conventional System (CS)—Plow with Kuhn Huard Multi Master 125T mold plow (depth of 28 cm) + preparation of the germinative bed (in spring) with Kuhn HRB 403 D rotary harrow + sowing + fertilizing with the Gaspardo Directa 400 seeder + crop maintenance + harvest;

b_2 Minimum Tillage—Chisel (MTC), the soil was prepared with the help of the Gaspardo Pinochio 2.5 chisel (depth of 28 cm) (in autumn) + preparation of the germinative bed (in spring) with Kuhn HRB 403 D rotary harrow + sowing + fertilizing with the Gaspardo Directa 400 seeder + crop maintenance + harvest;

b_3 Minimum Tillage—Disk (MTD), the soil is prepared with the help of the Discovery-4 heavy disk (depth of 12 cm) (in autumn) + preparation of the germinative bed (in spring) with Kuhn HRB 403 D rotary harrow + sowing + fertilizing with the Gaspardo Directa 400 seeder + crop maintenance + harvest;

b_4 No-Tillage (NT)—Direct sowing and fertilizing with Gaspardo Directa 400 seeder + crop maintenance + harvest.

C—Fertilization system: c_1 Unfertilized; c_2 Applied together with the seed $N_{20}P_{20}$ active substance kg ha^{-1} (20 kg ha^{-1} NP).

2.3. Technology Used in the Experimental Site

The Felix soybean variety was seeded at a sowing rate of 65 germinating grain m^{-2} at a 18 cm distance between rows and at a 5 cm sowing depth.

Weeds, pests and diseases control were identical in all experimental variants.

Weed control was carried out in two phases: pre-emergence with 0.35 L ha^{-1} Sencor (metribuzin 600 g L^{-1}) + 1.5 l ha^{-1} Tender (S-metolachlor 960 g L^{-1}) and post-emergence with 1.0 L ha^{-1} Pulsar 40 (imazamox 40 g L^{-1}) + after 4 days with 1.5 L ha^{-1} Agil 100 EC (propaquizafop 100 g L^{-1}).

Regarding the control of specific soybean pests, the following were used: for *Tetranichus urticae* and *Vannessa cardui* treatments with acaricide Omite 570 EW (propargit 570 g L^{-1}) were applied in a dose of 0.8 L ha^{-1} and Biscaya 240 OD (thiacloprid 240 g L^{-1}) 0.2 L ha^{-1}.

Disease management in the soybean crop *Peronospora manshurica* and *Pseudomonas glycine* involved a treatment with 2.5 kg ha^{-1} Ridomil Gold MZ 68 WG fungicide (4% mefenoxam, 64% mancozeb).

The climatic conditions for the experimental field (Turda meteorological station, longitude: 23°47′; latitude 46°35′; altitude 427 m) are presented in the results, these being considered as an experimental factor in this paper.

2.4. Methods of Analysis and Processing Experimental Data

Weed infestation of the soybean crop was determined using the metric frame. The determinations were made before post-emergence weed control and before harvesting, in three repetitions on the diagonal of the plot, being expressed in the number of weeds m^{-2}.

The harvest of the soybean experiment was gathered manually by meeting the methodological rules of the experimental technique. This operation consisted of the following steps: collecting the protective strips around the samples and collecting the frontal and lateral margins of the experimental samples (frontal eliminations were of 1 m and lateral eliminations of 2 row of 0.18 cm). The harvest surface of the experimental lot was 32.8 m^2. The soybean yield (grains) obtained on each experimental lot was weighed and transformed to standard humidity for soybean (12%).

Data were processed using Anova PoliFact Soft (V3) [39]. The least significance of the differences (LSD) was determined with the ANOVA test and established for each experimental factor reported to control, for *p*-values 0.05, 0.01 and 0.001.

3. Results

3.1. Climate Conditions and the Impact on Soybean Cultivation Technology

The temperature regime of the area has a particularly important role in choosing the adapted varieties. From the data presented in Table 1, during the research period, it can be seen that, in most months, the temperatures registered have positive deviations in relation to the multiannual monthly average. During the research period, only 6 months (from 30) recorded temperatures below the multi-year averages.

Table 1. The monthly average temperature and monthly amount of rainfall during April–September 2017–2021 at ARDS Turda.

			Monthly Temperature, °C				Average
Year/month	IV	V	VI	VII	VIII	IX	IV–IX
2017	9.9	15.7	20.7	20.3	22.3	15.8	17.5
2018	15.3	18.7	19.4	20.4	22.3	16.7	18.8
2019	11.3	13.6	21.8	20.4	22.1	17.1	17.7
2020	10.3	13.7	19.1	20.2	21.5	17.8	17.1
2021	7.8	14.1	19.8	22.7	19.7	15.0	16.5
1945–2010	10.0	15.0	18.0	19.8	19.5	15.2	16.3
			Monthly rainfall, mm				**Sum**
Year/month	IV	V	VI	VII	VIII	IX	IV–IX
2017	62.5	65.4	30.6	110.2	36.1	56.2	363.7
2018	26.2	56.8	98.3	85.7	38.2	29.8	335.0
2019	62.6	152.4	68.8	35.0	63.8	19.4	402.0
2020	17.8	44.4	166.6	86.8	58.0	57.4	431.0
2021	37.4	80.8	45.0	123.1	52.9	39.1	379.3
1945–2010	45.6	69.4	84.6	78.0	56.1	42.4	376.1

A limiting factor of a soybean crop is water. To obtain satisfactory yields, an optimal rainfall distribution of at least 500 mm precipitation between sowing until physiological maturity is required [12]. If we analyze the rainfall regime of the five years, it can be seen that there are negative deviations compared to the soybean requirements, but still, the reserve of moisture in the soil that had accumulated before the time of sowing must be taken into account [9,14].

3.2. Influence of the Tillage System upon Weed Infestation in the Soybean Crop

The weed spectrum was identified before the post-emergence treatment; it consists of 23 species (Table 2) as follows: 3 annual monocotyledonous (AM) species, 1 perennial monocotyledonous (PM) species, 5 perennial dicotyledonous (PD) species and 14 species annual dicotyledonous (AD) species. The AD species ranks first in terms of participation in crop weeding. After five years of experimentation, an increase in MA, MP and DP weeds was found in the MTD and NT systems.

Table 2. Weed species' infestation before post-emergence herbicide, 2017, 2021.

No./ Classification		Species/Soil Tillage System	No. Weeds m^{-2}, 2017				No. Weeds m^{-2}, 2021			
			CS	MTC	MTD	NT	CS	MTC	MTD	NT
1	AM	*Bromus tectorum*	-	-	-	-	-	-	8	11
2		*Setaria glauca*	-	1	1	-	1	-	-	-
3		*Echinochloa crus- galli*	1	-	1	1	-	1	1	-
		Total AM	1	1	2	1	1	1	9	11
1	PM	*Agropyron repens*	-	-	1	2	-	-	3	7
		Total PM	-	-	1	2	-	1	3	7
1	AD	*Xanthium strumarium*	3	5	7	4	4	6	7	3
2		*Chenopodium album*	1	-	2	1	2	1	1	-
3		*Polygonum convolvulus*	-	1	2	1	1	1	2	-
4		*Tragopogon dubius*	-	-	-	-	-	1	1	2
5		*Sonchus asper*	-	1	-	2	-	1	-	1
6		*Hibiscus trionum*	-	1	2	-	2	1	1	-
7		*Anthemis cotula*	-	-	-	-	-	-	1	3
8		*Viola arvensis*	1	-	1	2	-	-	1	-
9		*Daucus carota*	-	1	1	1	-	-	1	2
10		*Silene noctiflora*	2	1	1	1	1	1	1	-
11		*Amaranthus hybridus*	1	1	1	1	1	1	-	1
12		*Datura stramonium*	-	1	-	1	-	-	1	1
13		*Galeopsis ladanum*	1	1	-	-	1	2	-	-
14		*Polygonum lapathifolium*	1	1	1	2	-	1	-	-
		Total AD	10	14	18	16	12	16	17	13
1	PD	*Convolvulus arvensis*	1	1	2	3	1	1	3	4
2		*Rubus caesius*	1	1	1	2	1	1	2	3
3		*Cirsium arvense*	-	-	1	1	-	-	2	2
4		*Lathyrus tuberosus*	-	-	1	2	-	1	1	4
5		*Taraxacum officinale*	-	-	-	-	-	-	1	2
		Total PD	2	2	5	8	2	3	9	15
		Total weeds	13	17	26	27	15	21	38	46

Notes: CS = Conventional System; MTC = Minimum Tillage—Chisel; MTD = Minimum Tillage—Disk; NT = No-Tillage; AM = Annual Monocotyledonous; PM = Perennial Monocotyledonous; AD = Annual Dicotyledonous; PD = Perennial Dicotyledonous.

Tillage systems have modified the spectrum of weeds present in the soybean crop in the research area, so that after several years of applying the NT variants, species specific to the ruderal areas have been established.

Among the monocotyledonous weed species (MA and MP) determined before the post-emergence herbicide, it can be observed that *Bromus tectorum* and *Agropyron repens* are present only in the disk and direct seeded variant (Figures 1 and 2).

Dicotyledonous weeds (DA) are the predominant species in the soybean crop in the experimental area (Figure 3), *Xanthium strumarium* being present throughout the period regardless of the tillage system. After five years, the appearance of two weed species in the soybean crop was found, when the soil was prepared with the MTD system and in the version when NT was experimented. These weeds, *Tragopogon dubius* and *Anthemis cotula*, are specific, in general, to compacted soils.

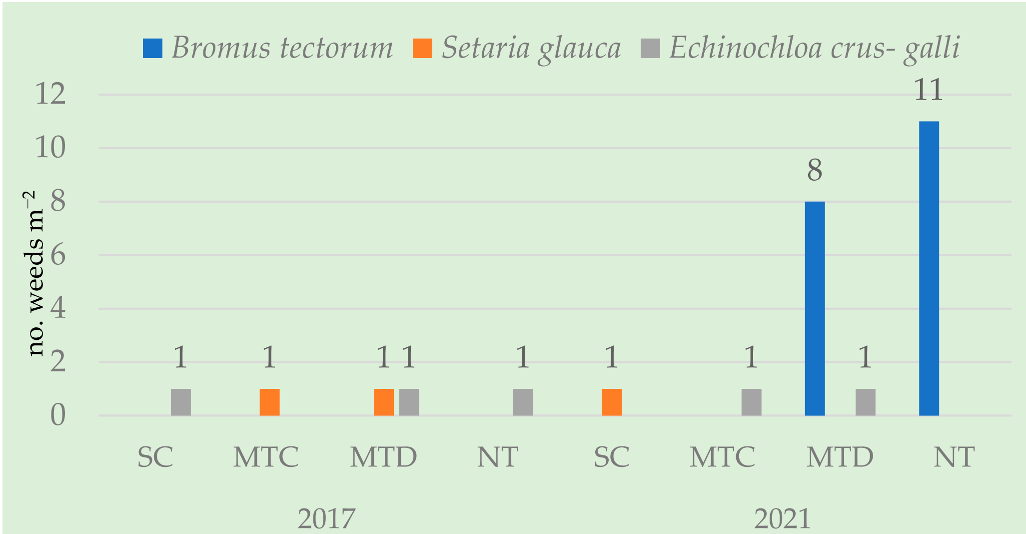

Figure 1. Annual monocotyledonous weeds before post-emergence herbicide, 2017, 2021. Notes: CS = Conventional System; MTC = Minimum Tillage—Chisel; MTD = Minimum Tillage—Disk; NT = No-Tillage.

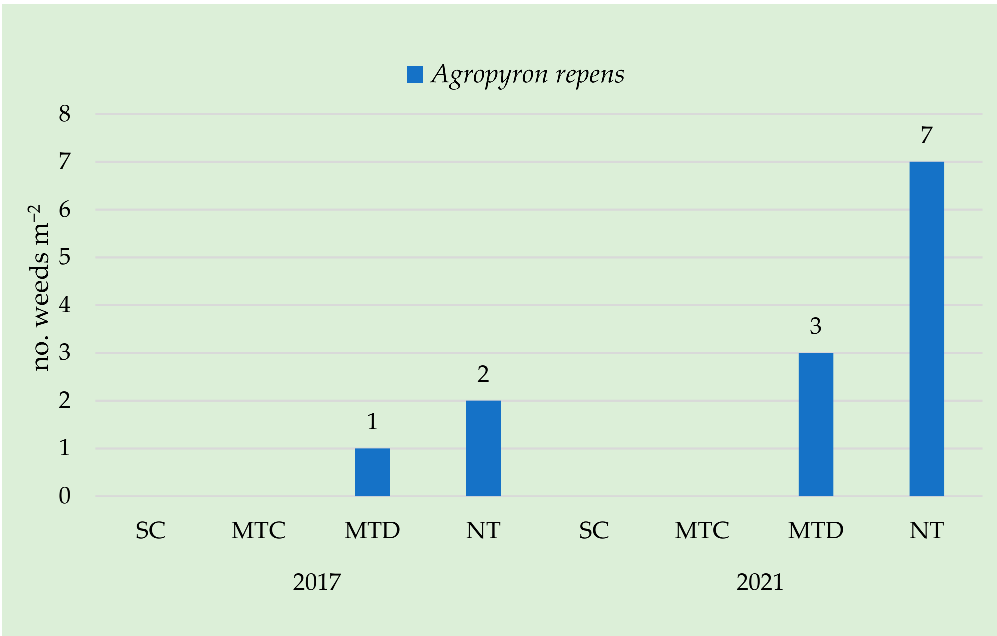

Figure 2. Perennial monocotyledonous weeds before post-emergence herbicide, 2017, 2021. Notes: CS = Conventional System; MTC = Minimum Tillage—Chisel; MTD = Minimum Tillage—Disk; NT = No-Tillage.

Among the perennial dicotyledonous weed species, *Rubus caesius* was present in all tillage systems throughout the experimental period. *Cirsium arvense* and *Lathyrus tuberosus* were identified only in the MTD and NT variants. Specific for the year 2021 is the presence of the species *Taraxum officinale* in the MTD and NT (Figure 4), variants where the soil has a high bulk density.

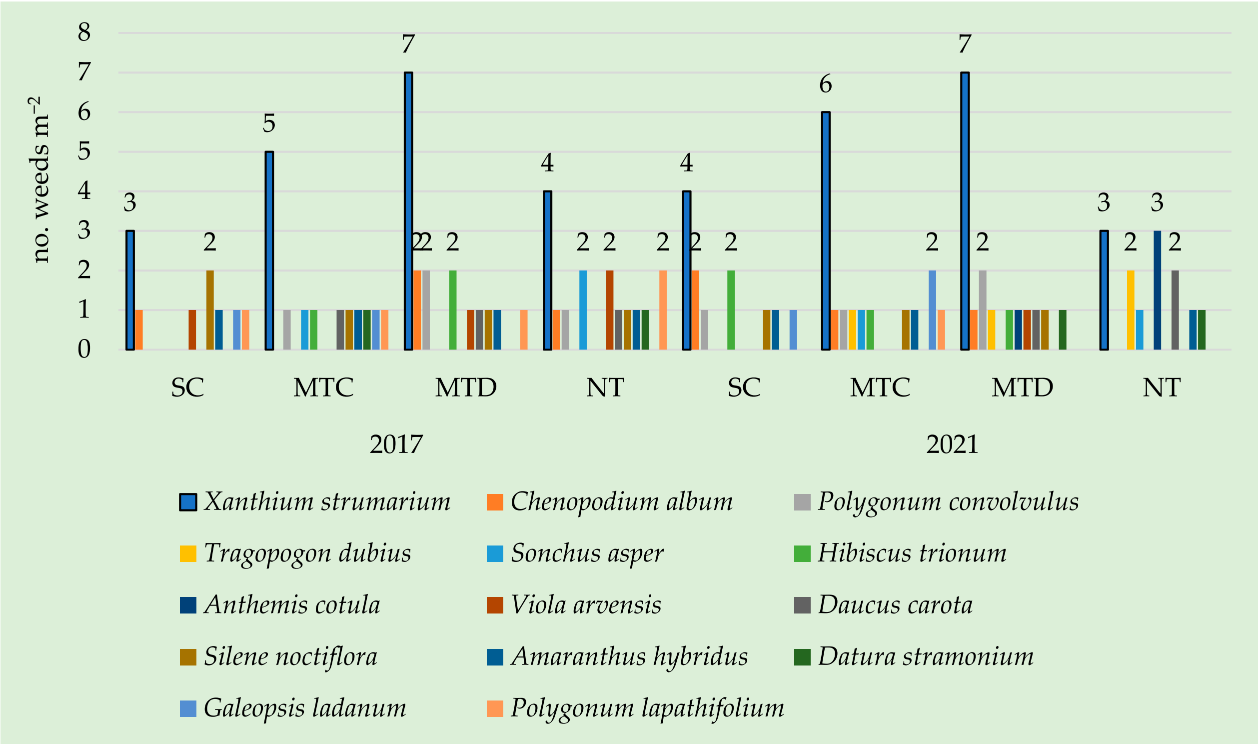

Figure 3. Annual dicotyledonous weeds before post-emergence herbicide, 2017, 2021. Notes: CS = Conventional System; MTC = Minimum Tillage—Chisel; MTD = Minimum Tillage—Disk; NT = No-Tillage.

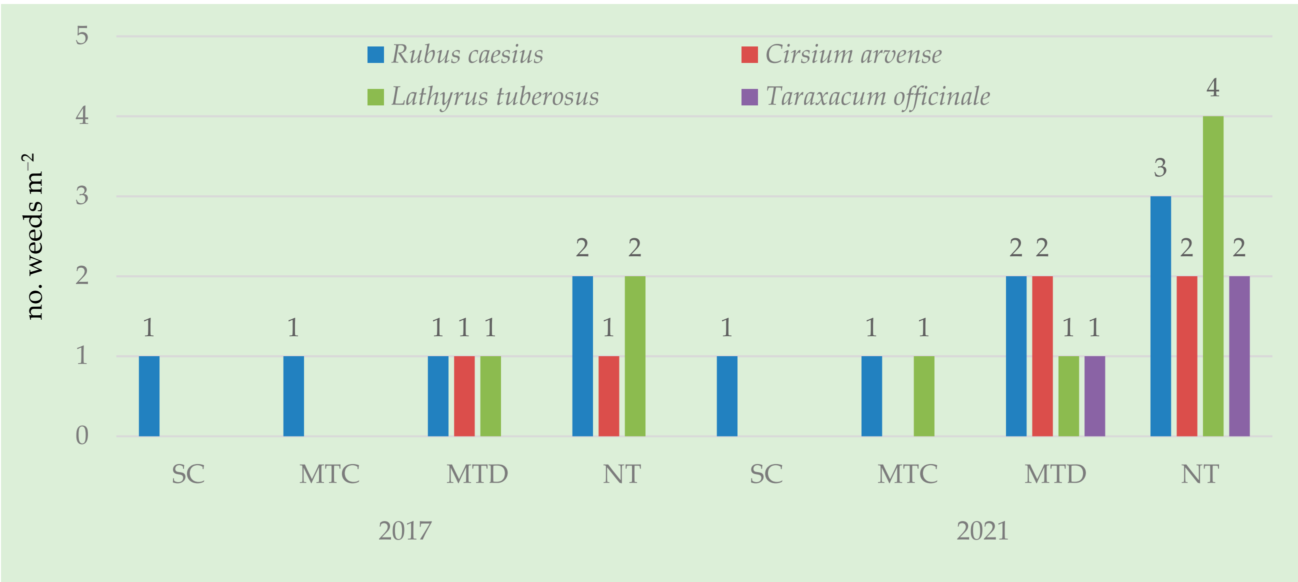

Figure 4. Perennial dicotyledonous weeds before post-emergence herbicide, 2017, 2021. Notes: CS = Conventional System; MTC = Minimum Tillage—Chisel; MTD = Minimum Tillage—Disk; NT = No-Tillage.

Soybeans are also sensitive to weeds at the maturity stage of plants. From the determinations made before the soybean harvest, the reinfestation of the crop was highlighted, the predominant species being the annual dicotyledonous in all tillage variants (Table 3).

Table 3. Soybean crop reinfestation with weeds before harvesting, 2017, 2021.

No./ Classification		Species/Soil Tillage System	No. Weeds m^{-2}, 2017				No. Weeds m^{-2}, 2021			
			CS	MTC	MTD	NT	CS	MTC	MTD	NT
1	AM	*Bromus tectorum*	-	-	-	-	-	-	3	5
2	AM	*Setaria glauca*	-	2	1	1	1	-	1	1
3	AM	*Echinochloa crus-galli*	1	-	1	-	1	2	1	-
		Total AM	1	2	2	1	2	2	5	6
1		*Agropyron repens*	-	-	3	2	-	-	4	8
		Total PM	-	-	3	2	-	-	4	8
1	AD	*Xanthium strumarium*	1	3	2	3	1	2	1	1
2	AD	*Polygonum convolvulus*	-	-	1	-	-	1	1	-
3	AD	*Tragopogon dubius*	-	-	-	-	-	-	-	1
4	AD	*Hibiscus trionum*	1	1	1	-	-	-	1	1
5	AD	*Galeopsis ladanum*	-	1	1	-	-	1	-	-
6	AD	*Polygonum lapathifolium*	-	-	1	-	1	-	1	-
		Total AD	2	5	6	3	2	4	4	3
1	PD	*Convolvulus arvensis*	-	-	-	1	-	-	2	3
2	PD	*Rubus caesius*	1	1	1	1	1	1	2	2
3	PD	*Cirsium arvense*	-	-	1	2	-	-	1	1
4	PD	*Taraxacum officinale*	-	-	-	-	-	-	-	-
		Total PD	1	1	2	4	1	1	5	6
		Total weeds	4	8	11	11	7	10	18	23

Notes: CS = Conventional System; MTC = Minimum Tillage—Chisel; MTD = Minimum Tillage—Disk; NT = No-Tillage; AM = Annual Monocotyledonous; PM = Perennial Monocotyledonous; AD = Annual Dicotyledonous; PD = Perennial Dicotyledonous.

It should be noted that in the variants with deep soil mobilization (SC, MTC) followed by the processing of the germinal bed in the spring by passing with a rotary harrow, the number of weeds is reduced compared to the variant with disc (MTD) and when NT system was applied.

The data collected, before harvesting, highlight the fact that the number of weeds increases as the tillage depth and the degree of soil mobilization are reduced: from CS to MTC, MTD and NT.

3.3. Soybean Yield in Relation to Experimental Factors

The influence of experimental factors on soybean yield, in the five experimental years (2017–2021), is presented in Table 4.

The climatic conditions during the experimental period had a great influence on the fluctuation of yield obtained from one year to another. It seems that only in one experimental year, out of the five, there were more favorable conditions for the crop, a fact materialized by the production of 2434 kg ha^{-1} with a difference of 226 kg ha^{-1} compared to the average production achieved during the experimentation period.

The MTD system and NT systems register higher percentages of weeds and negatively influence the soybean yield. In these variants, the production was lower by 243–675 kg ha^{-1} compared to the CS system. The yields obtained in the MTC system between the years 2017–2021 indicate that this variant can be used as an alternative to the conventional plow system.

Table 4. The influence of experimental factors in the soybean yield, 2017–2021.

Experimental Factor	Yield, kg ha^{-1}	Differences±, kg ha^{-1}
A—Experimental year		
Years mean	2209	ct ^{ct}
2017	2434	226 ***
2018	2187	−21 ^{ns}
2019	2205	−3 ^{ns}
2020	2072	−135^{00}
2021	2141	−67^{0}
Notes: LSD (5%) = 64 kg ha^{-1}, LSD (1%) = 106 kg ha^{-1}, LSD (0.1%) = 198 kg ha^{-1}; ct. = control; *** = 0.001 *p*-value significant, positive values; ^{0,00} = 0.05 and 0.01 *p*-value significant, negative values; ^{ns} = not significant.		
B—Soil tillage system		
Conventional system	2437	ct ^{ct}
Minimum tillage—Chisel	2460	23 ^{ns}
Minimum tillage—Disk	2194	−243 ^{000}
No tillage	1762	−675 ^{000}
Notes: LSD (5%) = 104 kg ha^{-1}, LSD (1%) = 144 kg ha^{-1}, LSD (0.1%) = 199 kg ha^{-1}; ct. = control; ^{ns} = not significant; ^{000} = 0.001 *p*-value significant, negative values.		
C—Fertilization system		
Unfertilized	2034	ct ^{ct}
Fertilized with $N_{20}P_{20}$	2381	347 ***
Notes: LSD (5%) = 31 kg ha^{-1}, LSD (1%) = 42 kg ha^{-1}, LSD (0.1%) = 57 kg ha^{-1}; ct. = control; *** = 0.001 *p*-value significant, positive values.		

Soybean, as with other legumes, establishes a reciprocal exchange with the nitrogen fixing bacteria *Bradyrhizobium japonicum* to produce nitrogen compounds used by the plant. Biological fixation, however, cannot provide all of the nitrogen needed by plants. That is why we included in the experiment a version with fertilization 20 kg N ha^{-1} + 20 kg *p* ha^{-1} essential for the absorption of nutrients from photosynthesis and in the accumulation of organic compounds with high energy value (fats). The application of these reduced doses of fertilizers very significantly influences the harvest, leading to an increase in yield by 347 kg ha^{-1}.

4. Discussion

Thermal resources constitute one of the main limiting factors in the expansion of culture in the northern areas, while in the southern areas, the efficiency of culture is conditioned, as a rule, by water resources [9,40]; this important aspect for soybean culture is also illustrated by Wijewardana et al. [41] and Henderson et al. [42]. In these conditions, both the conservation of water through the soil tillage system [19,43] and the water consumption of weeds (weed control) [44] are factors for the success of soybean cultivation.

Explosive weeding of the soybean crop [45] (due to sowing in late spring, when the entire vegetation is reborn explosively), the extremely diversified infestation and the variability of the ratio between weed species all impose a specific strategy of integrated control of weeds [46,47] in order to reduce their number below the economic threshold of damage. The warming of the climate in recent years [9,31] imposes the need for specific measures to adapt this strategy, especially in terms of technological management, to the soybean crop.

The most common weeds encountered in the soybean crop are, in particular, but not only, those with germination in late spring: *Echinochloa crus-galli, Setaria glauca, Digitaria sanguinalis, Sorghum halepense, Agropyron repens, Solanum nigrum, Amaranthus retroflexus, Chenopodium album, Galeopsis ladanum, Xanthium strumarium, Abutilon teophrasti, Tragopogon* *dubius, Polygonum sp., Cirsium arvense, Convolvulus arvensis*, etc., as also encountered by other authors [20,48].

The effect of soil tillage systems on weed control has become evident after specific technological operations [13,49–51]: weed cutting in vegetation; fragmentation of rhizomes and vegetative propagation; incorporation of weed seeds into the soil or, on the contrary, bringing weed seeds on the soil surface; mobilization and aeration of soil, determination of weed seeds germination, etc.

Modification of the floristic composition indicates the necessity of changing the strategy of weed control in the soybean crop in the minimum tillage and no-tillage variants [47]. The increase in the percentage of perennial dicotyledonous weeds forces the soybean rotation cultivating of straw cereal, supplemented by the use of integrated methods of using specific herbicides, both at the preliminary plant and at the soybean crop [40,43]. The presence of monocotyledonous completes the need to differentiate the control and correlation strategies, both in the level of weeding and in the type of weeding, including their annual or perennial character [22]. Thus, controlling perennial weeds on the stubble by using herbicides with total action is mandatory [52,53]. If the vegetation is also infested with annual or perennial monocotyledonous, good results are obtained by combining two complementary herbicides [54–56], which combat both monocotyledonous and dicotyledonous [57,58].

The differences recorded in the weeds' infestation in the soybean crop, the change in the weed spectrum and influence on yield require the continuation of the research by differentiating the weed control strategies depending on the soil tillage system applied [59,60].

5. Conclusions

The explosive weeding of the soybean crop (due to sowing in late spring, when the entire vegetation is reborn explosively), the extremely diversified infestation and the variability of the ratio between weed species impose a specific differentiated strategy of integrated control of weeds, in order to reduce their number below the economic threshold of damage.

The tillage system, climate conditions and technology specific to each system influence the yield potential of soybean. Reducing the intensity and depth of tillage causes an increase in the degree of weeding and the diversification of the spectrum of weeds. Soil mobilization by plowing significantly reduces the degree of weeding, especially of perennial weeds.

The research carried out confirms the research hypothesis and requires the continuation of the research by developing differentiated strategies in weed control depending on the tillage system. For the soybean crop, the most important aspect pursued through the applied technology is the conservation of water in the soil through minimal tillage or no-tillage, ensuring mulch is on the surface of the soil (including the role of weed control) and preventive control of weeds.

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