IMPACT OF CROP ROTATION AND SOIL MANAGEMENT PRACTICES ON WEEDING AND SOIL WATER DYNAMICS IN MAIZE CROP IN SOUTHERN ROMANIA

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Abstract

In the southern region of Romania, crop rotation and soil management practices play an important role in controlling weed infestation and soil water dynamics in corn cultivation. Studies suggest that rotation crops, combined with appropriate soil tillage techniques, can significantly reduce the number and diversity of perennial and annual weed species, helping to decrease weed pressure. Additionally, these practices influence soil water retention and distribution, directly impacting the development of the corn crop and yield. Adapting these techniques to the specific pedoclimatic conditions of southern Romania is essential for optimizing water resource use and supporting sustainable agriculture. The soil tillage system with the disk or chisel associated with the 4- or 5-year rotation creates the conditions for a superior storage of water in the soil and the preservation of a reserve necessary for the plants. The aim of present research is focused on the effects of crop rotation and tillage systems on weeding and soil moisture for the maize crop on cambic chernozem in the Southern part of Romania.

***Key words**: maize, crops rotation, weeding, soil water*

INTRODUCTION

Worldwide, the entire process of obtaining food raw material is based on the challenge of ensuring food security and environmental protection, in the conditions of unprecedented climate changes (Paunescu et al., 2023, 2024). Thus, crop rotations associated with tillage systems represent the main purpose to create favorable conditions for crop development and the maintenance and improvement of soil fertility over time. The possibilities of infiltration and storage of water in the soil are influenced by the amount of precipitation, water temperature and soil type, land slope, soil texture and compaction (Lupu, 2009; Rusu et al., 2021). Currently, genetic transformation has the potential to improve plant resistance to various stressors, including pests, pathogens and weeds (Bonciu, 2023a, b), in a sustainable way, in full harmony with the environment (Bonciu, 2023c). Despite of this aspect, soil tillage management leads to a series of changes in weed species in terms of number and possibilities of multiplication. Soil tillage systems in maize crop have led to the limitation of weed populations considered a problem (Wilson, 1993; Georgescu et al., 2021), so that harmful species can be identified more easily.

The damage caused by weeds can be diverse and often lead to decreased yields, increased production costs, a depreciation of product quality, being also an ideal host for pathogens and pests, etc. (Mortensen et al., 2000; Roman and Lazureanu, 2012). Petcu et al. (2015) identified Setaria spp., Sorghum halepense (from rhizomes and seeds) and Cirsium arvense as dominant species, as drought-resistant species. The reduced competition of maize in the fight against weeds (Wilson, 1988) requires specific research on the evolution of weed species and strategies for their control (Berca, 2004; Maxwell and O'Donovan, 2007). The temperatures and precipitation have a decisive influence on agricultural yields, depending on the type of soil and the technological measures applied in agricultural crops (Moss et al., 2010).

The purpose of the present research was focused on the effects of crop rotation and tillage systems on weed infestation and soil moisture, in maize cropped on cambic chernozem in southern Romania.

The research is of particular importance in maintaining the stability and increasing the productive level of maize crop, the preservation and protection of the environment, and last but not least the reduction of inputs in agriculture.

MATERIALS AND METHODS

The research on the influence of crop rotation and soil practices on weeding and soil water dynamics in maize crop was performed during 2022-2023 carried out on the cambic chernozem from Fundulea, in the non-irrigated area, in a stationary experiment. Regarding the physical properties of the soil, the humus content is higher in the first 15 cm due to the former bedding and gradually decreases to depth. The soil consists of several horizons:

- Ap + Aph - 0-30 cm, clay-clay-dust with 36.5% clay and permeability 492, pH 5.9.
- Am - 30-45 cm, clay-clay with 37.3% clay, compacted, DA 1.41g / cm³, pH 5.9.
- A/B(45-62 cm), Bv1 (62-80 cm), Bv2(82-112 cm), Cnk1(149-170 cm), Cnk2(170-200 cm).

The experimental factors studied have the following gradations: factor A – crop rotation: a1 - monoculture; a2 – 2 year rotation, a3 – 3 year rotation and a4 – 4 year rotation; factor B - soil works: b1 – no till; b2 – disk 2x, b3 – chisel + disk and b4 - plow at 20-25 cm + disk.

The experiments had five replications in a randomized block design (RBD); the maize hybrid was Magnus, created at NARDI Fundulea. The plot size for maize trail was 56.0 m^2 (4 rows x 20 m long x 70 cm distance between rows).

Regarding the soil moisture reserve, it was correlated with the precipitation regime. Soil samples were collected at a depth of 0.5 m to determine the state of humidity. The method of determining the soil moisture: the soil was dried at a temperature of 105°C to a constant weight and then weighed. The difference in weight before and after drying, represents the humidity that is expressed as a percentage (%). Materials used: termoadjustable drying oven; analytical balance; weighing ampoules; dryer.

The degree of weeding was determined with the metric frame of 0.25 m², according to the numerical method.

Processed and interpreted statistically according to the method of ANOVA.

Meteorological data were recorded at the NARDI Fundulea weather station and varied widely during the experimentation period especially depending on the distribution of precipitation during the vegetation period.

RESULTS AND DISCUSSIONS

Climatic aspects

The experimentation period recorded the differences from one year to another due to the amount and periodic distribution of precipitation (Table 1).

The year 2022 will be a reference year, being an extremely dry one. Regarding precipitation, the annual amount registered a decrease of 325.9 mm compared to the annual amount. The lowest amount of precipitation was recorded in July, with 29.2 mm, approximately 41.9 mm below the multiannual average. Regarding the thermal regime, during the period April - September, the recorded values showed that the average monthly temperatures were higher than the multiannual average, in August by 3.3°C and in July by 2.3°C above the multiannual average. Annual temperatures much higher than the multiannual average combined with low amounts of precipitation exacerbated the drought.

In 2023, a dry year in terms of water quantities recorded, with an uneven distribution. Regarding the precipitations, the month with the lowest amounts of precipitations was January with 5.2 mm, compared to the 42.3 mm multiannual average. May was very different in value from the multiannual average registering 32.4 mm and a deviation of -30.1 mm compared to the multiannual average.

Regarding the temperature, during January 2023 - July 2023, the recorded values show that the average monthly temperatures were higher than the multiannual average as follows: in February, characterized as a dry month with 3.3^0 C warmer. In June the temperatures registered higher values, compared to the multiannual average, with 1.8^0 C.

Table 1. *The meteorological parameters in the experimental period (Fundulea, 2022–2023)*

Years/Months		Jan	Febr	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total/ Average
Precipitations (mm)	2022	4.8	5.4	12.3	47.6	30.1	59.6	29.2	14.4	35.4	5.2	19.6	21.8	258.4
	2023	64.2	5.8	10.0	77.2	32.4	40.2	43.8	6.6	4.2	29.0	85.6	24.4	423.4
50 years average		**35.1**	**32.0**	**37.4**	**45.1**	**62.5**	**74.9**	**71.1**	**49.7**	**48.5**	**42.3**	**42.0**	**43.7**	**584.3**
Temperatures (oC)	2022	2.1	4.7	4.4	12.1	17.9	22.6	25.0	25.6	18.6	13.5	9.0	3.5	13.3
	2023	4.9	3.3	8.2	10.8	16.9	22.3	26.1	26.1	21.7	16.1	8.5	4.3	14.1
50 years average		**-2.4**	**-0.4**	**4.9**	**11.3**	**17.0**	**20.8**	**22.7**	**22.3**	**17.3**	**11.3**	**5.4**	**0.1**	**10.9**

Soil water dynamics

The soil moisture was measured in different years from a climatic point of view and the average values are presented in Table 2. Crop rotation and tillage systems had a significant influence on soil water retention measured as the average of the vegetation period.

Soil moisture determinations calculated as the average of the crop rotation associated with the tillage system, revealed different moisture values in all variants, throughout the depth of 0-25-50-75 cm. All these values of moisture parameters highlighted the dry nature of the agricultural years.

In 2022, the 3-year crop rotation associated with the no-tillage variant of the soil recorded the highest soil moisture value of 18.1% (601.8 m3 ha-1) at the depth of 0-25 cm, followed by the variant with the 4-year crop rotation associated with no-tillage with 18.0 % (598.5 m3 ha-1). At a depth of 25-50 cm, soil moisture recorded the highest values in the no-till system associated with the 3-year rotation with 18.2% (627.9 m3 ha-1), and the lowest in the plow + disc system associated with monoculture with 15.3% (527.9 m3 ha-1).

At a depth of 50-75 cm, soil moisture recorded stable and uniform values as follows: in the no-till system associated with the 3-year and 4-year rotation with 18.5% (661.4 m3 ha-1), and the lowest in the disc system associated with monoculture with 15.9% (568.4 m3 ha-1).

Overall, soil moisture recorded values between 15.1% (502.1 m3 ha-1) and 18.5% (661.4 m3 ha-1) depending on the technological variety and the recorded precipitation.

The moisture determinations carried out as an average in 2023 showed very low moisture values regardless of the technological variants applied, at a depth of 25-50-75 cm, a greater amount of water was found, which is made available to the plants. These moisture values are significantly lower in the 0-25 cm layer, but remain constant. The values of the moisture parameters highlighted the very dry specificity of the agricultural year, so that, at a depth of 0-25 cm, the no-till variant recorded the highest soil moisture values regardless of the crop rotation and were between 15.0% (498.8 m3 ha-1) and 16.4% (545.3 m3 ha-1). At a depth of 25-50 cm, soil moisture recorded the highest values in the 4-year crop rotation associated with the chisel + disc variant with 17.1% (590.0 m3 ha-1), and the lowest in the 2-year rotation associated with the disc at 10-15 cm with

15.2% (524.4 m3 ha-1).

The average moisture determinations in 2023 fall within the reference results due to the significantly negative values that characterized the year as very dry (Figure 1).

Tabel 2. *The effect of crop rotation and tillage systems on soil moisture in maize crop*

Tillage sistems/ Variant		Measures times - year average					
		2022			2023		
		Moisture sampling depth (cm) / Bulk density of the soil (g/cm³)					
		0-25 / 1.33	25-50 / 1.38	50-75 / 1.43	0-25 / 1.33	25-50 / 1.38	50-75 / 1.43
		Soil water content (volumetric, % / m³)					
A1	B1	16.9 / *561.9*	17.2 / *593.4*	17.0 / *607.8*	15.0 / *498.8*	16.2 / *558.9*	15.8 / *564.9*
	B2	15.4 / *512.1*	15.8 / *545.1*	15.9 / *568.4*	15.0 / *498.8*	16.0 / *552.0*	15.6 / *557.7*
	B3	15.7 / *522.0*	15.9 / *548.6*	16.1 / 575.6	16.0 / *532.0*	15.4 / *531.3*	15.4 / *550.6*
	B4	15.1 / *502.1*	15.3 / *527.9*	15.8 / *564.9*	16.2 / *538.7*	16.9 / *583.1*	15.4 / *550.6*
A2	B1	17.8 / *591.9*	18.1 / *624.5*	18.1 / *647.1*	15.0 / *502.1*	15.9 / *548.6*	15.0 / *536.3*
	B2	17.6 / *585.2*	17.9 / *617.6*	18.2 / *650.7*	14.8 / *492.1*	15.4 / *531.3*	15.5 / *554.1*
	B3	18.1 / *601.8*	18.4 / *634.8*	18.3 / *654.2*	14.7 / *488.8*	15.2 / *524.4*	15.2 / *543.4*
	B4	17.2 / *571.9*	17.7 / *610.7*	18.2 / *650.7*	15.0 / *498.8*	15.9 / *548.6*	15.0 / *536.3*
A3	B1	18.1 / *601.8*	18.2 / *627.9*	18.5 / *661.4*	16.0 / *532.0*	16.4 / *565.8*	16.4 / *586.3*
	B2	17.0 / *565.3*	17.2 / *593.4*	17.6 / *629.2*	15.6 / *518.7*	16.0 / *552.0*	15.4 / *550.6*
	B3	17.6 / *585.2*	17.6 / *585.2*	18.1 / *624.5*	15.1 / *502.1*	15.9 / *548.6*	14.7 / *525.5*
	B4	17.2 / *571.9*	17.9 / *617.6*	18.3 / *654.2*	14.5 / *482.1*	15.2 / *524.4*	14.9 / *532.7*
A4	B1	18.0 / *598.5*	18.1 / *624.5*	18.5 / *661.4*	16.2 / *538.7*	16.8 / *579.6*	16.0 / *572.0*
	B2	17.3 / *575.2*	17.6 / *607.2*	18.1 / *647.1*	15.4 / *512.1*	15.9 / *548.6*	15.0 / *536.3*
	B3	17.0 / *565.3*	17.6 / *607.2*	18.2 / *650.7*	16.4 / *545.3*	17.1 / *590.0*	16.4 / *586.3*
	B4	16.7 / *555.3*	17.0 / *586.5*	17.3 / *618.5*	15.0 / *498.8*	15.8 / *545.1*	14.9 / *532.7*
LSD		*1.40/2.04/3.07*	*1.16/1.80/2.57*	*1.27/1.82/2.75*	*0.48/0.67/1.07*	*0.87/1.26/1.91*	*0.35/0.49/0.78*

Notes: LSD at 5%, 1% and 0.1% levels;
Variant: A1 -monoculture, A2 – 2 year rotation; A3 – 3 year rotation; A4 – 4 year rotation;
B1 - No-tillage system (direct sowing). B2 - chisel plow (18-20 cm) + disk (8-10 cm); B3 - disk (10-15 cm) + 2 passes; B4 - plowing autumn (22-25 cm) + disk (8-10 cm)

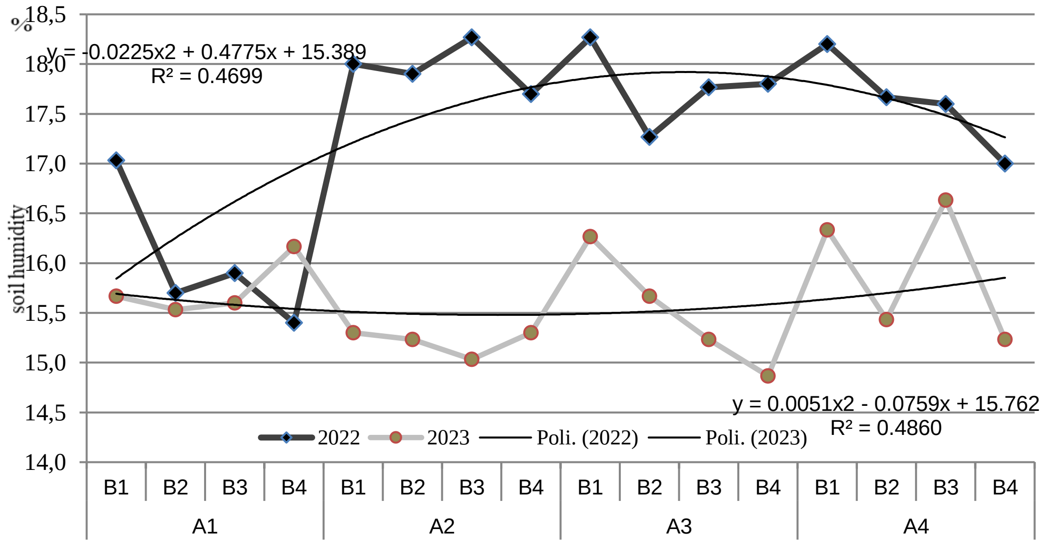

Figure 1. The correlation between soil moisture and maize cropping measures applied during 2022-2023

It can be observed that crop rotation associated with minimum tillage systems and even no-till systems increase and positively influence the soil's capacity to store and retain water, compared to the conventional system. Soil moisture determinations have shown that soil water reserves are a decisive indicator in adapting the tillage system to the particularities of the crop.

Weed control

The data obtained during the experimental period highlighted the contribution of crop rotation associated with soil work to reducing the degree of weeding with different weed species in maize crop.

Based on the results obtained, it was demonstrated that long rotations (3-4 year) and soil work depth contribute to a significant decrease in the total number of weeds depending on the agricultural year (Table 3).

Table 3*. Influence of crop rotation and soil tillage system on weeds control for maize crop*

Year	Variant *Witness variant		Total weeds		Monocotyledonous nr/m²		Dicotyledonous nr/m²	
					Annual	Perennial	Annual	Perennial
			nr/m²	%	nr/m²	nr/m²	nr/m²	nr/m²
2022	A1*	B1*	280	100	30	73	38	139
		B2	240	86	24	70	22	124
		B3	211	75	26	54	21	110
		B4	154	55	20	42	21	71
	A2*	B1*	*271*	*100*	*34*	*65*	*40*	*132*
		B2	*232*	*86*	*26*	*65*	*26*	*115*
		B3	*204*	*75*	*20*	*49*	*21*	*114*
		B4	*150*	*55*	*16*	*40*	*21*	*73*
	A3*	B1*	248	100	34	60	50	104
		B2	224	91	30	50	40	124
		B3	178	72	22	38	40	78
		B4	140	56	16	30	36	58
	A4*	B1*	*190*	*100*	*28*	*35*	*37*	*90*
		B2	*170*	*89*	*29*	*37*	*42*	*62*
		B3	*148*	*78*	*19*	*29*	*40*	*60*
		B4	*120*	*63*	*19*	*24*	*32*	*45*
LSD *Weeds/m²* (5%, 1%, 0.1%) 45.3 / 90.3 / 135.2								
2023	A1*	B1*	292	100	34	69	42	147
		B2	263	90	40	60	40	123
		B3	222	76	30	60	50	82
		B4	180	62	30	56	36	58
	A2*	B1*	*286*	*100*	*43*	*70*	*80*	*93*
		B2	*221*	*77*	*31*	*33*	*62*	*95*
		B3	*209*	*73*	*29*	*50*	*32*	*98*
		B4	*166*	*58*	*22*	*40*	*27*	*77*
	A3*	B1*	250	100	40	58	50	102
		B2	212	85	31	58	63	60
		B3	164	66	24	42	60	38
		B4	138	55	24	36	49	29
	A4*	B1*	*209*	*100*	*24*	*39*	*35*	*111*
		B2	*189*	*90*	*16*	*22*	*30*	*121*
		B3	*152*	*73*	*15*	*17*	*24*	*96*
		B4	*111*	*53*	*12*	*18*	*26*	*55*
LSD *Weeds/m²* (5%, 1%, 0.1%) 49.7 / 85.9 / 124.1								

In 2022, a dry year, the monoculture variant associated with the no-tillage system recorded the highest value of 280 weeds/m2, and the plowing + disc variant recorded a number of 154 weeds/m2, with approximately 126 weeds/m2 less. Compliance with the 4-year rotation variants associated with the plowing + disc work led to the recording of the lowest number of species, i.e. 120 weeds/m2, followed by the chisel + disc variant with 148 weeds/m2. From a classification point of view, dicotyledonous weeds recorded much higher percentages than monocotyledonous weeds. Thus, the monoculture associated with the no-till system recorded the highest number of annual and perennial dicotyledonous weeds, with 177 weeds/m2, and annual and perennial monocotyledonous weeds, with 103 weeds/m2, compared to the 4-year rotation variant associated with plowing+disc which recorded 77 annual and perennial dicotyledonous weeds/m2 and 43 weeds/m2 for annual and perennial monocotyledons. Competition for soil water in a crop/weed profile can be characterized by a significant increase in the water stress of the maize crop due to the presence of weeds.

The prolonged effect of water stress on corn represents a major impediment in all phases of plant development, and the presence of a large number of weeds accentuates the negative effects that are also found in the final production. Therefore, in 2023, a very dry year, crop rotation associated with basic soil tillage influenced the degree of weeding. Thus, the lowest infestation was recorded in the variants with 4-year crop rotation and autumn plowing + disk, with 111 pl/m2 and with chisel + disk with 152 pl/m2, while the highest values of the number of weeds were recorded in monoculture associated with no-till with 292 weeds/m2.

When applying the monoculture variants associated with the minimum tillage system and even with no-till, weeding of the corn crop with perennial dicotyledonous and monocotyledonous species was favored over the annual ones, due to the large reserve of seeds remaining in the soil and undisturbed and their ability to adapt to unfavorable conditions. On average, the year 2023 recorded a number of 204 weeds/m2, 3.5% higher than the year 2022, when 197 bur/m2 was recorded, regardless of the associated tillage variant. Every year, in the maize crop, perennial dicotyledonous weeds recorded higher numerical values compared to the other categories.

CONCLUSIONS

Crop rotation and tillage systems are very important for maize cultivation and determine the start of vegetation and the evolution of the crop at key moments by influencing the possibilities of water conservation and increasing the efficiency in weed control.

The structure of weeds present in the maize crop was as follows: 20-40% monocotyledons and 60-80% dicotyledons depending on the associated technological links and the year. The decrease in the number of weeds and their development can be stopped, not by eradication, but at levels that do not cause economic damage, by the combined application of technological links.

Soil moisture is conditioned by the soil tillage system and the preceding crop in association with the other links and is directly proportional to the amount of precipitation and the vegetation phase of the maize crop.

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