INFLUENCE OF THE CROP ROTATION ON YIELD AND WATER USE EFFICIENCY IN WINTER WHEAT FROM CRISURILOR PLAIN

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Abstract

The paper is based on the researches carried out at Agricultural Research and Development Station Oradea during 2013-2014 on the preluvosoil condition. In 2013 the lowest winter wheat yields were obtained in monoculture, 3270 kg / ha in unirrigated variant and 5830 kg / ha under irrigations condition. In crop rotation winter wheat-maize, winter wheat yield increased by 21.7% and 11.7%, and in winter wheat-maize-soybean crop rotation with 48.6% and 31.6%. Irrigation determined the obtaining a yield gain on that three crop rotations by 2633 kg / ha (65.2%), statistically highly significant. In 2014 the lowest winter wheat yields were recorded in monoculture both irrigated and unirrigated variant and higher yield registered in crop rotation with soybean. Irrigation determined the obtaining an gain yield of 23%. In 2013 the lowest values of grain protein, gluten content and falling indexes values were registered in monoculture, and the highest values in crop rotation with soybean. The same situation was registered in 2014, but the values of these indices indicate a higher quality.

Keywords*:* crop rotation, winter wheat, irrigation, yield, efficiency

INTRODUCTION

Crop rotation is the central pivot of the sustainable agriculture. It is considered as one of the most important agro-technical measures to maintain and enhance soil fertility, control of diseases and pests, increase the effectiveness of other pedoameliorative and agrophytotechnical measures of obtaining high yields and high quality in terms of profitability. Meanwhile crop rotation helps reduce chemicals used in agriculture, having special ecological importance. Crop rotation is a basic measure in planning and organizing the activities in farms.

In Romania, the first experiences with crop rotations were made after the establishment of the Romanian Institute for Agronomic Research but for various reasons this researches did not have continuity. So, now lasting experiences are older than 50 years (ARDS Şimnic), 40 years (ARDS Bottom), 30 years (Moara Domneasca), Oradea.

The way how crop rotation influence soil properties is more urgent particularly evident in the stationary experiences with long-term crop rotations. Such researches about crop rotations in all their aspects are very numerous in the country especially in countries with advanced agriculture where they far outweigh a century of observations. Using a specific crop rotation should aim primarily at maintaining a high level of potential soil fertility and improving conditions for aeration, moisture, soil temperature.

Crop rotation influences the evolution of soil structure and crop rotation, each of them having a specific effect directly through crop residues that remain in the soil and indirectly through their systems of fertilization, irrigation and soil work.

The structure degree of the soil depends primarily on humus content, nature and its quality being decisive in terms of the proportion of units hydro stabile which ultimately depends on the quality of the structure known as the "stable structure". Both the presence of organic matter in soils and percentage of aggregates hydrostabile depend and are influenced not only by plant species but also their sequence in a crop rotation, nature and quantities of fertilizer used.

MATERIAL AND METHOD

The paper is based on the researches carried out at Agricultural Research and Development Station Oradea during 2013-2014 on the preluvosoil condition. The soil from the research field had the following profile: Ap = 0-24 cm, El = 24-34 cm; BT_1 = 34-54 cm; Bt_2 = 54-78 cm; Bt / c = 78-95 cm, C = 95-145 cm. It is noted that migration of colloidal clay causes the apparition of horizon El with 31.6% colloidal clay and two horizons of colloidal clay accumulation with BT_1 and Bt_2 with 39.8% and 39.3% colloidal clay.

Field capacity (Fc) is median on the all soil profile and Wilting Point (Wp) has a median value till 80 cm depth and big value below this depth. Easily available water content (W_{ea}) was established by formula (Botzan 1966, Grumeza and all, 1989):

$$W_{ea} = WP + 2/3\ (Fc - WP)$$

Soil reaction is low acid, the humus content (1,8%) is small and the total nitrogen content (0,127-0,156 ppm) is small- median; the mobile potassium content is small – median, too. The annual fertilization with the specifically doses for irrigated crops increased the phosphorus content from 22,0 ppm to 150,8 ppm.

The experience had two factors as follows:

Factor A: Crop rotation

a_1: winter wheat, monoculture;

a_2: winter wheat - maize;

a_3: winter wheat -maize-soybean.

Factor B: Water regime

b_1- unirrigated

b_2 – irrigated

Experimental plot area: 50 m^2.

Method of experience arrangement was after block method in four repetitions.

Quality parameters of the winter wheat grains (protein, gluten, falling indices) were determined in the laboratory by usualy methods.

Water use efficiency (EVA) (Domuţa C., 2005) was determined using the following formula:

$$EVA = \frac{P}{\sum(e+t)} \quad [kg/m^3]$$

in which:

P = yield (kg/ha);

$\sum$(e+t) = total water consumpton (m^3/ha)

In irrigated variants was observed the maintaining of water reserve between easily available water content and field capacity on 0-50 cm depth. Irrigation was made by sprinkler through a device adapted.

Harvesting of experiences and calculating the results was performed by following instructions provided by experimental techniques (Săulescu NA., Săulescu NN, 1967 Domuta C., 2006).

RESULTS AND DISCUSSION

Crop rotation and water regime influenced on winter wheat yield quantity

In 2013 the lowest winter wheat yields were obtained in monoculture, 3270 kg / ha in unirrigated variant and 5830 kg / ha under irrigations condition. In crop rotation winter wheat-maize, winter wheat yield increased by 21.7% and 11.7%, and in winter wheat-maize-soybean crop rotation with 48.6% and 31.6%. Irrigation determined the obtaining a yield gain on that three crop rotations by 2633 kg / ha (65.2%), statistically highly significant (Table 1.)

Table 1

The influence of crop rotation and irrigation on winter wheat yield (kg/ha) Oradea 2013

Crop rotation	Water regime		Difference		Average on crop rotation
	Unirrigated	Irrigated	Kg/ha	%	
Winter wheat – monoculture	3270	5830	2560	78	4550
Winter wheat - Maize	3980	6510	2530	64	5245
Winter wheat – Maize - Soybean	4860	7670	2810	58	6265
Average on regime	4037	6670	2633	65	-

	Crop rotation	Water regime	x Water regime Crop rotation	Crop rotation x Water regime
LSD 5%	215	182	310	240
LSD 1%	326	296	530	460
LSD 0.1%	510	472	820	712

In 2014 the lowest winter wheat yields were recorded in monoculture both irrigated and unirrigated variant and higher yield registered in crop rotation with soybean. Irrigation determined the obtaining a gain yield of 23%. (Table 2).

Table 2

The influence of crop rotation and irrigation on winter wheat yield (kg/ha) Oradea 2014

Crop rotation	Water regime		Difference		Average on crop rotation
	Unirrigated	Irrigated	Kg/ha	%	
Winter wheat – monoculture	4030	5230	1200	30	4630
Winter wheat - Maize	4980	6060	1080	22	5520
Winter wheat – Maize - Soybean	5830	7010	1180	20	6420
Average on regime	4947	6100	1153	23	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
LSD 5%	270	206	340	250
LSD 1%	410	315	560	490
LSD 0,1%	660	525	856	730

The influence of crop rotation and water regime on quality indexes of winter wheat yield

In 2013 the lowest values of grain protein and gluten content and falling value were registered in monoculture, and the highest values in crop rotation with soybean. The same situation was registered in 2014, but the values of these quality indices were higher (Table 3. Table 4).

Table 3.

The influence of crop rotation and water regime on quality indexes of winter wheat yield, Oradea 2013

Crop rotation	Water regime		Difference %
	Unirrigated	Irrigated	
Protein (%)			
Winter wheat – monoculture	10.7	10.5	-2
Winter wheat - Maize	12.9	12.7	-2
Winter wheat – Maize - Soybean	15.0	14.8	-1
Gluten (%)			
Winter wheat – monoculture	21	20	-5
Winter wheat - Maize	24	23	-4
Winter wheat – Maize - Soybean	30	29	-3
Falling indexes (seconds)			
Winter wheat – monoculture	208	201	-3
Winter wheat - Maize	270	260	-4
Winter wheat – Maize - Soybean	310	304	-2

Table 4

The influence of crop rotation and water regime on quality indexes of winter wheat yield, Oradea 2014

Crop rotation	Water regime		Difference %
	Unirrigated	Irrigated	
Protein (%)			
Winter wheat – monoculture	10.9	10.6	97
Winter wheat - Maize	13.0	12.7	98
Winter wheat – Maize - Soybean	15.1	14.9	98
Gluten (%)			
Winter wheat – monoculture	23	21	92
Winter wheat - Maize	27	24	89
Winter wheat – Maize - Soybean	31	29	94
Falling indexes (seconds)			
Winter wheat – monoculture	210	205	97
Winter wheat - Maize	290	280	97
Winter wheat – Maize - Soybean	340	330	97

Influence of crop rotation and water regime on water use efficiency (EVA)

In 2013, water used efficiency by winter wheat crop had the lowest values in monoculture; in crop rotation winter wheat - maize water used efficiency increased by 27.5% and 11,2%, and in crop rotation winter wheat - maize-soybeans with 33.8% and 31.4%. (Table 5.)

Table 5

Influence of crop rotation and water regime on water use efficiency (EVA, kg/m^3) at winter wheat crop , Oradea 2013

Crop rotation	Water regime		Average on crop rotation
	Unirrigated	Irrigated	
Winter wheat – monoculture	1.60	1.37	1.49
Winter wheat - Maize	2.04	1.53	1.79
Winter wheat – Maize - Soybean	2.14	1.80	1.97
Average on regime	1.93	1.57	-

In 2014, water used efficiency by winter wheat crop had the lowest values in monoculture; in crop rotation winter wheat - maize water used efficiency increased by 24,0% and 32.0%, and in crop rotation winter wheat - maize-soybeans with 45% and 60%. (Table 6.)

Table 6.

Influence of crop rotation and water regime on water use efficiency (EVA, kg/m^3) at winter wheat crop , Oradea 2014

Crop rotation	Water regime		Average on crop rotation
	Unirrigated	Irrigated	
Winter wheat – monoculture	1.18	1.27	1.23
Winter wheat - Maize	1.46	1.67	1.47
Winter wheat – Maize - Soybean	1.71	1.90	1.81
Average on regime	1.45	1.62	-

CONCLUSIONS

The research were realized in 2013 and 2014 in long term trial placed in 1990 at the Agricultural Research and Development Station Oradea and the conclusions are:

- The lower winter wheat yields were obtained in monoculture winter wheat; in crop rotation winter wheat-maize winter wheat yield increased statistically very significant; the highest yields of winter wheat crop were obtained in crop rotation winter wheat-maize-soybean.
- Protein and gluten content in grains and falling indexes value were lowest in monoculture and in crop rotation with soybean was higher.

- The smallest quantity of winter wheat grains obtained from $1m^3$ of water consumed was obtained in monoculture and the higher quantity of yield was obtained in crop rotation with soybean.

Irrigation determined obtaining of yield gains statistically highly significant in both years studied but quality index values are lower than unirrigated conditions.

The research shows the importance of crop rotation with soybean at winter wheat crop and the necessity of irrigation for this crop.

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