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RESEARCHE REGARDING ON THE INFLUENCE OF CROP ROTATION AND NUTRITION REGIME ON THE GROWTH PROGRESS OF BIOMASS AND PRODUCTION IN WINTER WHEAT CULTIVATED ON LUVOSOILS

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Abstract

The paper is based on the research carried out during 2018-2020 in a long term trial placed in 2001 on the luvosoil from Agricultural Research and Development Station Oradea. The crop rotation and nutrition regime influence on the biomass and yield were studied in the following device: factor A- crop rotation (a_1= winter wheat, monocrop; a_2= winter wheat-maize; a_3= pea-winter wheat-maize a_4= pea-winter wheat-maize-maize) factor B- nutrition regime (b_1= N0P0; b_2= $N_{120}P_{80}$; b_3= $N_{120}P_{80}$+manure 10 t/ha (applied for every crop). The biggest quantity of total biomass was determined in the crop rotation pea-winter wheat-maize-maize and the smallest quantity was registered in the winter wheat monocrop in all stages of the vegetation period. The difference between these variants were of 128% at the beginning of the vegetation, of 39% at the first internod formation, of 22% at straw elongation, of 25% at spike formation, of 26% at the beginning of the seed formation, of 21% at early ripening, of 23% at incomplete ripening and of 29% at complete ripening; the nutrition regime had a great influence, too, on the total dry biomass. The highest values were registered in the variant fertilized with $N_{120}P_{80}$+manure 10 t/ha and the smallest in the variant N_0P_0. Between these variants, the following differences were determined: of 64% at the beginning of the vegetation, of 48% at the formation of the first internod, of 53% at straw elongation; at 38% at the formation of spike; of 32% at the beginning of seeds formation, of 39% at early ripening, of 41% at incomplete ripening and of 24% at complete ripening; in the total biomass, the grain mass represented 35%-43%, strain mass 22%-42%, chaff mass 4%-14%, foliar mass 5%-10% and root mass represented 4-9%; the crop rotation influenced the yield level. The smallest yield was obtained in winter wheat monocrop, 2920 kg/ha. In the other variants, the yields obtained were bigger; the differences were of 21% in winter wheat-maize, of 56% in pea-winter wheat-maize and of 57% in pea-winter wheat-maize-maize; the nutrition regime influenced very much (2610 kg/ha) the yield level, in comparison with the variant N_0P_0, the winter wheat yield obtained in the variant with $N_{120}P_{80}$ increased with 69% and in the variant $N_{120}P_{80}$+manure 10 t/ha with 80%.

Key words: winter wheat, crop rotation, fertilization level, phenophase, biomass wheat components

INTRODUCTION

The biomass accumulation, as well as a large yield of a superior quality, is conditioned by a series of factors as the intensity, quality and duration of illumination, atmospheric air warmth and soil temperature, water content of soil, plant water content, precipitations, atmospheric humidity, chemical composition of soil, fertility,crop rotation and fertilization (Bingham, 1980, Soltner, 1990, Salisbury, 1995).

The crop rotation together with other appropriate agricultural practices contribute to the favourableness of growth and development conditions of wheat root system, to an improved synthesis of specific organic compounds and their improved translocation to plant's organs (Ionescu, 1985, Ardelean, 2009, 2013).

At the low temperature during winter, the process of photosynthesis does not stop, but the content of chlorophyll decreases, the content of ascorbic acid increases, the concentration of the cellular juice increases, the percent of dry substance increases, which points out a better adaptation to the conditions during winter (Austin, 1978, Schmidt, 1980,).

The intensity of the growth of wheat plants in spring stands under the influence of the moisture and temperature conditions, important differences in the quantity of dry substance accumulated by the wheat plants being determined by the mineral and organic-mineral nutrition factors. (Bandici, et. al., 2003).

Plant growth is fundamental in obtaining yield and it is related to vegetation and technological factors, the level of yield being reflected in the intensity of biomass accumulation. In the majority of cases, total growth of green mass is considered on the assumption that a maximum yield is obtained by increasing total dry weight biomass production and by a favourable repartition of it among plant's organs (Dincă, 1982).

However, as a known fact roots are not only absorbing water and nutrients from soil but play a key role in plant's general metabolism. Roots harbour the biosynthesis of some essential compounds for the rest of the plant to which they send the biosynthetic products (Lazany, 2000).

The conclusions that were reached with regard to a normal development of plants, point the importance of a balanced NP fertilisation. This ensures the avoidance of disturbances caused by drought during the vegetation period which decrease plant's resistance. Also, a balanced fertilisation promotes a corresponding passage over each growth stage in order to equilibrate the other vital process, the development and finally to reach corresponding productions (Lazany, 2003).

Most of the research was centred on the influence of crop rotation on the yields, namely on the biomass accumulation. The crop rotations with regard to wheat was very satisfactory in this order as forerunner plant: pea, beans, winter rape, linseed, soy, red clover, potato, sugar beet, sunflower, corn etc. (Muntean L.S., et al., Domuţa, Bandici, 2007).

After long tests it was demonstrated the importance of crop rotation on wheat yields on brown-red soils in Romanian Plain. On clay-illuvial podzols, the introduction of ameliorative plants, such as red clover represented an element of outmost importance for the increase of the wheat yield (Bîlteanu, 1993, Ardelean, 2006).

It is demonstrated that after 10 years monocrop, wheat yield decreases continously in comparative with rotations. It fluctuates as a consequence of changing climatic conditions. Under such circumstances, fertilization does not induce a significant yield increase. A particularly important problem is linked to wheat crop increase, which must fit the rising consumption needs of world population (Domuta, et., al., 2007, 2008, Bandici, Guş, 2001).

Advances in biomass accumulation dynamics in winter wheat in the pedo-climatic conditions of Western Plain of Romania were made (Zăhan, 1989a) during their studies on Transylvanian wheat race.

The influence of fertilization on biomass accumulation in winter wheat was studied. Frequent research put in a direct relationship the phytomass accumulation with the fertilizers that were utilized (Zăhan, 1989b).

The dynamics of the phenomena dealing with winter wheat growth made the object of field research (Domuţa, 2012).

The forerunner plant is a decisive factor influencing growth and development of wheat. The role of forerunner plant on wheat growth and development is stressed out by: Zăhan (Zăhan,1989a).

Forerunner plant together with other appropriate agricultural practices contribute to the favourableness of growth and development conditions of wheat root system, to an improved synthesis of specific organic compounds and their improved translocation to plant's organs (Lazany, 2000; 2003). Finally, all the enumerated conditions lead to improved efficiency per area unit. Plant growth is fundamental in obtaining yield and is related to vegetation and technological factors, the level of yield being reflected in the intensity of production (Dincă, 1971; Bîlteanu,1993)

In the majority of cases, total growth of green mass is considered on the assumption that a maximum yield is obtained by increasing total production and by a favourable distribution of it among plant's organs (Zăhan, Zăhan,1989b, Bandici, 1997; 2001). However, roots are not only absorbing water and nutrients from soil but play a key role in plant's general metabolism. Roots harbour the biosynthesis of some essential compounds for the rest of the plant to which they send the biosynthetic products (Zamfirescu, 1977).

MATERIAL AND METHOD

The research were carried out during 2018-2020 in a long trial placed in 2001 at Agricultural Research and Development Station Oradea. The soil from the research field is a luvosoils characterized by macroaggregates hydrostability of 46.7%, a clay content of 31.5% in Ap horizon and of 39.8% in Bt horizon; field capacity on watering depth of the winter wheat is of 24.0% (178.7 mm), wilting point is of 9.7% (72.0 mm) and easily available water content is of 19.2% (143.1 mm); on the same depth, the value of the bulk density (1.49 g/cm^3) indicates a low settling, total porosity (49%) is median and hydraulic conductivity is of 12.0 mm/hour.

The presence of the Bt horizon determines the succesive appearance of the water excess in the cold season and the first part of the warm season and of the water deficit in the second part of the summer.

Chemical parameters indicate a soil with pH of 6.8, humus content of 1.75%, mobile phosphorus of 22.0 ppm and mobile potassium of 140.4 ppm on the ploughed depth (0-20 cm).

The following device of the experiment was studied.

Factor A: crop rotation:

a_1= winter wheat, monocrop;

a_2= winter wheat-maize;

a_3= pea-winter wheat-maize

a_4= pea-winter wheat-maize-maize

Factor B: nutrition regime:

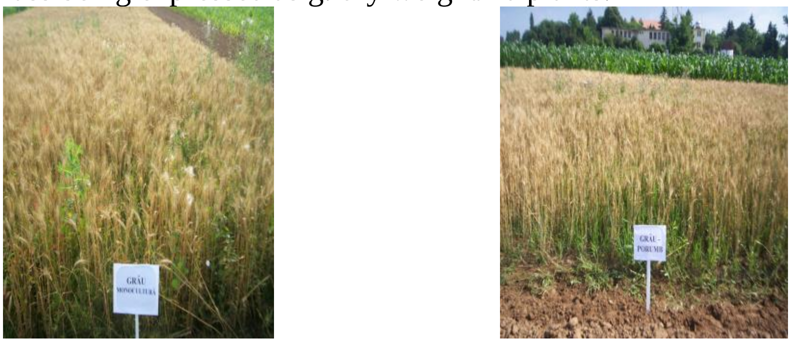
b_1= N_0P_0

b_2= $N_{120}P_{80}$

b_3= $N_{120}P_{80}$+manure 10 t/ha (applied for every crop).

Number of repetition: 4. Cultivar used: Delia.

Total biomass and separately every plants parts were weighted in the laboratory. The results were analysed with ANOVA (analysis of variance), the biomass being expressed as g. dry weight/10 plants.



a) b)

Fig. 1 Aspects from research field: a)winter wheat - monocrop ; b)winter wheat-maize crop rotation

RESULTS AND DISCUSSION

From the data in Table 1, we notice the fact that until the beginning of the vegetation, the quantity of biomass accumulated in the wheat plants on phenophases, is even larger as the precursory plant is better, that is 1.94 g. d.s./10 plants in the case of the crop rotation of two years (W-M), and of 2.72 g. d.s./10 plants in the crop rotation of three years (B-W-M), respectively of 3.88 g. d.s./10 plants in the case of the crop rotation of four years (M-G-P-P), compared to the monoculture of 1.70 g. d.s./10 plants.

Along with the advancement in vegetation of the wheat plants, we observe a gradual growth of the quantity of accumulated dry substance, but the quality step regarding the accumulation of biomass is recorded between the phenophase of the elongation of the straw and the phenophase of the formation of wheat spike, a case in which the quantity of accumulated dry substance is even larger as the precursory plant is better (peas), of 32.2 g. d.s./10 plants, compared to the monoculture of wheat (25.43 g. d.s./10 plants), and in the next phenophases the accumulation of dry substances will have a slowed rhythm, until the phenophase of full maturation.

Regarding the quantity of biomass (g. d.s./10 plants) accumulated in the wheat plants under the influence of the mineral and organic-mineral nutrition (table 2), we notice a growth of the dry substance even larger as the fertilization is better, complex organic-mineral (3.32 g. d.s./10 plants), compared to the unfertilized control sample (2.03 g. d.s./10 planta). Also in this case, the quality step of the growth of the biomass was recorded between the phenophase of the elongation of the straw and the phenophase of the formation of wheat spike, the accumulation being even larger as the fertilization level was better (complex, organic-mineral, - 31.64 g. d.s./10 plants), compared to the unfertilized control sample (22.97 g. d.s./10 plants). In the following phenophases until full maturation we notice a slowing of the rhythm of the biomass accumulation.

The data in table 3 point out better the features of the formation of the biomass of autumn wheat. Unlike other species, autumn wheat is characterized in spring by a very high growth rhythm, as in a period of 90 days over 90 % of the total biomass of the plant is realized. In the period previous to the intensive growth (October-March), the wheat plant accumulates only 5.5 % of the total quantity of biomass.

Until the formation of spike, the wheat plant has accumulated 60.4 % of the total biomass, and from this in the period 01. 04 – 15.05, in only 45 days – 54.9 %. It results that in the 45 days before the formation of spike, autumn wheat has the most intense growth rhythm, the plants requesting in this time span a large quantity of water and nourishing elements.

Table 1

The influence of crop rotation plant on total dry biomass (g.d.w./10 plants) in winter wheat cultivated on luvosoils (Oradea, Romania 2018-2020)

Crop rotation	Stage															
	1		2		3		4		5		6		7		8	
1. Winter wheat- monocrop	1.70	100	4.19	100	10.70	100	**25.43**	**100**	33.42	100	38.21	100	40.70	100	40.93	100
2. Winter wheat-maize	1.94	114	4.52	108	12.08	113	**26.16**	**103**	34.21	103	41.47	109	44.69	110	45.25	111
3. Pea-winter wheat-maize	2.72	156	5.64	135	12.37	116	**32.20**	**127**	41.51	124	43.12	113	46.28	114	48.01	117
4. Pea-winter wheat-maize-maize	3.88	228	5.83	139	13.01	122	**31.84**	**125**	42.29	127	46.41	121	50.17	123	52.76	129

1. The beginning of the vegetation
2. The formation of the first internode
3. Straw elongation
4. The formation of spike
5. Beginning of seeds formation
6. Early ripening
7. Incomplete ripening
8. Complete ripening

Table 2

The influence of nutrition regime on total dry biomass (g.d.w./10 plants) in winter wheat cultivated on luvosoils (Oradea, Romania 2018-2020)

Crop rotation	Stage															
	1		2		3		4		5		6		7		8	
	Total dry biomass															
	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%
N_0P_0 (Control)	2.03	100	4.06	100	9.09	100	**22.97**	**100**	31.80	100	34.59	100	36.91	100	42.95	100
$N_{120}P_{80}$	2.33	115	5.08	125	13.11	144	**30.65**	**133**	39.91	125	44.29	128	47.22	128	47.92	112
$N_{120}P_{80}$+manure 10 t/ha	3.32	164	6.01	148	13.95	153	**31.64**	**138**	41.82	132	48.04	139	52.22	141	53.13	124

1. The beginning of the vegetation
2. The formation of the first internode
3. Straw elongation
4. The formation of spike
5. Beginning of seeds formation
6. Early ripening
7. Incomplete ripening
8. Complete ripening

Table 3

The influence of the phenophase on the progess of growth of the total biomass of the winter wheat , cultivated on luvosoils Oradea, Romania 2018-2020

Phenophase/Date of taking of samples	Dry biomass (g)	% of the total bitomass	Growth enhancement (g)	Growth enhancement (%)
At winter beginning	0.53	1.1	-	1.1
At the end of winter	0.95	2.0	0.42	0.9
Beginning of the vegetation	2.56	5.5	1.61	3.5 **(5.5)**
Formation of the first internode	5.04	10.7	2.48	5.2
Elongation of the straw	12.04	25.6	7.00	14.9
The formation of spike	28.40	60.4	16.36	34.8 **(54.9)**
Beginning of the formation of the grains	37.86	80.6	9.46	20.2
Maturation in milk	42.28	90.0	4.42	9.4
Maturation in ripening	45.44	96.7	3.16	6.7
Full maturation	46.98	100.0	1.54	3.3 **(39.6)**

If we analyse the structure of the biomass of autumn wheat, we notice that it shows significant variations, determined by the characteristics of the soil, crop rotation and the nutrition regime of the plants (table 4). Thus, the grain production is currently under 50% of the total production of the plants.

Table 4

The compounds of the winter wheat biomass, depending on the crop rotation and the nutrition regime of winter wheat cultivated on luvosoils (Oradea, Romania 2018-2020)

Biological element	% of the total biomass
Root mass	4-9
Strain mass	22-42
Foliar mass	5-10
Grain mass	35-43
Chaff mass	4-14

Analysing the data in table 5, we notice a growth of the wheat production over the monoculture (29.2 q/ha), depending on the rotation, the production being larger as the precursory plant is better, 35.3 q/ha in the case of the rotation W-M (crop rotation 2 years) and of 45.5-45.9 in the case of the crop rotations of 3 and 4 years.

The mineral nutrition regime influences the growth of wheat production, so that over the unfertilized witness (26.1 q/ha), in the case of mineral and organic-mineral fertilization, a production of 43.9 q/ha and respectively of 46.9 q/ha was obtained.

Table 5

The influence of crop rotation, of the mineral and organic-mineral nutrition regime on the production of winter wheat cultivated on luvosoils (Oradea, Romania 2018-2020)

Variant	Grains production kg/ha	Grains yield	
		%	
		winter wheat monocrop	winter wheat-maize
		a. Rotation	
Winter wheat- monocrop	2920	100	83
Winter wheat-maize	3530	121	100
Pea-winter wheat-maize	4550	156	129
Pea-winter wheat-maize-maize	4590	157	130
		b. Nutrition regime	
N_0P_0 (Control)	2610	100	59,0
$N_{120}P_{80}$	4390	169	100
$N_{120}P_{80}$+manure 10 t/ha	4690	180	107

CONCLUSIONS

The results of the research obtained during 2018-2020 in a long term trial with crop rotation (winter wheat- monocrop, winter wheat-maize, pea-winter wheat-maize, pea-winter wheat-maize-maize) and nutrition regime (N_0P_0; $N_{120}P_{80}$; $N_{120}P_{80}$+manure 10 t/ha applied for every crop) determined the following conclusions:

- the biggest quantity of total biomass was determined in the crop rotation pea-winter wheat-maize-maize and the smallest quantity was registered in the winter wheat monocrop in all the stages of the vegetation period. The difference between these variants were of 128% at the beginning of the vegetation, of the 39% at the first internode formation, of 22% at straw elongation, of 25% at spike formation, of 26% at the beginning of the seed formation, of 21% at early ripening, of 23% at incomplete ripening and of 29% at complete ripening;
- the nutrition regime had a big influence, too on the total dry biomass. The biggest values were registered in the variant fertilized with $N_{120}P_{80}$+manure 10 t/ha and the smallest in the variant N_0P_0. Between these variants a following differences were determined: of 64% at the beginning of the vegetation, of 48% at the formation of the first internode, of 53% at straw elongation; at 38% at the formation of spike; of 32% at beginning of seeds formation, of 39% at early ripening, of 41% at incomplete ripening and of 24% at complete ripening;
- in the total biomas, the grain mass represented 35%-43%, strain mass 22%-42%, chaff mass 4%-14%, foliar mass 5%-10% and root mass represented 4-9%;
- the crop rotation influenced the yield level. The smallest yield was obtained in winter wheat monocrop, 2920 kg/ha. In the other variants the yields obtained were bigger; the differences were of 21% in winter wheat-maize, of 56% in pea-winter wheat-maize and of 57% in pea-winter wheat-maize-maize;
- the nutrition regime influenced very much (2610 kg/ha) the yield level, in comparison with the variant N_0P_0, the winter wheat yield obtained in the variant with $N_{120}P_{80}$ increased with 69% and in the variant $N_{120}P_{80}$+manure 10 t/ha with 80%.

The results of the research sustain the importance of the crop rotation (central pivot) and fertilizers, two important components of the sustainable agriculture system.

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