©LUMEN Proceedings Series
ISSN: 2601 – 2510 | e-ISSN: 2601 – 2529

2022, Volume 18: Globalization, Innovation and Development, Trends and Prospects (GIDTP 2019), pages: 13-22| https://doi.org/10.18662/lumproc/gidtp2022/02

Research on the Soil-Plant-Fertilizer Interaction in the Main Field Crops

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Abstract: *In the context of world agriculture, the application of chemical fertilizers remains one of the main ways to increase agricultural production, manage crop quality and improve soil fertility. The application of cultivation technologies, meant to lead to the improvement of agricultural production, determines biological, chemical, physiological changes in the plant and in the soil.*

Keywords: *wheat; corn; soil; climatic conditions; fertilizer; plant; economic efficiency.*

How to cite: Cernat, S., Nitu, I., & Neagu Frasin, L. B. (2022). Research on the Soil-Plant-Fertilizer Interaction in the Main Field Crops. In I. Panagoreț & G. Gorghiu (vol. ed.), *Lumen Proceedings: Vol. 18. Globalization, Innovation and Development, Trends and Prospects (GIDTP 2019)* (pp. 13-22). Iasi, Romania: LUMEN Publishing House. https://doi.org/10.18662/lumproc/gidtp2022/02

1. Introduction

This paper presents the results of research on the use of nitrogen and phosphorus fertilizers in the cultivation of wheat and corn, their influence on production change, physiological properties of plants, soil fertility and economic efficiency.

According to the FAO estimate, world agricultural production is expected to increase by 18-20 million per year, given that an average annual consumption of 227 kg of cereals / man is needed [7; 8]. In the direction of increasing agricultural production, mineral nutrition is one of the main places.

2. Problem Statement

Our research demonstrates the importance of applying chemical fertilizers to agricultural crops, the positive effect on production, on the quality of production, on soil chemistry.

Fertilization of winter wheat and corn significantly influenced production, improved production quality and soil fertility. In the southern part of the country, the limiting factor of production is water, both the production and the use of chemical fertilizers being dependent on this factor. As in the three years analyzed, for the most part they were dry years and taking into account the morpho-physiological peculiarities of the plants, the coefficients of use of the active substance from nitrogen and phosphorus fertilizers ranged between 46-54% for azot and 9.1-27% for phosphorus, these being lower for corn culture compared to wheat.

3. Research Questions/Aims of the research

Maintaining and improving soil fertility is a favorable effect of nitrogen and phosphorus fertilization. Fertilization for three years with doses of 100 kgN / ha +80 kg P_2O_5 / ha increased the total nitrogen content by 0.06%, the total carbon content by 0.02%, maintaining the humus content at 3,60%, CAH / CAF ratio to 2.55, increase in mobile phosphate content by 9-36 ppmP (with an average specific accumulation rate of 0.0243 ppmP / 1 kg P_2O_5 applied), maintenance of potassium content mobile at the value of 200 ppmK, maintaining the soil reaction at 6.0-6.2 pH units.

4. Research Methods

The results were obtained in long-term stationary experiments, located in 2015, with wheat and corn, in non-irrigated conditions. These two

experiences are part of a five-year solution: soybean-wheat-sunflower-corn-wheat, so the autumn wheat had corn as its forerunner, and corn had sunflower as its forerunner. The method of setting the experiments was the method of subdivided plots, with two factors: factor A = phosphorus (kg P_2O_5 / ha), and factor B = nitrogen (kg N / ha).

In the two experiments the specific cultivation technology for the experimental area was observed, and the fertilizers were applied as follows: phosphorus, entirely by spreading, before plowing, and nitrogen in three phases to wheat: half when preparing the field for sowing, a quarter at spring and a quarter before harvesting for maize, nitrogen was applied in two phases: when preparing the ground for sowing and before the second plowing.

In the field were made vegetation observations and determinations related to: density, leaf area, dry matter, productivity elements, and in the laboratory were determined the content of macroelements in the plant, grain and soil, technological and baking indices of flour of wheat.

Based on the determinations made, the main and secondary yields, the harvest index, the export of nutrients from the soil, the nitrogen and phosphorus balance, the correlations between the important factors, the economic efficiency of fertilization were calculated.

The wheat varieties used in the experiments were: Izvor, Flamura 85, Miranda, Glosa, Boema, and the corn hybrids were: F376, Olt.

5. Findings and discussions

The action of nitrogen and phosphorus fertilizers on wheat and corn production.

Autumn wheat reacted favorably to fertilization with nitrogen and phosphorus, the average grain production being 2497 kg / ha in the absence of fertilizers and 4751 kg / ha with 160 kg / ha + 80 kg P_2O_5 / ha. The average production increase of 88.9%, in the production of 4709 kg / ha (11.06 kg increase/1 kg s.a.), recommends as effective the doses of 120 kg N/ha + 80 kg P_2O_5 / ha for wheat.

Maize, although a large consumer of nutrients, reacts less to fertilizers compared to wheat, this priority crop being to provide the necessary water and then fertilization. Thus, compared to the average production of 4048 kg / ha obtained without fertilizers for three years, the nitrogen applied alone determined the increase of maize production by 975 kg / ha at the dose of 200 kg / ha (4.9 kg increase /1 kg N) and 912 kg / ha at a dose of 100 kg / ha (9.1 increase /1 kg N).

Unilaterally applied phosphorus contributed to the increase of maize production by 453 kg / ha at a dose of 80 kg P_2O_5 / ha, which proved to be the most effective (5.7 kg increase / 1 kg P_2O_5). The interaction of azotxphosphorus materialized by obtaining an increase of 1532 kg / ha 98.5 kg increase / 1 kg s.a.) at doses of 80 kg P_2O_5 / ha + 100 kg N /ha.

In the period 2015-2016, non-irrigation conditions, the lowest corn production was obtained in 2016 (1395 kg / ha) and the highest was obtained in 2018 (10063 kg / ha). Fertilization has increased the number of years with yields of over 4000 kg / ha. In maize cultivation, the water supply in the soil is vital, both for grain production and for the recovery of chemical fertilizers, the correlation coefficients between water supply and grain production, show that drought in the soil most affects maize after the emergence phase. Of the 5 leaves, followed by the sowing-emergence phase, the formation and filling of the grain.

5.1. Productivity elements for wheat and corn

The elements of productivity that formed the wheat production were: density, number of productive brothers, number of grains per ear, MMB; MH (Table 1).

Table 1. Productivity elements for winter wheat depending on fertilization 2015-2016

Kg P_2O_5/ha	**0**					**80**					**160**				
Kg N/ha	**0**	**40**	**80**	**120**	**160**	**0**	**40**	**80**	**120**	**160**	**0**	**40**	**80**	**120**	**160**
Dense. sp / m2	493	557	558	598	597	548	570	582	588	621	593	608	670	653	662
No brothers / m2	-	-	1,03	1,08	1,05	1,00	1,03	1,4	1,05	1,08	1,02	1,08	1,09	1,12	1,12
No grains / sp.	15	20	23	24	24	16	23	25	25	25	18	22	23	23	24
MMB g.	36,0	37,0	37,2	36,6	36,6	36,3	37,6	37,6	37,0	35,8	36,4	37,5	36,1	35,2	35,1
MH kg	74,6	75,0	75,6	75,6	75,6	74,9	75,5	75,8	75,1	75,3	74,2	74,7	75,2	75,2	75,9
DL 5%	Density P x N 41 68			No brothers P x N 0,4 0,7		No grains P x N 3 6			M.M.B P x N 0,3 0,5		M.H. P x N 0,6 0,9				

Source: Authors own contribution

Fertilization with 80-120 kg N / ha + 80 kg P_2O_5 / ha, contributed to the increase of the density of ears by 89-95 / m^2, of the number of productive brothers by 1.05 / m^2, to the increase of the number of grains per ear, with 10 grains, of MMB with 1.6 grams and MH with 1.2 kg.

In maize, fertilization reduced the degree of fertility, favorably influenced the number of cobs / ha, the number of grains per 1 cob (table 2). For maize cultivation, by applying 100 kg N / ha + 80 kg P_2O_5 / ha, the most favorable productivity elements were obtained.

Table 2. Elements of productivity in maize according to fertilization
Average 2015-2016-2017-2018

Kg P_2O_5/ha	**0**					**100**					**150**				
Kg N/ha	**0**	**50**	**100**	**150**	**200**	**0**	**50**	**100**	**150**	**200**	**0**	**50**	**100**	**150**	**200**
Dense. pl / m2	48620	40310	49600	48900	49300	48320	49610	49010	48230	49100	48820	48910	49560	49010	49820
No st / ha	41320	42820	43730	43830	44530	43620	44620	43500	43920	44020	43880	44280	45390	44580	45050
Degree of sterilty	15,1	13,1	11,8	10,4	9,7	9,8	10,1	9,6	9,0	10,4	10,1	9,5	8,9	9,1	9,6
No grains/st	380	408	424	429	432	396	428	456	468	470	398	433	458	465	468
MMB g	260	268	270	269	265	264	270	276	275	270	266	270	270	270	268
MH kg	74	74	75	75	75	74	75	75	75	75	74	75	75	75	75
DL 5%	Degree of sterility P x N 1,8 5,1					No grains P x N 32,0 69,0					M.M.B P x N 4,0 11,0				
											M.H. P x N 1,0 1,5				

(Source: Authors own contribution)

5.2. The action of nitrogen and phosphorus fertilization on physiological indices in wheat and corn

Wheat is part of the category of agricultural plants that form after absorption of CO_2 , 3 phosphoglyceric acid, a stable compound with 3 carbon atoms, while corn, falls into plant species that form stable compounds with 4 carbon atoms, so it has a higher phosphosynthetic capacity great and therefore a possibility to obtain productions of over 10-15 t / ha.

5.3. The action of chemical fertilization on physiological indices in winter wheat

The foliar surface of autumn wheat, one of the physiological indices dependent on chemical fertilization, was determined in 4 phases of

vegetation. at spring release, during growth, at split and at physiological maturity (table 3).

Table 3. Average leaf area achieved for winter wheat depending on fertilization (m² /ha) Average 2016-2017-2018

Kg P_2O_5/ha	Kg N/ha	Spring		Growth		Roan		Maturity	
		Total	Growth	Total	Growth	Total	Growth	Total	Growth
0	**0**	2804	0	8805	0	15217	0	1021	0
	40	3041	237	11135	2330	19139	3922	1220	199
	80	3611	807	12675	3870	21703	6486	1654	633
	120	3996	1172	13474	4669	22382	7165	1818	797
	160	4048	1244	13739	4934	22975	7758	1813	792
80	**0**	3262	458	9037	232	15961	774	1103	82
	40	3865	1061	13140	4335	21187	5970	1281	260
	80	4410	1606	15810	7005	25047	9830	1793	772
	120	4475	1653	16157	7352	26273	11056	2130	1109
	160	4422	1618	16220	7415	26337	11120	2002	981
180	**0**	3376	572	9140	338	16093	876	1233	212
	40	4169	1365	13317	4512	20770	5553	1327	306
	80	4191	1387	16240	7435	26013	10796	1777	756
	120	4339	1535	16383	7578	26533	11316	1960	939
	160	4330	1516	16467	7662	26767	11550	2003	1002
DL 5%		**P x N**		**P x N**		**P x N**		**P x N**	
		180	**250**	**290**	**1270**	**760**	**1560**	**140**	**170**

Source: Authors own contribution

In the splitting phase, the largest assimilation area 15217-26767 m^2 / ha was achieved. Fertilization contributed to the significant increase of leaf areas, the highest increase (55.28 m^2 / 1 kg sa) being obtained with 80 kg P_2O_5 / ha +120 kg N / ha (11056 m^2 / ha), while the application of 80 kg P_2O_5 / ha + 80 kg N / ha determined the achievement of a leaf area of 9380 m^2 / ha.

Depending on the assimilation area, the index of the leaf area obtained by relating the leaf area to the land area, was the highest at the splitting phase, with values of 1.5-2.7, characteristic for the southern area and non-irrigation conditions. and drought. Nitrogen had the strongest influence on the assimilation surface, the correlation ratios between the two factors being over 0.900 compared to the correlation ratios calculated for the dependence between the assimilation surface and phosphorus, which were lower.

Also between the assimilation surface to wheat and the obtained grain production is a strong dependence, the correlation ratios being 0.969-0.990.

5.4. The action of nitrogen and phosphorus fertilization on physiological indices in corn

For maize, in non-irrigated conditions, in the southern part of the country, where the hydrothermal index is 6.05, the obtaining of grain productions higher than 6-8 t / ha is dependent on the correct application of the cultivation technology, in which chemical fertilization plays an important role.

Leaf area, nitrogen and phosphorus fertilization in maize led to the improvement of the assimilation surface in all the years experienced, in all the determined vegetation phases: 3-5 leaves; 8-10 leaves; the appearance of panic; physiological maturity (Table 4).

The average assimilation area for maize was the largest in the panic phase, it reached 32650 m^2 / ha in the absence of fertilizers and 36403 m^2 / ha, in case of application of quantities of 100 kg N / ha + 80 kg P_2O_5 / ha, fertilization bringing an increase of 3753 m^2 / ha. The presence of the green leaf at the maturity of the grain was due to the favorable conditions in 2016, in the southern part of the country, in most years a premature drying of the foliar apparatus and grain ripening, due to drought installed after the formation and filling of the grain.

Table 4. Average leaf area in maize cultivation, depending on nitrogen and phosphorus fertilization, (m^2 / ha), average 2016, 2017, 2018

Kg P_2O_5/ha	Kg N/ha	3-5 leaves		8-10 leaves		Panic onest		Maturity	
		Total	Growth	Total	Growth	Total	Growth	Total	Growth
0	**0**	2228	0	7160	0	32650	0	607	0
	50	2463	235	8253	1093	33967	1317	607	20
	100	2712	484	9597	2437	35227	2577	637	30
	150	2707	479	10000	2840	35803	3153	663	56
	200	2757	529	10185	3025	36167	3517	663	56
80	**0**	2673	445	8377	1217	33307	657	683	76
	50	3020	792	9233	2073	35233	2583	763	156
	100	3331	1103	10441	3281	36403	3753	787	180
	150	3407	1179	10550	3390	36733	4083	800	190
	200	3454	1226	10678	3518	36767	4117	803	196
180	**0**	2773	545	8470	1310	33393	743	690	83
	50	3177	949	9410	2250	25637	2987	767	160
	100	3334	1106	10267	3107	35560	3850	783	176
	150	3362	1134	10717	3557	36803	4153	830	223
	200	3321	1093	10787	3627	36800	4150	827	220
DL 5%		**P x N**		**P x N**		**P x N**		**P x N**	
		280 530		**940 1210**		**530 1120**		**40 120**	

Source: Authors own contribution

The average assimilation area of 36000 m^2 / ha is reduced to obtain productions of more than 9-10000 kg / ha of maize grains, because for this crop large yields are obtained with a leaf index of 5-6 thousand m^2 s.f / m^2 t, or under the given experimental conditions, the values of the leaf surface index were 3.26-3.61 thousand m^2 s.f / m^2 t. As a result of these values of the photosynthesis surface, the average grain productions were between 4532 kg / ha and 5596 kg / ha, with correlation ratios of 0.973 and 0.989 also in dry years, such as 2017, the index of leaf area was a maximum of 1.9 thousand m^2 s.f / m^2 t, and grain production was a maximum of 1450 kg / ha, while in a year rich in rainfall, as in 2018, the index of leaf area was 4.5-4.6 thousand m^2 s.f / m^2 t, and grain production was 10000-11000 kg / ha of grain, at the same quantities of fertilizers: 100 kg n / ha + 80 kg P_2O_5 / ha. In dry years, reducing the amount of phosphorus and nitrogen becomes economical, because physiological indices close in value are achieved.

Chemical fertilization contributed to the accumulation of dry matter in all phases of vegetation in proportion to the doses of fertilizers applied, being determined by the assimilation surface. The average amount of dry matter accumulated was maximum in the period between panic and physiological maturity that is, during grain formation and filling; 12218 kg s.u./ha in the absence of fertilizers and 15996 kg s.u./ha, with 100 kg N / ha + 80 kg P_2O_5 / ha.

Based on the data obtained on the distribution of dry matter on the plant elements in maize, it was found that the dry matter is found in a proportion of 33.4-46.7% in grain; 26.4-36.2% in strains; 15.8-22.0% in leaves; 6.8-11.1% in rachis; 0.7-1.1% in panic, in dry years accumulating a lower percentage in the grain and higher in the stems.

As a result of the assimilation surface obtained in climatic and nutritional conditions, the average net assimilation in maize had values between 1.7-2.2 g / pl / day in the period between 3-5 leaves and 8-10 leaves, of 1 , 0-1.1 g / pl / day. In the period between 8-10 leaves and the appearance of the panicle, when usually in the southern part of the country settles the second dry period and 1.6-2.1 g / pl / day between the appearance of the panicle and maturity (table 5).

Table 5. Average net assimilation of maize by fertilization (gsu/ pl/day)

Kg P_2O_5/ha	Kg N/ha	8-10 leaves - 3-5 leaves	8-10 leaves- panic onest	panic onest-maturity
0	**0**	1,7	1,0	1,6
	50	1,8	1,1	2,0
	100	1,9	1,1	1,9
	150	1,9	1,1	1,8
	200	1,8	1,1	1,8
80	**0**	2,0	1,0	1,9
	50	2,1	1,1	2,1
	100	2,1	1,1	2,0
	150	2,2	1,1	2,1
	200	2,2	1,1	2,1
160	**0**	1,9	1,0	1,7
	50	2,1	1,1	1,9
	100	2,1	1,1	1,9
	150	2,1	1,1	2,0
	200	2,1	1,1	2,0
DL 5%		**N x P** **0,4 0,2**	**N x P** **0,2 0,1**	**N x P** **0,5 0,3**

Source: Authors own contribution

Chemical fertilization contributed to the improvement of photosynthetic yield, the most favorable values being obtained with 100 kg N/ha + 80 kg P_2O_5/ ha, namely 2.1 g s.u./pl/day, 1.1. g.s.u/pl/day and 2.0 g.s.u/pl/day, in the three periods.

During the panic, the net assimilation was maintained in all three years analyzed, and the values obtained were different: in 2017, the net assimilation was maximum in the phase of grain formation and filling (0.9-0.6 gsu / pl / day), while in 2018, in the same vegetation phase, the net assimilation was 2.0-2.9 gsu / pl / day.

The dependence between net assimilation and production on maize cultivation is also demonstrated by the correlation coefficients: of 0.645 obtained according to nitrogen and in the absence of phosphorus, 0.541 obtained depending on the application of phosphorus, but without nitrogen, 0.710 depending on nitrogen on the land with 80 kg P_2O_5 / ha. Although insignificant, these correlation coefficients demonstrate the strong involvement of nitrogen in the process of photosynthesis in maize, especially when applied on the agrofund of 80 kg P_2O_5 / ha.

6. Conclusions

Of the two crops covered by this paper, wheat fertilization was more efficient than corn fertilization. The application of quantities of nitrogen and phosphorus higher than 80 kg P_2O_5 + 80 kg N / ha to wheat and than 80 kg P_2O_5 / ha +100 kg N / ha to maize, determined the reduction of economic and energy efficiency. The quantities of nitrogen and phosphorus at which the highest additional net profit was achieved at 1000 ron expenses with fertilizers, were: -80 kg N / ha + 80 kg P_2O_5 / ha for wheat; 100 kg N / ha + 80 kg P_2O_5 / ha and for maize; quantities that were also energetically effective.

The average economic optimal doses of nitrogen and phosphorus are under the influence of the increase in current fertilizer prices.

The increase of agricultural production cannot be achieved without the rational application of chemical fertilizers.

Fertilization of winter wheat and corn significantly influenced production, improved production quality and soil fertilization.

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