CHANGES REGARDING MAGNESIUM MOBILITY ON A CAMBIC CHERNOZEM SOIL DEPENDING ON CROP TECHNOLOGY

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ABSTRACT

Within some long-term experiments on cambic chernozem of Fundulea, in which for 30 years only nitrogen and phosphorus fertilizers were applied, under dry land conditions, important modifications have been observed with regard to both content of mobile forms of some nutritive elements and the relationships between them. Comparatively, in experimental plots under various irrigations norms, these modifications are much faster, especially due to the composition of irrigation water, a more intensive leaching of some ions with the water flow, as well as some more important exports of nutritive elements at harvesting. The present study reveals clear variations of magnesium mobility on the same soil type, depending on the technologies applied. Fertilization with nitrogen and phosphorus evidently influences pH and the concentrations of mobile phosphorus, potassium and magnesium forms. Between K^+ and Mg^{2+} ions, a negative interactions has been pointed out. Under irrigation conditions, values of soluble magnesium are lower due to leaching and export at harvesting. Among the hybrids cultivated, Fundulea 365 showed the best magnesium translocation capacity.

Key words: cambic chernozem, irrigation, magnesium, maize, mobility, nitrogen and phosphorus fertilization.

INTRODUCTION

Magnesium ions play a vital role in plant, animal and human metabolism. Being a central atom of chlorophyll it is essential in the photosynthesis process which represents the source of life on the earth. From unicellular plants up to the most complex superior organisms, magnesium conditions important reactions involved in metabolism such as synthesis of proteins, of nucleic acids or the production of energy. It is co-factor or activator of over 300 enzymes due to the capacity of Mg^{2+} ions to form chelates with the organic matter (Mengel and Kirkby, 1982).

Almost all reactions with energy transfer depend on the presence of Mg^{2+} ions. Phosphorylation process which has a huge significance in transformations of substances and energy in the cells, greatly depends on this natural activator (Bergmann, 1992). According to Aikawa (1981) where there exists ATP there necessarity exists the need for magnesium. A large number of reactions, starting from decomposition of carbon hydrates up to transformations of aminoacids and pectic substances, are conditioned by Mg^{2+}. DNA and RNA synthesis cannot develop under optimum parameters in the case of magnesium deficiency. Mg^{2+} favourably influences synthesis of carotene and xantophyll.

In most plants total magnesium content generally ranges around 0.10-0.50% dry matter, on the extreme limits, but depending on the species, the physiological state and nutrition conditions these limits may vary between 0.13-3.15% dry matter (Davidescu, 1981; Bergmann, 1992). Soils in which the cationic change capacity of the adsorbtive complex is saturated by less than 4% magnesium are always deficient in this element, whereby the optimum ranges between 6 and 12%. In the fertile soils cationic change capacity is saturated as follows: 25% N, 60% Ca^{2+}, 10% Mg^{2+}, 5% K^+ and Na^+ (Jokinen, 1981).

Magnesium deficiency may occur even on soils with a normal magnesium content, when through cropping technologies concentration of N^+, K^+, NH_4^+ and especially of Ca^{2+} and Mn^{2+} increases (Borlan and Hera, 1994).

Studies regarding cropping conditions that influence magnesium mobility in soils of agricultural use in Romania are of relatively recent date (Lãcãtuºu, 1972; Kurtinecz, 1989; Borlan and Hera, 1994) and papers regarding magnesium absorption and transport are less numerous (Idriceanu, 1984; Bogaci, 1985).

This paper presents the evolution of the state of supplying soluble magnesium to the cambic chernozem soil of Fundulea as well as the state of some maize hybrids cultivated under dryland and irrigation conditions, on experimental plots that show certain important variations of agrochemical indicators.

MATERIALS AND METHODS

Research was developed on cambic chernozem of Fundulea in two experiments whose experimental plots differ in terms of agrochemical indicators (Tables 1 and 2).

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Table 1. Effect of long term dryland application of nitrogen and phosphorus fertilizers on the main agrochemical indices of Fundulea cambic chernozem

Fertilizers (kg a.i./ha) N	P_2O_5	pH (H_2O)	C%	N%	P ppm	K ppm	Mg ppm
0	0	6.35	1.67	0.165	8.6	174	110
50	0	6.25	1.77	0.179	8.0	160	110
100	0	6.15	1.77	0.179	8.2	160	110
150	0	5.85	1.81	0.180	13.2	188	110
200	0	5.70	1.86	0.185	10.4	165	105
0	40	6.30	1.73	0.170	29.2	158	120
50	40	6.20	1.79	0.175	25.2	160	110
100	40	6.15	1.79	0.176	34.2	165	120
150	40	5.90	1.86	0.180	26.0	164	120
200	40	5.55	1.82	0.178	32.4	158	140
0	80	6.25	1.82	0.170	64.0	151	140
50	80	6.10	1.88	0.176	53.0	150	150
100	80	6.00	1.89	0.178	42.0	156	160
150	80	5.80	1.82	0.175	53.6	155	160
200	80	5.85	1.84	0.180	87.6	158	145
0	120	6.25	1.84	0.172	91.4	151	150
50	120	6.10	1.91	0.178	91.6	151	160
100	120	6.00	1.86	0.180	86.8	151	170
150	120	5.80	1.88	0.182	89.2	143	160
200	120	5.85	1.84	0.181	84.0	146	150
0	160	6.22	1.77	0.177	114.0	146	170
50	160	6.10	1.80	0.181	112.0	156	168
100	160	5.90	1.84	0.183	114.0	140	170
150	160	5.85	1.86	0.185	110.0	140	160
200	160	5.65	1.90	0.188	108.0	136	165
LSD 5%	A	0.10	0.05	0.008	1.03	5.02	3.04
	B	0.21	0.04	0.005	0.95	9.20	5.20
	AB	0.52	0.07	0.012	210	14.1	7.40

Table 2. Water stress influence on the main agrochemical indices of Fundulea chernozem soil cropped with various maize hybrids

Water stress variants	Hybrids (Factor B)	pH (H_2O)	C %	N %	P ppm	K ppm	Ca ppm	Mg ppm
Optimum irrigated	F 322	7.45	1.60	0.142	28.2	180	35.0	91
	F 340	7.50	1.62	0.143	30.0	190	33.0	94
	F 365	7.46	1.59	0.144	29.0	182	34.4	95
	F 376	7.47	1.61	0.144	29.2	185	30.0	90
Irrigated 60% from optimum	F 322	7.39	1.62	0.145	30.9	186	34.4	90
	F 340	7.41	1.64	0.145	32.0	178	35.0	92
	F 365	7.42	1.60	0.146	31.0	175	36.0	84
	F 376	7.40	1.63	0.142	30.0	176	35.7	93
Irrigated 30% from optimum	F 322	7.30	1.63	0.150	33.0	172	35.2	88
	F 340	7.32	1.65	0.152	35.0	168	35.8	80
	F 365	7.35	1.64	0.151	37.0	170	34.8	84
	F 376	7.30	1.66	0.150	36.5	176	35.5	79
LSD 5%	A	0.40	0.04	0.003	2.3	8.1	1.8	6
	B	0.30	0.02	0.002	1.9	6.2	1.4	4
	AB	0.56	0.04	0.005	5.6	9.8	2.4	11

In the first experiment different basal dressings were created by stationary application of certain nitrogen rates of 50, 100, 150, 200 kg active ingredient/ha and phosphorus rates of 40, 80, 120, 160 kg P_2O_5/ha. Fundulea 376 hybrid was cultivated under dryland conditions.

Another experiment considered in the study refers to the influence of applying three irrigation norms for the main agrochemical indicators and for the absorption and translocation of some nutritive elements in various maize hybrids. The following hybrids created at the Research Institute for Cereals and Industrial Crops – Fundulea were cultivated: Fundulea 322, Fundulea 340, Fundulea 365 and Fundulea 376.

Basal dressing for fertilization was 180 kg N/ha and 80 kg P_2O_5/ha.

Irrigation water had a total content of soluble salts of 530-805 mg/l as follows: K^+ (2.85-3.80); Na^+ (30.2-40.7); Ca^{2+} (34.0-38.6); Mg^{2+} (48.1-57.6); HCO_3^- (6.80-6.96) while Mg $(HCO_3)_2$ represents 41.6% from the total quantity of mineral salts.

Soil samples were taken from the depth of 0-20 cm, and conditioned and analysed in accordance with the methodology of agrochemistry laboratories.

Plant samples were collected in the phase of 3-4 leaves, during ear formation, whereby analyses were made on the leaves. Grain was analysed in the final harvest.

In the soil samples pH was determined in a watery suspension in a ratio of 1:2.5, carbon was assessed by spectrophotometry according to Kononova method modified by Salfeld and total nitrogen was analysed according to Kjeldahl method. Extraction of soluble phosphorus and potassium forms was done in an acid solution of ammonium acetate-lactate, buffered at pH 3.7. Phosphorus was colorimetrically determined by Egner-Riehm-Domingo method, and potassium by flame photometry. The soluble magnesium was established in accordance with Schachtschabel's colorimetric method using $CaCl_2$ 0.025 N as extract.

In plant samples magnesium was determined by atomic absorption spectrophotometry from an extract obtained by dry mineralization and resumption with HCl 2N, at a wave length of 2852 Å.

RESULTS AND DISCUSSIONS

The effect of stationary application of nitrogen and phosphorus fertilizers is clearly revealed in the modification of two agrochemical indices of fundamental importance in soil fertility and plant nutrition, namely pH and concentration of mobile phosphorus in the soil (Table 1). The application of nitrogen in rates ranging between 50-200 kg active ingredient/ha leads in time to a decrease of pH, proportionally to the nitrogen rate applied. The contribution of mineral phosphorus in the soil in rates ranging between 40-160 kg P_2O_5/ha has as an effect the increase of mobile phosphorus content, in a directly ascending relation depending on the rate applied.

Thus, within the same experiment pH varies between maximum 6.35 and minimum 5.55, while the values of mobile phosphorus vary between 8 ppm (unfertilized with phosphorus) and 114 ppm when rates of 160 kg P_2O_5/ha were applied.

Both pH decrease depending on the nitrogen rate applied, and mobile phosphorus increase simultaneously with phosphatic fertilization, involve the manifestation of certain secondary effects on other chemical parameters of the soil and plant nutrition.

Accessibility of all nutritive elements for plants is tightly dependent on soil reaction. Its effect is manifested both directly on their solubility and indirectly through the influence over the microbiological activity on which depends the release of ionic forms from organic matter and the development of oxide-reduction reactions.

This motivates the tight relationship existing between soil chemistry studies, fertilizer application and plant nutrition. In this field the most comprehensive knowledge refers to nitrogen, phosphorus and potassium and less to secondary elements, among which magnesium represents an extremely important element of nutrition.

Magnesium mobility in the soil, even under conditions of better soils, may be diminished when there exist high concentrations of H^+, K^+, NH_4^+ or Ca^{2+} and Mn^{2+} ions (Mengel and Kirkby, 1982).

For this reason, under the influence of plant cropping technologies, especially by applying fertilization and irrigation, a progressive modification of changeable magnesium content in the upper soil layer (0-20 cm) takes place. Among the chemical fertilizers produced on an industrial scale (except those specific with magnesium), simple superphosphate contains 2.4 kg MgO /t, and concentrated superphosphate 1.5 kg MgO /t (Bogaci, 1985).

By stationary application of phosphorus fertilizers, for 30 years, on cambic chernozem of Fundulea, an important increase of mobile phosphorus as well as of changeable magnesium in the upper soil layer has been revealed. In the variants in which phosphorus fertilizers were not applied, values of changeable magnesium in the soil amounted to 105-110 ppm while at the rate of 120-160 kg P_2O_5/ha values of 150-170 ppm were observed.

A reverse correlation may be observed in soil solution between K^+ and Mg^{2+} ions. Cambic chernozem at Fundulea may be ranked in the group of soils well supplied with mobile potassium (132-200 ppm).

Data presented in table 1 show that in the exclusive stationary application of nitrogen and phosphorus fertilizers, modifications take place also with regard to mobile potassium content. The highest values (160-180 ppm) were obtained in the variants in which no phosphorus fertilizers were applied, and the lowest ones (134-156 ppm) in experimental plots in which annually 120-160 kg P_2O_5/ha were applied.

Some values approach the inferior limit of values that provide a good supply with mobile potassium.

These reductions of the content of mobile potassium in the soil, on basal dressings with high inputs of nitrogen and phosphorus fertilizers, may be explained by an effective consumption and export of potassium at harvesting. In maize (main+secondary product) export amounts to 16.2 kg K_2O/t (Borlan and Hera, 1994). The variants with the lowest content of mobile potassium in the soil also provided annually the highest yields in the present experiment (Hera, 1982).

The variations of mobile potassium may also lead to modifications of magnesium content in the soil, as the negative correlation between the ions of these elements, both in the soil and as regards their absorbtion in the plants, is well known.

Correlations between potassium and magnesium content in the soil (Figure 1) depending on fertilization with nitrogen and phosphorus prove the negative interactions between K^+ and Mg^{2+}. The highest concentrations of Mg^+ in the soil solution are situated among the lowest values of mobile potassium.

As regards magnesium absorbtion in Fundulea 376 maize hybrid, in different vegetation phases, the application of both nitrogen and phosphorus fertilizers had a favourable effect (Table 3).

The optimum concentrations of magnesium in the first vegetation phases ensure the normal development of plant metabolism up to yield formation. In the case of the optimum plant development, a great root mass also develops, which plays an important role in bringing magnesium from the depths into the upper soil layer.

Table 3. Effect of nitrogen and phosphorus fertilizer application on magnesium uptake and translocation in maize critical phases (Fundulea 376 hybrid)

Fertilizers, kg N/ha	P_0	P_{40}	P_{80}	P_{120}	P_{160}
		1. 3-4 leaf phase (Mg, g/100 g d.m.)			
0	0.362	0.422	0.354	0.366	0.374
50	0.372	0.434	0.416	0.444	0.402
100	0.418	0.470	0.417	0.474	0.410
150	0.470	0.466	0.510	0.496	0.448
200	0.478	0.514	0.526	0.518	0.490
		2. Spiking phase (Mg, g/100 g d.m.)			
0	0.276	0.310	0.324	0.296	0.290
50	0.288	0.334	0324	0.340	0.302
100	0.342	0.366	0.360	0.340	0.304
150	0.356	0.396	0.378	0.366	0.362
200	0.370	0.386	0.400	0.394	0.380
		3. Grain (Mg, g/100 g d.m.)			
0	0.110	0.121	0.120	0.140	0.148
50	0.123	0.124	0.141	0.143	0.156
100	0.136	0.143	0.162	0.173	0.172
150	0.136	0.178	0.183	0.196	0.214
200	0.178	0.195	0.198	0.216	0.256

LSD 5%						
	1. A	0.04	2. A	0.03	3. A	0.02
	B	0.02	B	0.02	B	0.03
	AB	0.07	AB	0.07	AB	0.06

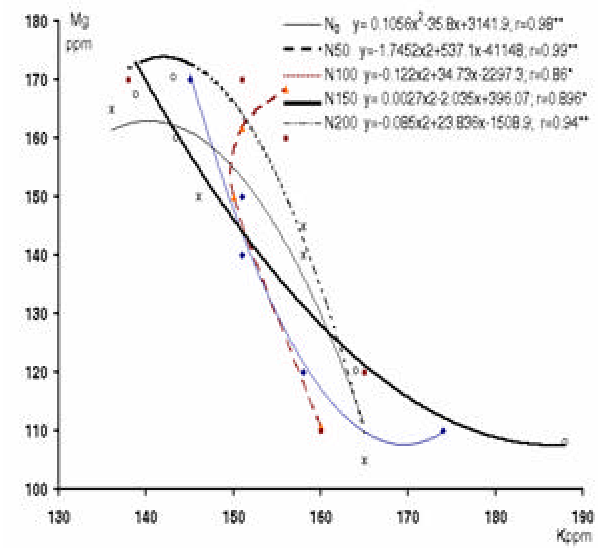

Figure 1. Correlations between soil mobile potassium and magnesium content depending on nitrogen and phosphorus fertilizer aplication

In deep rooted crops which have a great root mass, 1/4 - 1/3 of magnesium content in the roots that remains in the soil after harvesting, comes from deeper layers and positively influences the quantity of soil mobile magnesium.

Magnesium is preferentially accumulated in tissues that have the greatest vital activity. In cereals approximately 2/3 of magnesium is translocated into the grain and accumulated in the embryo and the gluten layers. It is necessary for the formation of seeds and reserve organs because it activates processes in the generative organs from the very beginning of their formation (Kiss, 1981).

As regards the grain, Fundulea 376 hybrid accumulated the highest magnesium concentrations in variants well supplied with phosphorus (80-160 P_2O_5/ha). Nitrogen determined an increase of magnesium content in the grain, to a smaller extent than phosphorus. The positive effect of phosphorus is manifested both directly on the whole metabolism and indirectly by introducing into the soil some magnesium quantities present in the applied superphosphate.

Under irrigation conditions, on the same soil type, pH values increased over 7.30, while the values of carbon, nitrogen and magnesium were lower than in the experiments carried out under dryland conditions (Table 2).

Increase of pH is conditioned by the composition of irrigation water rich in alcaline ions, which during pumping shows a pH of 7.80-8.95. Irrigation water represents an additional source of magnesium ions. An irrigation norm of 500 m^3/ha of water with 1/l ml/Mg brings into the soil 10 Kg MgO/ha.

At the same time, the concentration of K^+ and Ca^{2+} ions in the soil increased, a fact which disadvantages the maintaining of a high Mg^{2+} concentration in the soil solution.

Under irrigation conditions, the elimination of ions from the upper soil layer by profile leaching is rather important and it explains to a certain extent the smaller concentrations of soluble Mg^{2+}.

Table 4. Effect of irrigation norms on magnesium content in various maize hybrids cropped on Fundulea cambic chernozem soil

Irrigation variants	Hybrids	Vegetation phases (Mg, g/100 g d.m.)		
		3-4 leaves	Spiking	Grain
Optimum irrigated	F 322	0.510	0.400	0.180
	F 340	0.525	0.400	0.183
	F 365	0.478	0.510	0.198
	F 376	0.548	0.390	0.190
Irrigated 60% from optimum	F 322	0.458	0.460	0.173
	F 340	0.478	0.410	0.171
	F 365	0.448	0.500	0.230
	F 376	0.458	0.410	0.160
Irrigated 30% from optimum	F 322	0.463	0.438	0.213
	F 340	0.478	0.350	0.230
	F 365	0.425	0.450	0.250
	F 376	0.425	0.350	0.198
LSD 5%	A	0.03	0.02	0.02
	B	0.05	0.04	0.03
	AB	0.07	0.06	0.06

The power of their retention on coloids is poorer that of K^+ ions. (Lin, 1990; Brar and Bojwa, 1990). At the same time, the higher maize yields obtained under irrigation conditions lead to a substantial elimination of magnesium from the soil at harvesting.

The effect of irrigation norms on magnesium content in various maize hybrids is emphasized by the high values obtained by optimum irrigation, as compared to the variants in which 30% of the optimum was applied in early vegetation phases (Table 4).

By comparing the concentration values in the leaves one could observe that Fundulea 365 hybrid absorbs less magnesium in the leaves, in early development phases (3-4 leaves), but on the other hand it has the capacity of a better translocation than in other hybrids, this phenomenon being evident also in the grain, In the grain, the smallest magnesium concentrations were in the optimum irrigation variant in all hybrids under study. As these variants produced the highest yields, the effect of dilution was very evident.

In general, maize hybrids which contain higher quantities of magnesium are more tolerant to the deficiency of this element on soils with poor supplies. From this point of view, translocation capacity is very important. The characteristic symptoms of magnesium deficiency appear firstly in old leaves, because a part of chlorophyll is being decomposed in order to release magnesium ions necessary to maintain metabolism within normal parameters.

Assessment of the ability of various maize hybrids to absorb and translocate magnesium, under normal nutrition conditions makes it possible to avoid the cultivation of sensitive hybrids on deficient soils.

Cambic chernozem of Fundulea may be classified among the soil types which do not lack magnesium in plant cultivation, but nevertheless agrochemical analyses show important variations of soluble magnesium concentration depending on cropping technologies applied.

CONCLUSIONS

Important modifications of agrochemical soil indicators were determined on the cambic chernozem of Fundulea in experimental plots, depending on technologies applied. Magnesium mobility in the soil, expressed by soluble magnesium concentrations, was influenced both by the stationary fertilizer application and by irrigation.

A negative interaction was pointed out between K^+ and Mg^{2+} ions even in the case of a good supply with these nutritive elements in the soil.

Under irrigation conditions soluble magnesium values are much lower due to leaching and high exports at harvesting.

The hybrid Fundulea 365 manifests the best capacity of magnesium translocation, as compared to Fundulea 322, Fundulea 340 and Fundulea 376 hybrids.

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NP fertilzers

NP fertilizers		pH	C %	N%	P ppm	K ppm	Mg ppm
kg/ha	a.i.	(H_2O)					
N_0	P_0	6.35	1.67	0.165	8.6	174	110
N_{50}	P_0	6.25	1.77	0.179	8.0	160	110
N_{100}	P_0	6.15	1.77	0.179	8.2	160	110
N_{150}	P_0	5.85	1.81	0.180	13.2	188	110
N_{200}	P_0	5.70	1.86	0.185	10.4	165	105
N_0	P_{40}	6.30	1.73	0.170	29.2	158	120
N_{50}	P_{40}	6.20	1.79	0.175	25.2	160	110
N_{100}	P_{40}	6.15	1.79	0.176	34.2	165	120
N_{150}	P_{40}	5.90	1.86	0.180	26.0	164	120
N_{200}	P_{40}	5.55	1.82	0.178	32.4	158	140
N_0	P_{80}	6.25	1.82	0.170	64.0	151	140
N_{50}	P_{80}	6.10	1.88	0.176	53.0	150	150
N_{100}	P_{80}	6.00	1.89	0.178	42.0	156	160
N_{150}	P_{80}	5.80	1.82	0.175	53.6	155	160
N_{200}	P_{80}	5.85	1.84	0.180	87.6	158	145
N_0	P_{120}	6.25	1.84	0.172	91.4	151	150
N_{50}	P_{120}	6.10	1.91	0.178	91.6	151	160
N_{100}	P_{120}	6.00	1.86	0.180	86.8	151	170
N_{150}	P_{120}	5.80	1.88	0.182	89.2	143	160
N_{200}	P_{120}	5.85	1.84	0.181	84.0	146	150
N_0	P_{160}	6.22	1.77	0.177	114.0	146	170
N_{50}	P_{160}	6.10	1.80	0.181	112.0	156	168
N_{100}	P_{160}	5.90	1.84	0.183	114.0	140	170
N_{150}	P_{160}	5.85	1.86	0.185	110.0	140	160
N_{200}	P_{160}	5.65	1.90	0.188	108.0	136	165
LSD 5%	A	0.10	0.05	0.008	1.03	5.02	3.04
1%	B	0.21	0.04	0.005	0.95	9.20	5.20
0.1%	AB	0.52	0.07	0.012	210	14.1	7.40

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		(H_2O)						
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irrigated	F-340	7.50	1.62	0.143	30.0	190	33.0	94
	F-365	7.46	1.59	0.144	29.0	182	34.4	95
	F-376	7.47	1.61	0.144	29.2	185	30.0	90
Irrigated 60%	F-322	7.39	1.62	0.145	30.9	186	34.4	90
from optimum	F-340	7.41	1.64	0.145	32.0	178	35.0	92
	F-365	7.42	1.60	0.146	31.0	175	36.0	84
	F-376	7.40	1.63	0.142	30.0	176	35.7	93
Irrigated 30%	F-322	7.30	1.63	0.150	33.0	172	35.2	88
from optimum	F-340	7.32	1.65	0.152	35.0	168	35.8	80
	F-365	7.35	1.64	0.151	37.0	170	34.8	84
	F-376	7.30	1.66	0.150	36.5	176	35.5	79
LSD	5% A	0.40	0.04	0.003	2.3	8.1	1.8	6
	1% B	0.30	0.02	0.002	1.9	6.2	1.4	4
	0.1% AB	0.56	0.04	0.005	5.6	9.8	2.4	11

Table 3. Effect of nitrogen and phosphorus fertilizer application on magnesium uptake and translocation in maize critical phases (hybrid Fundulea 376)

Rates kg/ha	P_0	P_{40}	P_{80}	P_{120}	P_{160}
1. 3-4 leaf phas e (Mg g/100 g d.m.)					
N0	0.362	0.422	0.354	0.366	0.374
N50	0.372	0.434	0.416	0.444	0.402
N100	0.418	0.470	0.417	0.474	0.410
N150	0.470	0.466	0.510	0.496	0.448
N200	0.478	0.514	0.526	0.518	0.490
2. Spiking phase (Mg g/100 g d.m.)					
N0	0.276	0.310	0.324	0.296	0.290
N50	0.288	0.334	0324	0.340	0.302
N100	0.342	0.366	0.360	0.340	0.304
N150	0.356	0.396	0.378	0.366	0.362
N200	0.370	0.386	0.400	0.394	0.380
3. Grain (Mg g/100 g d.m.)					
N0	0.110	0.121	0.120	0.140	0.148
N50	0.123	0.124	0.141	0.143	0.156
N100	0.136	0.143	0.162	0.173	0.172
N150	0.136	0.178	0.183	0.196	0.214
N200	0.178	0.195	0.198	0.216	0.256
LSD	5% A	1) 0.04	2) 0.03	3) 0.02	
	1% B	0.02	0.02	0.03	
	0.1% AB	0.07	0.07	0.06	

Table 4. Effect of irrigation norms on magnesium content in various maize hybrids cropped on Fundulea cambic chernozem soil

Irrigation variants	Hybrids	Vegetation phases (mg g/100 g d.m.)		
		3-4 leaves	spiking	grain
Optimum	F-322	0.510	0.400	0.180
irrigated	F-340	0.525	0.400	0.183
	F-365	0.478	0.510	0.198
	F-376	0.548	0.390	0.190
Irrigated 60%	F-322	0.458	0.460	0.173
from optimum	F-340	0.478	0.410	0.171
	F-365	0.448	0.500	0.230
	F-376	0.458	0.410	0.160
Irrigated 30%	F-322	0.463	0.438	0.213
from optimum	F-340	0.478	0.350	0.230

	F-365	0.425	0.450	0.250
LSD	F-376 5% A 1% B	0.425 0.03 0.05	0.350 0.02 0.04	0.198 0.02 0.03
	0.1% AB	0.07	0.06	0.06