THE EFFECT OF MINERAL FERTILIZATION ON UPTAKE OF SOME NUTRIENTS IN MAIZE UNDER IRRIGATED CONDITIONS

Ioana Chirnogeanu, Ecaterina Badea, Elena Petcu and Ion Picu [1]

ABSTRACT

The effect of phosphorus and nitrogen fertilization on nitrogen, phosphorus, potassium and calcium uptake in maize under irrigated conditions was studied. The changes induced by mineral fertilization on organic matter, nitrogen and soil pH were also studied. The results obtained showed that uptake of nitrogen, phosphorus, potassium and calcium in maize was related better to the vegetation stage of the plant. The highest rate of assimilation was registered in the earlier vegetation stage. In the maize seedlings the potassium concentration was ten times higher then in seeds. The content of nitrogen and zinc decreased in plants cultivated without nitrogen fertilization while the phosphorus content increased. Positive relationships between phosphorus concentration in soil and nitrogen and phosphorus concentration in plants were obtained (r=0.95, r=0.89**).**

Key words: fertilizer, irrigation, maize, nutrient uptake.

INTRODUCTION

It has been demonstrated that long administration of mineral fertilizers produces soil reaction, organic matter and potassium and phosphorus content modification (Hera et al., 1980; Eliade et al., 1983; Borlan et al., 1984).

Also, mineral fertilization influences the uptake and accumulation of nutrients by the plants and their effects on plant growth, development and yield (Idriceanu, 1985).

The purpose of this paper was to analyse the agro-chemical soil modifications and their influence on plant nutrition in an long term experiment, on a cambic chermozem soil, under irrigation conditions.

MATERIALS AND METHODS

Research was conducted in a long term experiment, where maize plants were cultivated in four years crops rotation (maize sunflower, winter wheat) under irrigation conditions. Nitrogen, as ammonium nitrate, and phosphorus, as superphosphate were applied at rates of zero and 240 kg/ha nitrogen and 0, 40, 80, 120 kg/ha phosphorus. Fundulea 420 maize hybrid was used. Nitrogen, phosphorus, calcium, potassium and zinc content were determined in different stages of vegetation (4-5 leaves, 6-8 leaves, 10-12 leaves and silking stage). The same analyses were been done for grains, too. The total N was determined by Kjeldahl method, the total P colorimetrically by the ammonium molybdovanadate method, calcium and potassium by flamephotometry and zinc content by atomic absorption. Soil chemical properties were also determined: pH (in water), organic matter (Walkley and Blanck method), total nitrogen (Kjeldahl method), assimilable P and K (Egner-Riehm-Domingo method).

RESULTS AND DISCUSSIONS

Natural to slightly acid reaction of this type of soil has evolved towards alkaline condition due to irrigation water rich in calcium and magnesium carbonates and bicarbonates (Eliade et al., 1977). The influence of fertilization on the increase of pH values was attenuated when 240 kg N/ha were applied (Table 1).

The total soil nitrogen content increased with 6-11 percentages in the variants where nitrogen fertilizers were applied over 30 years. Phosphorus mobility in soil has increased also from 10 mg in unfertilized variant to 90 mg/kg of dry soil in the variant with 120 kg P_2O_5/ha.

The total phosphorus content increased from 70 to 90 mg/100 g of soil, depending on the applied rates of superphosphate.

Soluble soil potassium, with values ranging from 190 to 210 ppm, has no significant correlation with chemical fertilization.

The high level of soil nitrogen and phosphorus significantly influenced the nutrient uptake and translocation in leaves. Thus, the N and P content in maize plants increased in variants with high fertilizer rates (Table 2). The concentration of the absorbed phosphorus in leaves was 70-80% higher in plants which received 120 kg P_2O_5 /ha, as compared to unfertilized variants.

[1] Research Institute for Cereals and Industrial Crops. 8264 Fundulea., Romania

Table 1. The effect on nitrogen and phosphorus rates on the main characteristics of the typical chernozem soil of Fundulea

Nitrogen rates (NH_4NO_3) Kg/ha	Phosphorus rates (P_2O_5) Kg/ha	pH	Oraganic matter (Cv %)	Nitrogen content (Nt%)	Phosphorus content (Pt%)	Available phosphorus ppm	Available potassium ppm
0	0	7.72	1.636	0.141	0.069	10.4	210
	40	7.85	1.644	0.143	0.078	34	198
	80	7.87	1.690	0.144	0.092	70.9	205.7
	120	7.82	1.650	0.143	0.096	90.5	206.1
240	0	7.47	1.725	0.150	0.068	12.4	202.7
	40	7.57	1.741	0.152	0.075	20.4	201.6
	80	7.41	1.747	0.155	0.091	58.8	197.7
	120	7.46	1.767	0.157	0.091	81	210
	LSD 5%		0.004	0.005	0.004	3.05	17.7

Table 2. The effect of nitrogen and phosporus rates on chemical composition of maize(4-5 leaves stage)

Nitrogen rates (NH_4NO_3) kg/ha	Phosphorus rates (P_2O_5) kg/ha	Nitrogen content (%/d.m.)	Phosphorus content (%/d.m.)	Potassium content (%/d.m.)	Calcium content (%/d.m)
0	0	3.46	0.252	3.01	0.342
	40	3.78	0.393	2.55	0.402
	80	3.80	0.424	2.72	0.396
	120	3.95	0.460	2.73	0.401
240	0	3.76	0.203	3.40	0.319
	40	3.90	0.322	2.72	0.366
	80	3.97	0.408	3.16	0.414
	120	4.09	0.433	2.76	0.412
	LSD 5%	0.194	0.009	0.102	0.008

The increase potassium content in plant from in variants without phosphorus could be due to the antagonism between potassium and calcium (Vintilă et al., 1984). So, the highest values of potassium content correspond to the lowest values of plant calcium content. Such differences are not evident in mineral fertilized variants.

Variance analysis shows that phosphorus and nitrogen and their interaction have influenced the uptake of the main nutrients by the maize plants in the stage of 4-5 leaves (Table 3).

Table 3. ANOVA (s^2) concerning the influence of NP fertilization on plant nutrients content (4-5 leaves)

Source of variance	Nt % d.w.	Pt % d.w.	Kt % d.w.	Cat % d.w.
Nt	0.258*	0.011***	0.377***	0.0004
P_2O_5	0.213***	0.057***	0.366***	0.00075***
$N+P_2O_5$	0.010	0.0008***	0.060***	0.0010***

The obtained values are significant. Some correlations also exist between nutrient concentrations in soil solution and their accumulation in plants. Thus, there is a significant positive correlation between the level of soil mobile phosphorus and plant phosphorus content (Figure 1). This is an upward increase until soil mobile phosphorus concentration of 82 ppm, when the highest total phosphorus quality is accumulated in plants (0.44% P). Afterwards, the phosphorus uptake decreases, although the soil mobile phosphorus content exceeds 90 ppm.

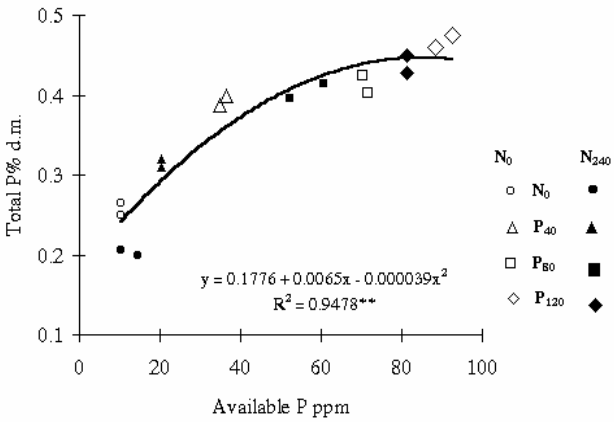

Figure 1. Relationship between avaiable phosphorus in soil and phosphorus content of maize (4 -5 leaves)

Total plant nitrogen content also increases in connection with soil mobile phosphorus concentration, but reaches the highest values

(4.12% N) only in variants fertilized with 240 kg N/ha and at 80 ppm soil mobile phosphorus content (Figure 2).

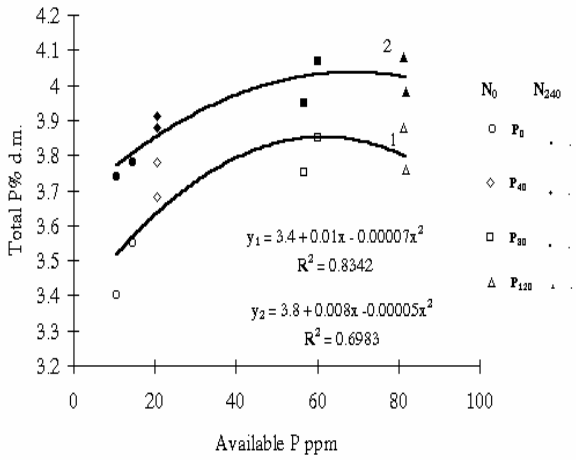

Figure 2. Relationship between avaiable phosphorus in soil and total nitrogen content of maize (4-5 leaves)

Increasing soil phosphorus mobility resulted in an unbalanced zinc absortion, accentuated by the fact that mobile zinc varies in cambic chernozem between 1.1 and 1.5 ppm. Plant chemical analysis in 4-5 leaves stage showed a diminution of zinc content in the aboveground part of plants which significantly correlates with soil phosphorus levels (Figure 3). .

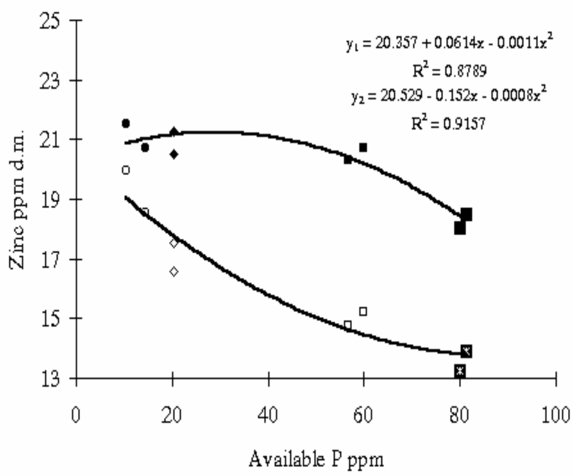

Figure 3. Relationship between available phosphorus in soil and zinc content of maize (4-5 leaves)

The values of plant zinc concentration diminished even at low rates of zinc applications, this phenomenon being accentuated at the same time with the increase of phosphorus quality per hectare.

Nitrogen soil fertilization keeps plant zinc concentration between 19-22 ppm, no matter of the phosphorus fertilization level. This could be due to the acidifying effect which produces soil zinc mobilization (Idriceanu et al., 1985).

Dynamic study of plant nutrient content (N,P,K) showed their accumulation until the silky stage, after which the uptake is gradually reduced in favour of synthesis processes (Figure 4).

The lowest values are in grain. Thus, potassium concentration in grain is ten times smaller then in leaves, and nitrogen approximately three times in comparison with phosphorus content which modifies less from leaf to grain.

The assimilation difference due to chemical fertilization is kept all along the vegetation period with respect to nitrogen and phosphorus and is canceled in the case of plant potassium content.

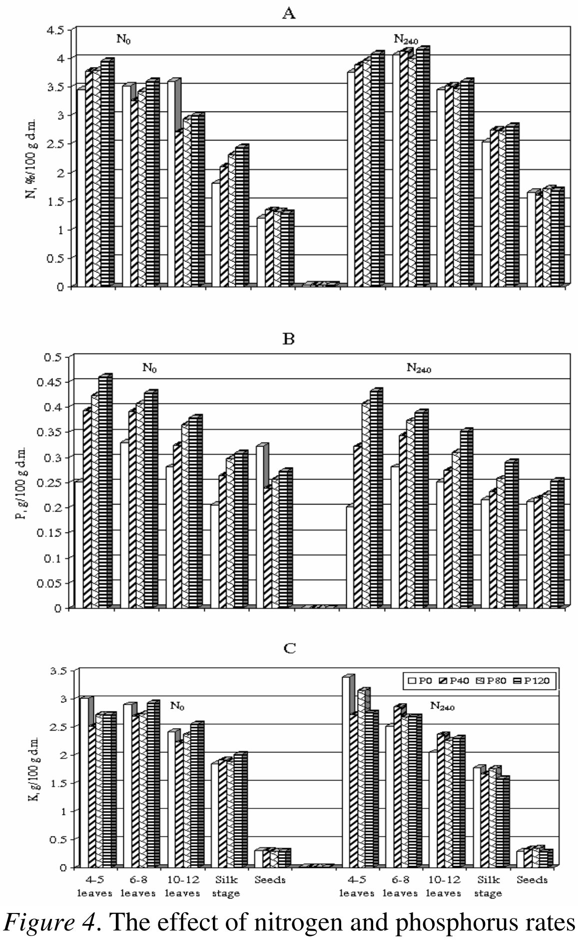

Figure 4. The effect of nitrogen and phosphorus rates on nitrogen (A), phosphorus (B) and potassium (C) content in maize plants

CONCLUSIONS

Mineral fertilization for 30 years determined the increasing of organic matter, total nitrogen, total available phosphorus of the soil; the available potassium content wasn't influenced by the mineral fertilization. This could be possible due to high potassium content of the chernozem soil at Fundulea; the nitrogen and phosphorus rates did not influenced the values of soil pH, because water used for irrigation has a high concentration in $Mg(HCO_3)_2$ and $Ca(HCO^3)_2$. The mineral fertilization determined the increase of nitrogen and phosphorus content in maize, but the concentration of calcium and potassium in plant remained the same. The content of zinc decreased in maize without nitrogen fertilization while the phosphorus content increased. Positive relationships between phosphorus concentration in the soil and nitrogen and phosphorus concentration in the maize plants were obtained (r=0.95**, r=0.89**).

REFERENCES

Borlan, Z., Hera, C., 1984. Optimizarea agrochimică a sistemului sol-plantă, Edit. Academiei, București: 115-118.

Eliade, G., Păltineanu, I., Petrescu, R., 1977. Considerații asupra calității apei de irigare și a influenței ei asupra solului, Edit.Comisia Națională a Româneie pentru UNESCO.

Eliade, G., Ghinea, L., Ștefanic, G., 1983. Bazele biologice ale fertilității solului, Edit.Ceres, București: 119-127.

Hera, C., Borlan, Z., 1980. Ghid pentru alcătuirea planurilor de fertilizare, Edit.Ceres.București.

Idriceanu, A., Hera, C., 1985. Probleme de agrofitotehnie teoretică și aplicata, vol.VII, 2: 175-185.

Vintilă, I., Borlan, Z., Răuță, C., Daniluc, D., Țigănaș, L., 1984. Situația agrochimică a solurilor din România, Edit.Ceres, București: 129-134.

Table 1. The effect on nitrogen and phosphorus rates on main charateristics of the typical chernozom soil at Fundulea

Nitrogen rates (NH_4NO_3) Kg/ha	Phosphorus rates (P_2O_5) Kg/ha	pH	Oraganic matter (C_v %)	Nitrogen content (N_t%)	Phosphorus content (P_t%)	Available phosphorus ppm	Available kalium ppm
N_0	P_0	7.72	1.636	0.141	0.069	10.4	210
	P_{40}	7.85	1.644	0.143	0.078	34	198
	P_{80}	7.87	1.690	0.144	0.092	70.9	205.7
	P_{120}	7.82	1.650	0.143	0.096	90.5	206.1
N_{240}	P_0	7.47	1.725	0.150	0.068	12.4	202.7
	P_{40}	7.57	1.741	0.152	0.075	20.4	201.6
	P_{80}	7.41	1.747	0.155	0.091	58.8	197.7
	P_{120}	7.46	1.767	0.157	0.091	81	210
	LSD 5%		0.004	0.005	0.004	3.05	17.7

Table 2. The effect of nitrogen and phosporus rates on chemical composition of maize(4-5 lever stage)

Nitrogen rates (NH_4NO_3) kg/ha	Phosphorus rates (P_2O_5) kg/ha	Nitrogen content (%/d.w.)	Phosphorus content (%/d.w.)	Kallium content (%/d.w.)	Calcium content (%/d.w/)
N_0	P_0	3.46	0.252	3.01	0.342
	P_{40}	3.78	0.393	2.55	0.402
	P_{80}	3.80	0.424	2.72	0.396
	P_{120}	3.95	0.460	2.73	0.401
N_{240}	P_0	3.76	0.203	3.40	0.319
	P_{40}	3.90	0.322	2.72	0.366
	P_{80}	3.97	0.408	3.16	0.414
	P_{120}	4.09	0.433	2.76	0.412
	LSD 5%	0.194	0.009	0.102	0.008

Tabelul 3. Analiza varianței (S^2) privind influența fertilizării cu NP asupra conținutului plantei (4-5 frunze) în elemetele nutritive

Sursa varianței	Nt % s.u.	Pt % s.u.	Kt % s.u.	Cat % s.u.
Nt	0.258*	0.011***	0.377***	0.0004
P_2O_5	0.213***	0.057***	0.366***	0.00075***
$N+P_2O_5$	0.010	0.0008***	0.060***	0.0010***

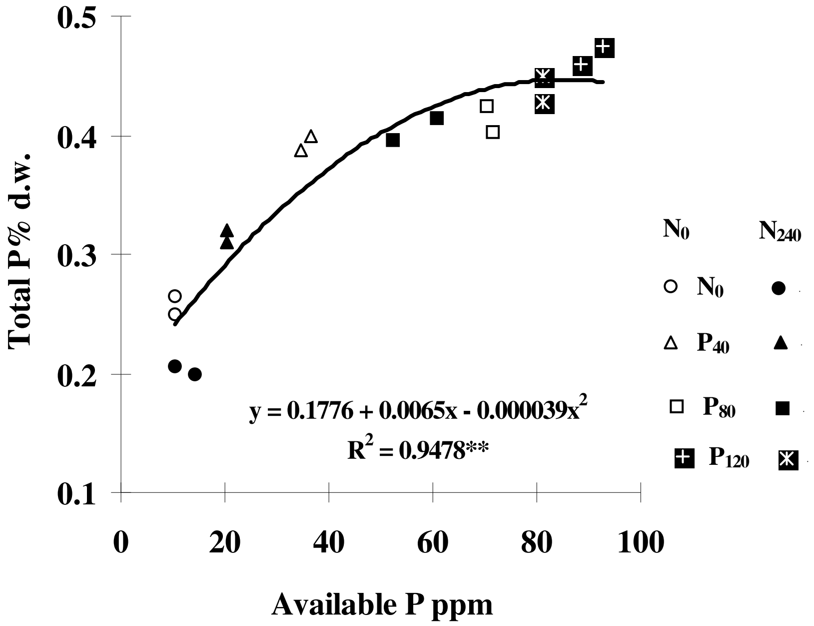

Figure 1. Relationship between avaiable phosphorus in soil and phosphorus content of maize (4 -5 leaves).

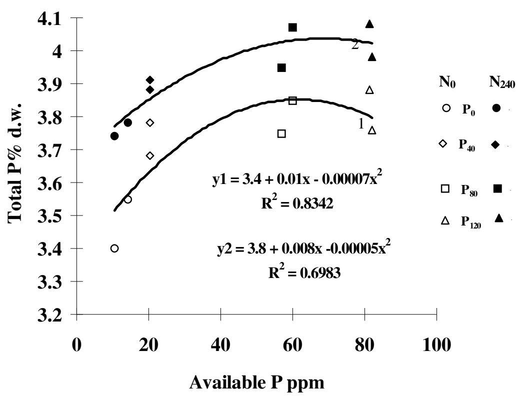

Figure 2. Relationship between avaiable phosphorus in soil and total nitrogen content of maize (4-5 leaves).

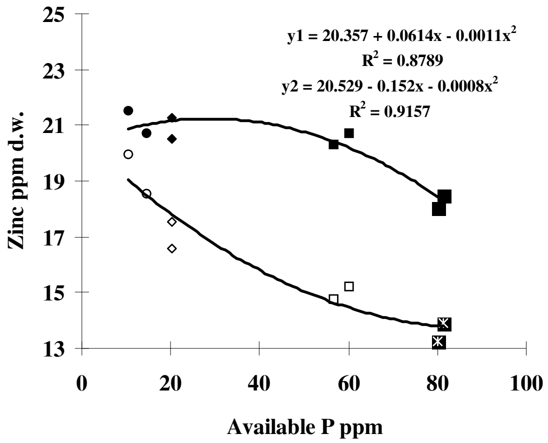

Figure 3. Relationship between available phosphorus in soil and zinc content of maize (4-5 leaves)

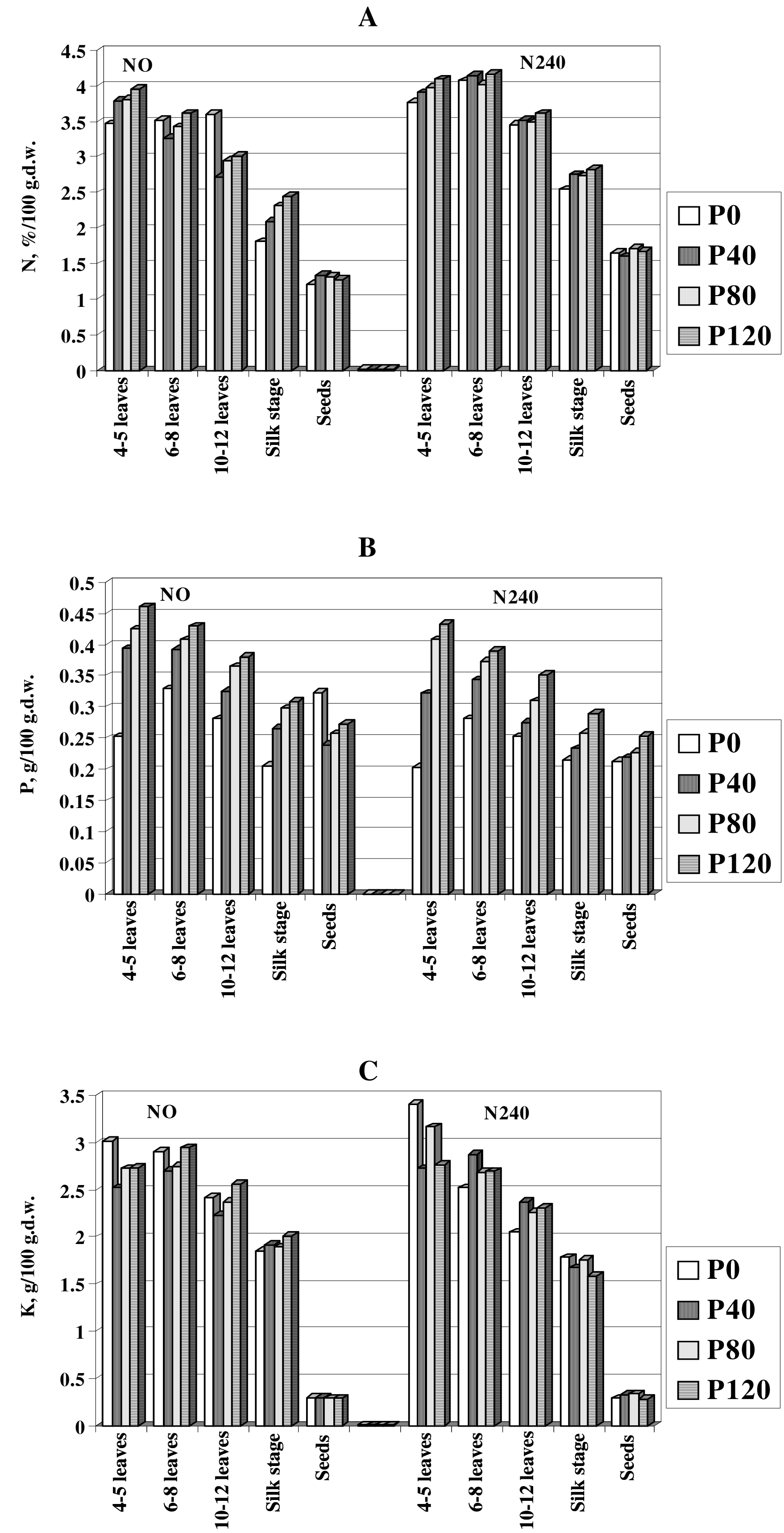

Figure 4. The effect of nitrogen and phosphorus rates on nitrogen (A), phosphorus (B) and kalium (C) content in maize plants.

Relația dintre fosforul mobil din sol si fosforul total din planta (porumb 4-5 frunze)

Varianta	**Repetiția**	**XP mobil ppm**	**Ypt% s.u.**
P_0N_0	1	10.4	0.250
	2	10.4	0.255
P_0N_{240}	1	10.4	0.206
	2	14.4	0.200
$P_{40}N_0$	1	34.8	0.387
	2	36.6	0.399
$P_{40}N_{240}$	1	20.4	0.321
	2	20.4	0.324
$P_{80}N_0$	1	71.6	0.413
	2	70.2	0.424
$P_{80}N_{240}$	1	56.8	0.404
	2	60.8	0.414
$P_{120}N_0$	1	88.4	0.459
	2	92.6	0.474
$P_{120}N_{240}$	1	81.2	0.427
	2	81.2	0.440

Figura 2. Relația dintre continutul de fosfor mobil din sol si azotul total din plantă

Nr.	Varianta	N_0		N_{240}	
crt.		P mobil ppm X	Nt % s.u.Y	P mobil ppm X	Nt% s.u.Y
1	P_0R_1	10.40	3.40	10.40	3.74

2	P_0R_2	10.40	3.55	14.40	3.78
3	$P_{40}R_1$	34.80	3.68	20.40	3.88
4	$P_{40}R_2$	36.60	3.78	20.40	3.91
5	$P_{80}R_1$	71.60	3.75	56.80	3.95
6	$P_{80}R_2$	70.20	3.85	60.00	4.07
7	$P_{120}R_1$	88.40	3.76	81.90	3.98
8	$P_{120}R_2$	92.50	3.88	81.20	4.08

Figura 3. Relația dintre conținutul de fosfor mobil din sol și conținutul de zinc din porumb (4-5 frunze)

Nr.	Varianta	N_0		N_{240}	
crt.		P mobil ppm X	Zinc ppmY	P mobil ppm X	Zinc ppm Y
1	P_0R_1	10.40	20.45	10.40	21.50
2	P_0R_2	10.40	19.70	14.40	20.71
3	$P_{40}R_1$	34.80	17.52	20.40	20.53
4	$P_{40}R_2$	36.60	16.58	20.40	20.80
5	$P_{80}R_1$	71.60	14.75	56.80	20.32
6	$P_{80}R_2$	70.20	15.20	60.00	20.70
7	$P_{120}R_1$	88.40	13.25	81.90	18.50
8	$P_{120}R_2$	92.50	13.93	81.20	19.20

Figura 4. The effect of nitrogen and phosphorus rates on nitrogen (A), phosphorus (B) and kalium (C) content in maize plants.

A.

Mineral fertilization	N, % 100 g.d.w.
	Vegetation stages

Nitorgen kg/ha	Phospho-rus kg/ha	4-5 leaves	6-8 leaves	10-12 leaves	Silk stage	Seeds
N_0	**P_0**	3.46	3.52	3.60	1.81	1.21
	P_{40}	3.78	3.26	2.72	2.10	1.34
	P_{80}	3.80	3.42	2.95	2.31	1.32
	P_{120}	3.95	3.61	3.01	2.45	1.28
	P_0	3.76	4.07	3.45	2.54	1.65
N_{240}	**P_{40}**	3.90	4.14	3.52	2.75	1.60
	P_{80}	3.97	4.01	3.48	2.73	1.72
	P_{120}	4.09	4.16	3.61	2.82	1.68

B.

Mineral fertilization		N, % 100 g.d.w. Vegetation stages				
Nitorgen kg/ha	Phospho-rus kg/ha	4-5 leaves	6-8 leaves	10-12 leaves	Silk stage	Seeds
N_0	**P_0**	0.252	0.329	0.281	0.206	0.323
	P_{40}	0.393	0.392	0.325	0.265	0.239
	P_{80}	0.424	0.408	0.365	0.298	0.257
	P_{120}	0.460	0.429	0.380	0.309	0.273
	P_0	0.203	0.281	0.252	0.216	0.213
N_{240}	**P_{40}**	0.322	0.343	0.275	0.233	0.219
	P_{80}	0.408	0.373	0.310	0.258	0.227
	P_{120}	0.433	0.389	0.352	0.290	0.254

C.

Mineral fertilization		N, % 100 g.d.w. Vegetation stages				
Nitorgen kg/ha	Phospho-rus kg/ha	4-5 leaves	6-8 leaves	10-12 leaves	Silk stage	Seeds
N_0	**P_0**	3.01	2.90	2.42	1.85	0.30
	P_{40}	2.52	2.70	2.23	1.92	0.30
	P_{80}	2.72	2.74	2.37	1.89	0.29
	P_{120}	2.73	2.94	2.56	2.01	0.29
	P_0	3.40	2.52	2.05	1.78	0.29
N_{240}	**P_{40}**	2.72	2.87	2.37	1.67	0.33
	P_{80}	3.16	2.68	2.26	1.76	0.34
	P_{120}	2.76	2.69	2.31	1.58	0.28