

ELEMENT DIVERSITY IN SUNFLOWER INBRED LINES

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INTRODUCTION

Genetic specificity of plant mineral nutrition has been studied from various aspects (Saric and Loughman, 1983; Gabelman and Loughman, 1987). Most investigations were aimed at establishing differences between individual genotypes in demands for certain elements of mineral nutrition. Evidence was provided by investigating a great number of plant species, in particular different wheat varieties, maize and sugar beet inbreds and hybrids, whereas for example sunflower was among those species which were studied to a far lesser extent (Modhok and Walker, 1969; Foy et al., 1974; Blamey et al., 1980; Diaz de la Guardia, et al., 1980).

It may be assumed that plant species which have a noticeably larger number of varieties will also show larger differences among them regarding the specific requirements for mineral nutrition. Considering the fact that sunflower genotypes are much fewer than maize or wheat genotypes, as well as that papers on genotypic specificity of sunflower for mineral nutrition are scarce, we decided to study this problem with sunflower plant model.

MATERIAL AND METHODS

Genotypic specificity for mineral nutrition was studied on 20 sunflower inbreds which virtually did not differ in vegetation period (OCM 2, 4, 6, 10, 12, 16, 20, 24, 26, 28, 36, 38, 40, 44, 46, 48, 50, 52, 54 and 56). The inbreds were grown by the method of water cultures for 25 days. The plants were examined for the content of N, P, K, Ca and Mg. Nitrogen content was determined according to the method by Kjeldhal, phosphorus by the vanadate — molybdate method (Gericke and Kurmies, 1952), potassium flamephotometrically, and calcium and magnesium by an atomic absorption spectrophotometric method. Also, dry mass of root, stem, and leaf, as well as leaf area (using a portable areameter Li—3 000) were measured.

All experiments were performed in five replications. The obtained results were statistically processed by the variance analysis (LSD test).

RESULTS AND DISCUSSION

Dry mass. The sunflower inbreds varied largely in the mass of dry matter (*Table 1*). Dry mass of roots ranged from 0.66 to 1.03, that of stem from 1.40 to 2.61 while of leaf from 1.69 to 2.83 mg per plant. It is characteristic that the inbreds OCMS 36 had the largest dry matter mass of root but not of the stem and leaf. The ratio stem/leaf differed also. It was al-

Table 1

Dry matter mass and leaf area of different sunflower inbreds*

Inbreds	Dry matter weight (mg/plant)			Leaf area (cm ² /plant)
	Root	Stem	Leaf	
2	0.96	2.15	1.83	9.09
4	0.83	1.84	1.71	8.57
6	0.91	2.10	1.91	7.72
10	0.80	1.86	2.26	11.55
12	0.85	2.52	2.04	9.94
16	0.78	2.11	2.40	10.84
20	0.97	2.12	2.63	11.34
24	0.88	2.32	2.57	12.30
26	0.81	1.55	2.21	8.61
28	0.77	1.40	1.83	7.97
36	1.03	1.95	2.75	11.93
38	0.66	1.45	1.69	7.57
40	0.71	1.94	1.92	7.83
44	0.81	1.79	2.33	10.89
46	0.68	1.83	2.07	8.71
48	0.98	2.61	2.60	11.20
50	0.92	2.43	2.83	11.11
52	0.73	1.73	2.01	8.97
54	0.91	2.46	2.79	12.61
56	0.72	1.94	2.27	12.13
LSD 5 %	0.10	0.24	0.28	1.43
1 %	0.13	0.32	0.88	1.92

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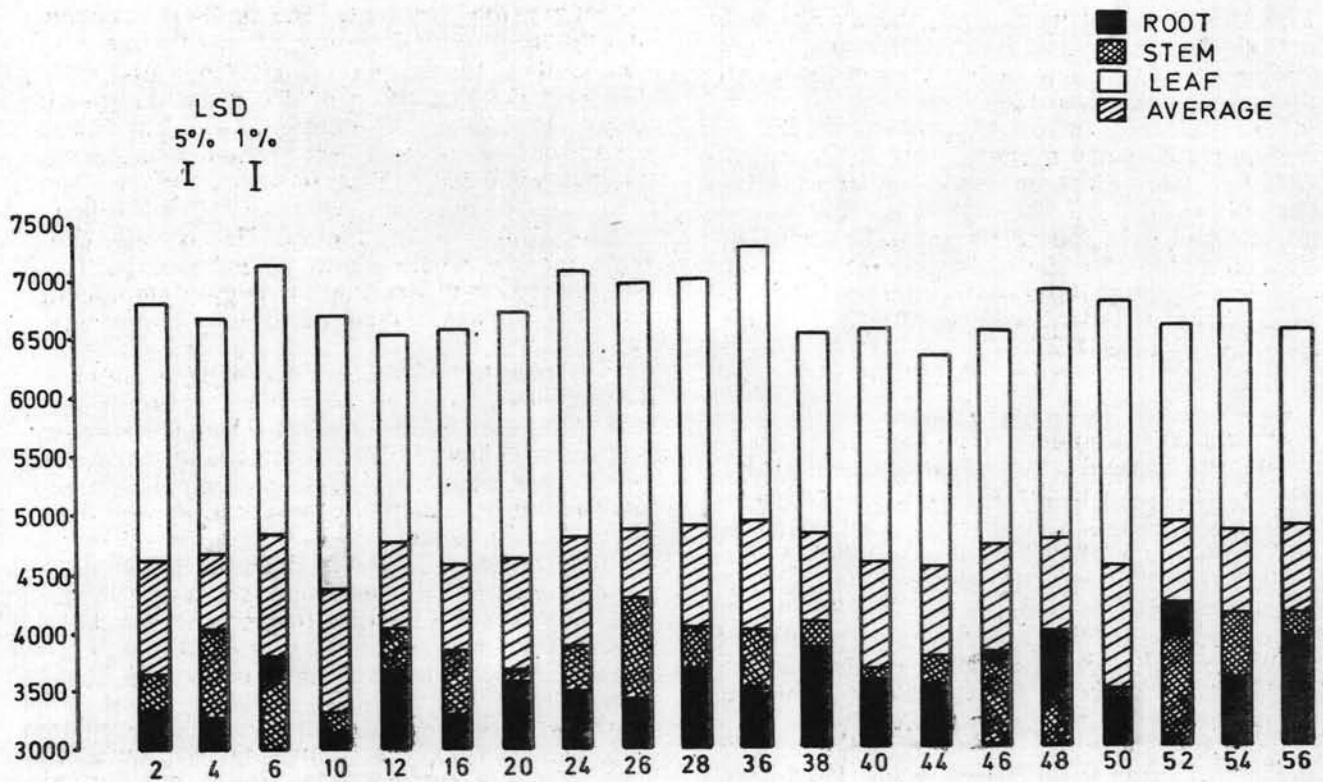


Fig. 1. — Concentration of nitrogen in different plant organs of sunflower inbred lines (mg/100 g dry matter)

most 1:1 with the inbreds 40 and 48; some inbreds (2.6 and 12) had larger mass of the stem and some other (20,44 etc.) of the leaves.

Leaf area. The examined inbreds differed in

leaf area (Table 1). The inbred 54 had the largest leaf area of 12.61 cm², whereas the inbred 38 the smallest, 7.57 cm² per plant.

Nitrogen content. The highest average content

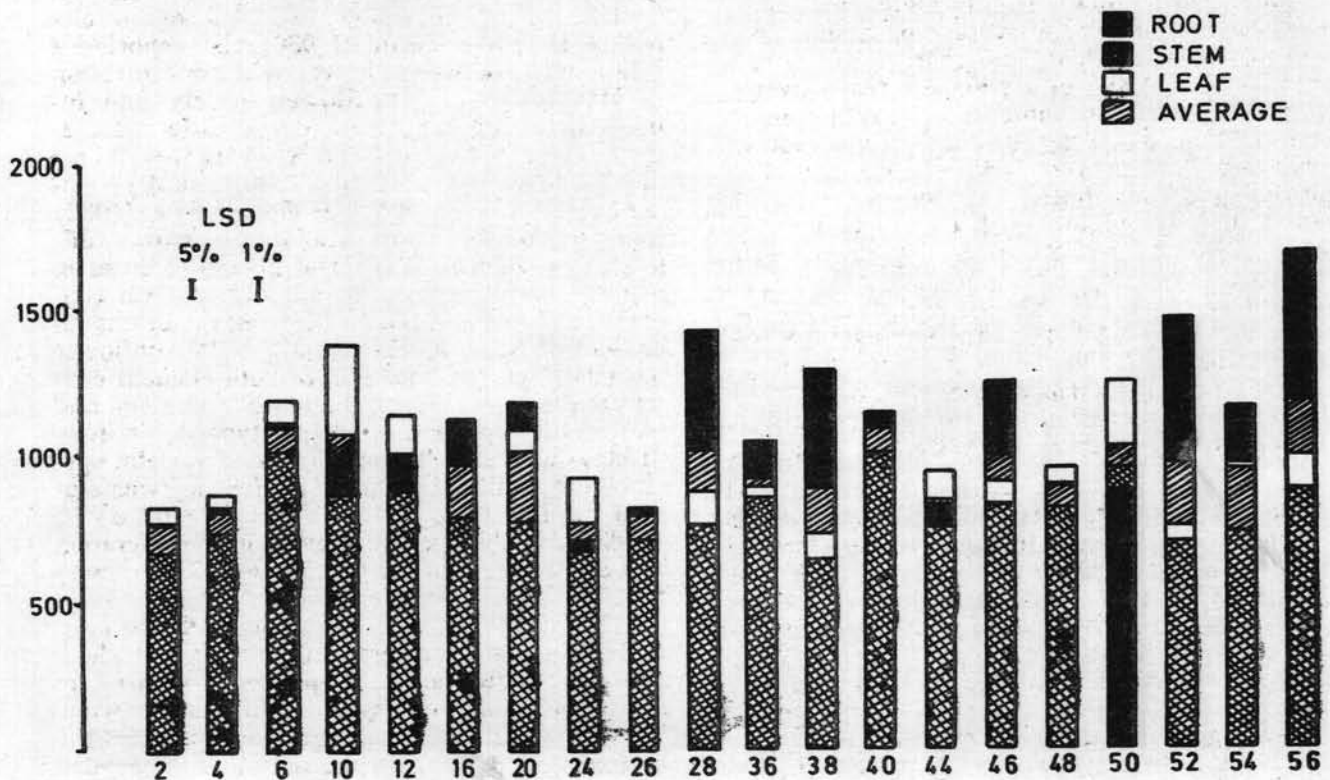


Fig. 2. — Concentration of phosphorus in different plant organs of sunflower inbred lines (mg/100 g dry matter)

(Fig. 1) was found in the leaf, then in the root and the lowest in the stem (6 765, 3 829 and 3 462 mg/100 g of dry matter, respectively). All inbreds examined had the highest nitrogen content in the leaves which ranged from 6 342 to 7 255 mg/100 g dry matter. However, some inbreds had more nitrogen in the root than in the stem (4, 12, 16, 26, 28, 36) while the others (48, 52) had the opposite situation. The average nitrogen contents for the whole plant ranged from 4 388 to 4 937 mg/100 g of dry matter. Differences in nitrogen content were significant in many cases, i.e. at LSD 1 %.

Phosphorus content. The highest average phosphorus content (Fig. 2) was found in the root then in the leaf and the lowest in the stem (1 067, 975 and 795 mg/100 g of dry matter, respectively). Phosphorus content in leaves ranged from 730 to 1 387, in stems from 655 to 1 010, and in roots from 715 to 1 687 mg/100 g of dry matter. Phosphorus contents were exceptionally high in the root and very low in the aboveground plant parts (leaves and stems) with some inbreds (56, 52, 46, 38, 28); some other inbreds had much higher phosphorus contents in the leaves and lower contents in the roots (the inbreds 50, 24, 12 and 10). The third group of inbreds had similar contents in all three plant parts (48, 44, 26, 6, 4, 2). The average phosphorus contents for the whole plant ranged from 760 to 1 185 mg/100 g of dry matter. In the case of phosphorus content too, there were significant differences in many cases at LSD 1 %.

Potassium content. Highly significant differences were found in the average potassium contents of the stem, leaf, and root (6 356, 4 797, and 4 482 mg/100 g of dry matter, respectively) (Fig. 3). Potassium contents in leaves ranged from 3 900 to 6 300 mg, in stems from 4 950 to 7 900 mg and in roots from 2 652 to 5 800 mg/100 g of dry matter. All inbreds except 1 and 2 had the highest potassium contents in stems; inbreds 1 and 2 had the highest contents in leaves. However, some inbreds had more potassium in roots (56, 52, 38, 28, 6) and some in leaves (10, 16, 24, 26, 44). The average potassium content for the whole plant ranged from 4 366 to 6 000 mg/100 g of dry matter. Significant differences in potassium content were found in a large number of cases for LSD 1 % (Fig. 3).

Calcium content. Outstandingly high calcium contents (Fig. 4) were found in leaves, then in stems, and the lowest in roots (1 011, 824, and 176 mg/100 g of dry matter, respectively). This order in calcium content was found in all inbreds. The contents in leaves ranged from 771 to 1 898 mg, in stems from 640 to 1 294 mg, and in roots from 152 to 199 mg/100 g of dry matter. The average contents for the whole plant ranged from 569 to 1 964 mg/100 g of dry matter. Highly significant differences in calcium contents were found among the examined inbreds.

Magnesium content. The highest average magnesium content (Fig. 5) was found in stems, then leaves, and finally in roots (675, 397, and 178 mg/100 g of dry matter, respectively). This order in magnesium content was found in all inbreds. The contents in leaves ranged from 285 to 582, in stems ranged from 563 to 822 mg, and in roots from 139 to 231 mg/100 g of dry matter. The average contents for the whole plant ranged from 353 to 530 mg/100 g of dry matter. Highly significant differences were also found for magnesium contents.

The results indicate the existence of high genotype specificity for the content of individual ions with the examined inbreds. There is a specific relationship between roots, stems, and leaves regarding the contents of N, P, and K. All inbreds had the highest calcium contents in leaves, then in stems and roots as well as the highest magnesium contents in stems, then in leaves and roots. However, the inbreds had specific contents, i.e., distribution of nitrogen and especially phosphorus and potassium. Certain inbreds varied highly in the distribution of these elements.

As we have already emphasized, the problem of genetic aspects of sunflower mineral nutrition has been less studied than that of other plant species. Madhok and Walker (1969) were the first to report on this problem. These authors, investigating Mg nutrition with two sunflower species (*H. annuus* L. and *H. bolanderi* Gray ssp. *exilis* Heiser), found that these two species showed different tolerance to Mg and that they had different content of this element. Foy et al. (1974) found differences among 13 sunflower genotypes both in organic matter synthesis and content of certain macro — and micro elements. Blamey et al. (1980) also reported a relationship between the element concentration in leaf tissue and sunflower variety and inbred. Investigating the genotypic differences among inbreds, hybrids, and two varieties, Diaz de la Guardia et al. (1980) and Alcantro and Diaz de la Guardia (1982) found various ability of genotypes to grow in different Ca concentrations and also differences in organic matter synthesis and Mg and Ca contents. Sarić and Skorić (1981), working on content of N, P, K, Ca and Mg of 20 sunflower inbreds, reported variation of both element content and element distribution into root, stem, and leaf which depended upon genotype. Kannan (1984) suggested the occurrence of varietal specificity of sunflower when Fe deficiency was studied while Kastori and Stanković (1985) also observed differences in root excretion and ability of Fe utilization between 3 sunflower hybrids. The evidence presented by Sfredo et al. (1985) on phosphorus content of the two varieties showed considerable differences in phosphorus accumulation and dependence of variation range upon the ontogenetic differences while Luizzi et al. (1985) suggested that variations between hybrids in phosphorus content depended upon plant organ examined. Investigating the variability of concentration of N, P, and K in

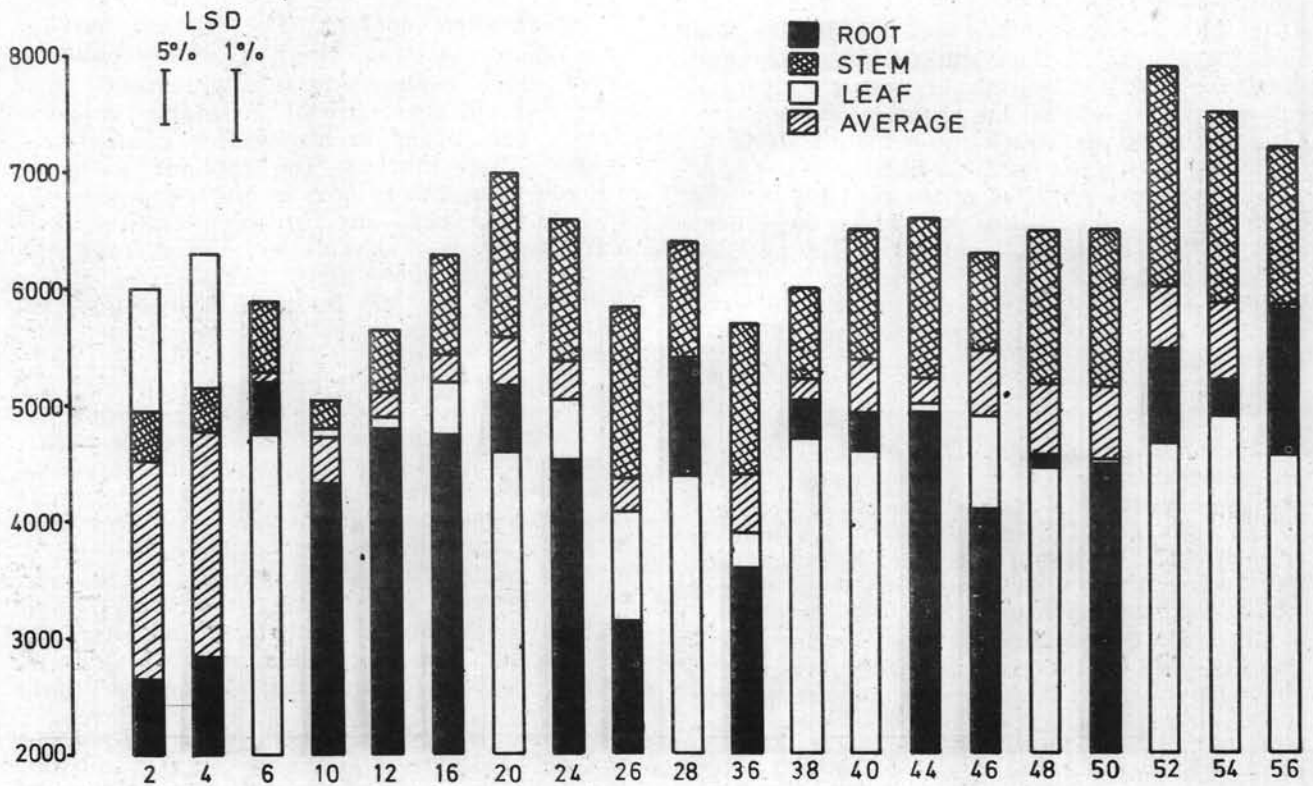


Fig. 3. — Concentration of potassium in different plant organs of sunflower inbred lines (mg/100 g dry matter)

12 wild species and 20 sunflower inbreds, Krstić and Sarić (1987) found great differences in concentration of these elements both in wild species and inbreds. These authors also

reported a considerable greater variation range of N+P+K in wild species than in inbreds.

The results available and also our investigations show that also in sunflower plants there

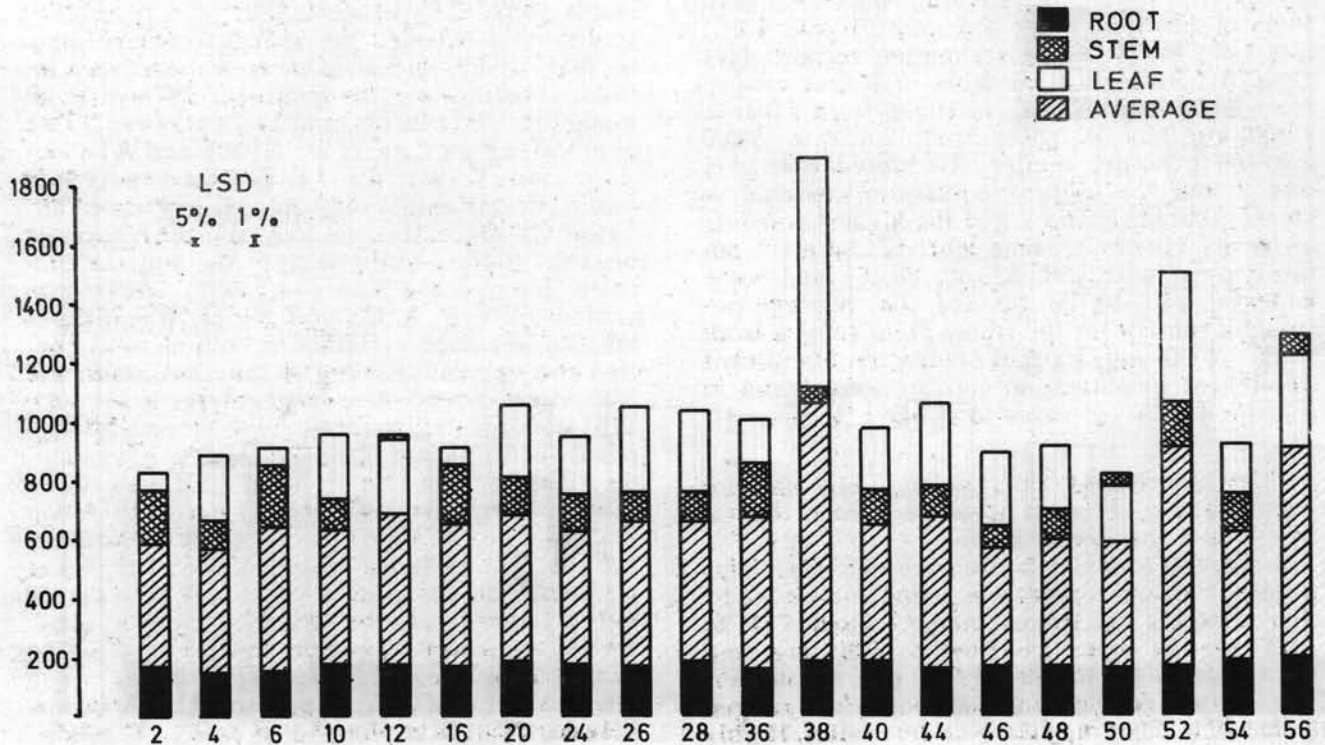


Fig. 4. — Concentration of calcium in different plant organs of sunflower inbred lines (mg/100 g dry matter)

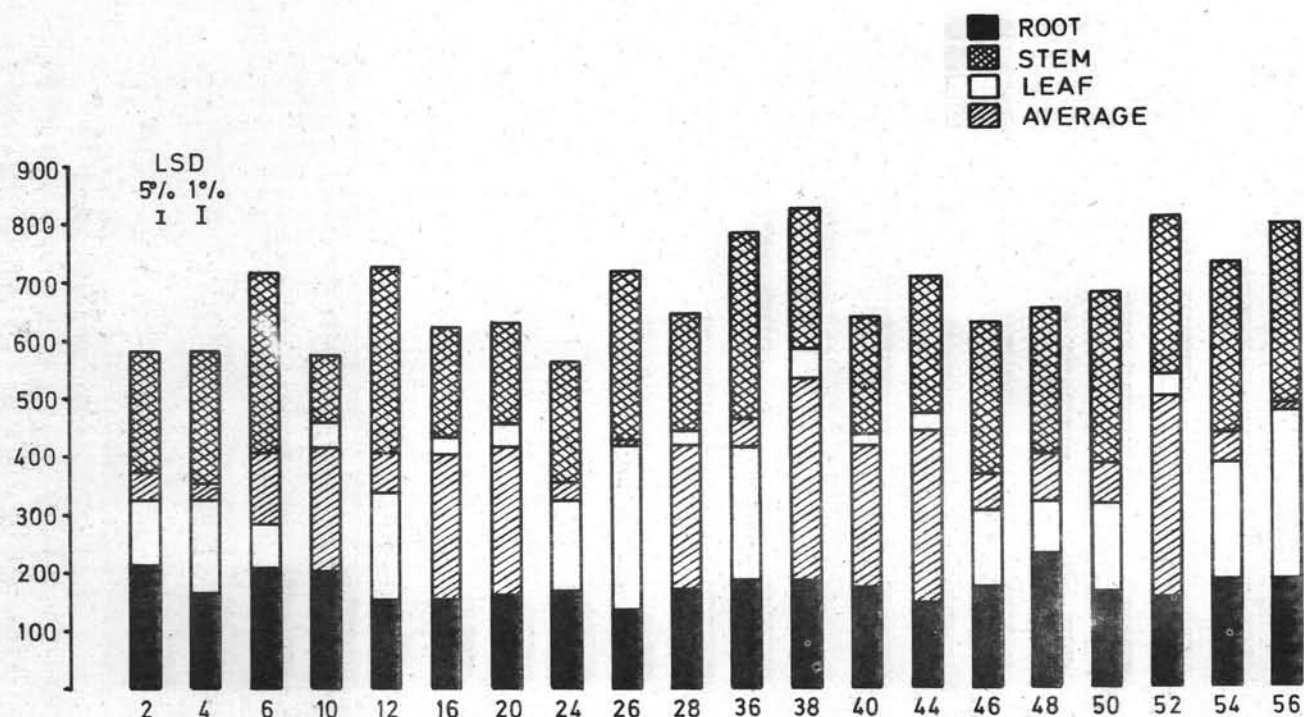


Fig. 5. — Concentration of magnesium in different plant organs of sunflower inbred lines (mg/100 g dry matter)

are great differences in requirements of individual genotypes for certain elements of mineral nutrition.

CONCLUSION

We concluded that there was a remarkable specificity of concentration of individual ions in sunflower inbreds under investigation. Concentration of the elements also depended upon plant organ analyzed (root, stem, leaf). In all inbreds examined the highest concentration of N and Ca was found in leaf, then in stem and root, and the highest Mg concentration was recorded in stem, then in leaf and root. In a great number of lines, the highest P concentration was found in root. The highest chemical heterogeneity in different plant organs was recorded with K. All the results showed that the genetic specificity of mineral nutrition was manifested not only through different content of mineral elements but also in their distribution into individual plant organs.

REFERENCES

- Alcantro E., Diaz de la Guardia M.D., 1982. *Genotypic differences in calcium and magnesium nutrition in sunflower*. In: Genetic Specificity of Mineral Nutrition of Plants (Sarić ed), Serbian Academy of Sciences and Arts, Beograd.
- Blamey F.P.C., Vermeulen W.J., Chapman J., 1980. *Variation in leaf chemical composition of sunflower cultivars and inbred lines*. Communications in Soil Science and Plant Analysis 11, 1067—1075.
- Diaz de la Guardia M.D., Saiz de Omenaca J.A., Perez Torres E.B., Montes Agusti F., 1980. *Diferentes respuestas de las líneas, híbridos y variedades de girasol a la nutrición con bajo nivel de calcio*. IX Conferencia internacional del girasol, Madrid, 239—148.
- Foy E.D., Orellana R.G., Schwarz J.W., Elemetry A.L., 1974. *Responses of sunflower genotypes to aluminium in acid soil and nutrient solution*. Agron. J. 66, 293—296.
- Gabelman H.W., Loughman B.E. (Eds.), 1987. *Genetic aspects of plant mineral nutrition*. Martines Nijhoff Publishers, Dordeet/Boston/Lancaster.
- Gericke S., Kurmics B., 1952. *Die kolorimetrische Phosphorsäurebestimmung mit Ammonium-vanadatmolybdat und ihre Anwendung in der Pflanzenanalyse*. Z. Pflanzenernchr, Bodenk, 59, 8.
- Kastori R., Stanković Z., 1985. *Ekskrecija korena i sposobnost iskoriscavanja gvozdja razlicitih hibrida suncokreta (Root excretion and capacity for iron uptake in some sunflower hybrids)*. Zbornik Matice srspe za prirodne nauke, 69, 79—88.
- Kannan S., 1984. *Studies on Fe deficiency response in three cultivars of sunflower*, 7 (8), 1203—1212.
- Krstić B., Sarić M., 1987. *Genotipska raznolikost koncentracije azota, fosfora i kalijuma divljih vrsta i inbred linija suncokreta (Genetic diversity in iron acquisition of wild species and inbred lines of sunflower)*. Savremena poljoprivreda, 5, 6.
- Luizzi D., Viega L., Roverta A., Schiavo C., 1985. *Crecimiento y absorcion de nutrientes en dos cultivares de girasol*. Proceedings of XI International Sunflower Conference, 10/13 March, Mar del Plata, 195—202.
- Modhok O.P., Walker R.B., 1969. *Magnesium nutrition of two species of sunflower*. Plant Physiol. 44, 1016—1022.
- Reid P.H., Yotk E.T., 1958. *Effect of nutrient deficiencies on growth and fruiting characteristics of peanuts*. Agronomy Journal 50, 2, 17—63.

- Sarić M.R., Skorić D., 1981. *Relationship between the root and above ground parts of different sunflower inbreds regarding the content of some mineral elements*. R. Brower et al.; (eds), *Structure and Function of Plant Roots*, 399—401, Martinus Nijhoff/Dr. Junk Publishers, The Hague/Boston/London.
- Sarić M.R., Loughman B.C. (Eds), 1983. *Genetic aspects of plant nutrition*. Martinus Nijhoff/Dr. W. Junk Publishers, The Hague/Boston/Lancaster.
- Sarić M.R., 1984. *Genetic improvement of yields as related to plant nutrient requirements*. Proceedings of 9th World Fertilizer Congress. June 11—16, Budapest.
- Sifredo G.J., Sarrugi J.R., Campo R.J., 1985. *Accumulation of macro nutrients by two sunflower (Helianthus annuus L.) Cultivars under field conditions*. Proceedings of XI International Sunflower Conference, 10/13 March, Mar del Plata, 189—194.

LA DIVERSITÉ DES ÉLÉMENTS MINÉRAUX CHEZ LES LIGNÉES AUTOFÉCONDÉES DE TOURNESOL

Résumé

Compte tenu de l'importance théorique et pratique de la diversité génétique de la teneur en éléments minéraux, les auteurs ont étudié cette diversité chez les plantes de tournesol.

Les concentrations spécifiques de N, P, K, Ca et Mg ont été étudiées chez 20 lignées autofécondées de tournesol. La collection de lignées appartient à l'Institut pour Cultures de Champ et Légumes de Novi Sad.

Les lignées ont été cultivées en solution nutritive d'après la méthode des cultures aquatiques en serre, durant 25 jours. La teneur des plantes en N, P, K, Ca et Mg a été déterminée ainsi que la masse sèche des racines, des tiges et des feuilles. La surface foliaire a également été calculée. Le résultat des recherches a établi que chez toutes les lignées la plus haute concentration en N et Ca se trouve

dans les feuilles, suivie par les tiges et les racines; la plus haute concentration en Mg se trouve dans les tiges, suivie par les feuilles et les racines. Chez un grand nombre de lignées, le P atteint la plus haute concentration dans la racine. La plus importante hétérogénéité chimique dans les différents organes des plantes a été établie pour le K. Les résultats révèlent que la spécificité génétique de la nutrition minérale ne se manifeste pas seulement par les variations de la teneur en éléments minéraux, mais aussi par leur distribution dans les différents organes de la plante.

DIVERSIDAD EN CONTENIDO DE ELEMENTOS MINERALES EN LINEAS PURAS DE GIRASOL

Resúmen

Teniendo en cuenta el hecho de la importancia que la base genética tiene en la diversidad de concentración de elementos nutritivos minerales, se llevó a cabo la presente investigación.

La especificidad del girasol para las concentraciones de N, P, K, Ca y Mg fué examinada en 20 líneas puras de girasol, perteneciendo éstas al Instituto de Cultivos Extensivos y Hortícolas de Novi-Sad.

Las líneas puras se cultivaron en soluciones nutritivas por el método de cultivo en agua, en invernadero y durante 25 días. Las plantas fueron examinadas para el contenido en N, P, K, Ca y Mg, midiéndose también la materia seca de raíces, tallos y hojas, así como el área foliar.

Las siguientes conclusiones se destacan de los resultados: La concentración en elementos minerales depende del órgano analizado (raíz, tallo hoja). En todas las líneas puras examinadas las mayores concentraciones de N y Ca se encontraron en las hojas, bajando en el tallo y las raíces. La más alta concentración de Magnesio se encontró en el tallo, bajando en la hoja y la raíz. En una gran mayoría de líneas, la más alta concentración de P, se encontró para el K. Los resultados obtenidos demuestran que la especificidad genética en la nutrición mineral no solo se manifiesta por los diferentes contenidos de los elementos, sino también por su distribución dentro de los órganos individuales de la planta.