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ELEMENT DIVERSITY IN SUNFLOWER INBRED LINES

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SUMMARY

Taking into consideration fact that the genetic diversity for concentration of individual elements of mineral nutrition is an important problem both theoretically and practically, we undertook an investigation with sunflower plants.

Sunflower specificity in N, P, K, Ca and Mg concentration was examined with 20 inbred lines. Collections of inbreds belong to the Institute of Field and Vegetable Crops, Faculty of Agriculture, Novi Sad.

The inbreds were grown in nutrient solution by the method of water culture, in greenhouse for 25 days. The plants were examined for the content of N, P, K, Ca, and Mg. Also, dry mass of root, stem and leaf as well as leaf area were measured.

On the basis of the results obtained one can draw the following conclusions. Concentration of the elements depended on 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. The results show that the genetic specificity for mineral nutrition is manifested not only through different contents of mineral elements but also in their distribution into individual plant organs.

Key words: Mineral elements, diversity, inbred lines, root, stem and leaf

INTRODUCTION

Genetic specificity of plant mineral nutrition has been studied from various aspects (Sarić and Aoughman, 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 Gvardia, 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. (OCMS 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 Kjeldahl, phosphorus by the vanadate–molybdate method, (Gericke, 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 areametar Li–3000) were measured.

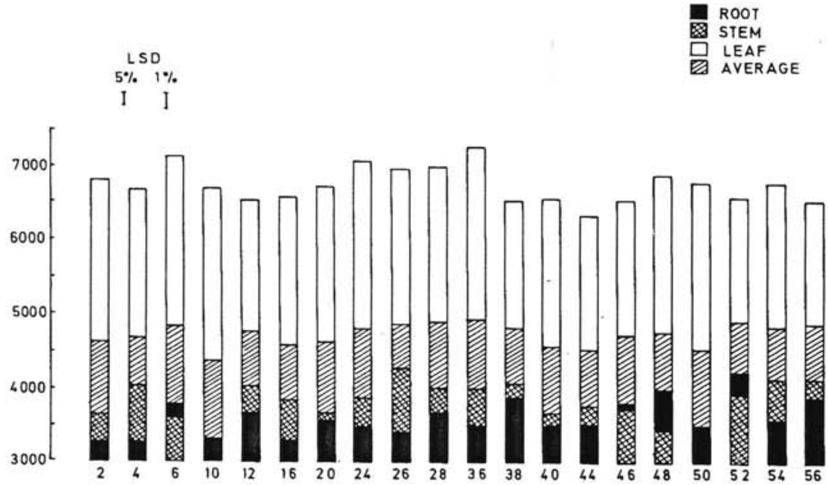
All experiments were performed in five replications. the obtained results were statistically processed by the variance analysis (LSD.test).

RESULTS AND DISCUSSION

Dry mass. The sunflower inbreds varied by large 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 that of leaf from 1,69 to 2,83 mg per plant. It is characteristic that the inbred 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 almost 1:1 with the inbreds 40 and 48; some inbreds (26 and 12) had larger mass of the stem and some other (20,44, etc.) of the leaves.

Table 1. Dry matter mass and leaf area of different sunflower inbreds

Inbred	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	7,79
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%	0,13	0,32	0,88



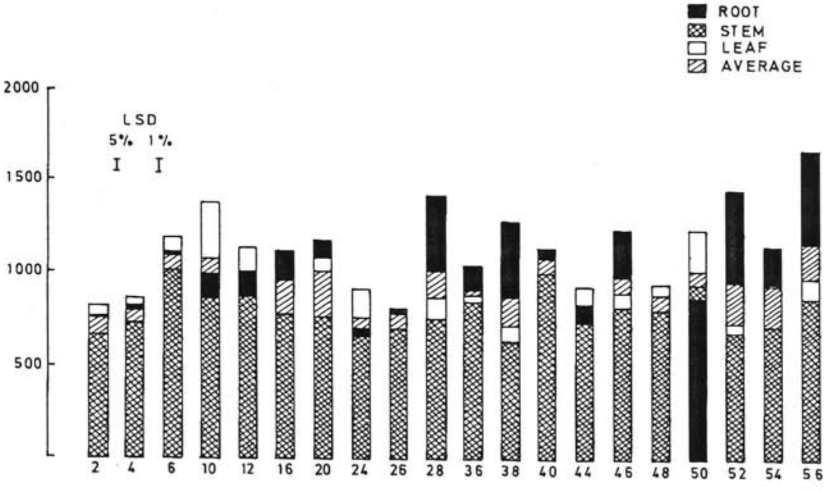
Graph.1 – Concentration of nitrogen in different plant organs of sunflower inbred lines (mg/100g dry matter)

Leaf area. The examined inbreds differed in leaf area (Table 1). The inbred 54 had the largest leaf area of 12,61, whereas the inbred 38 the smallest amounting 7,57 cm^2 per plant (Table 1).

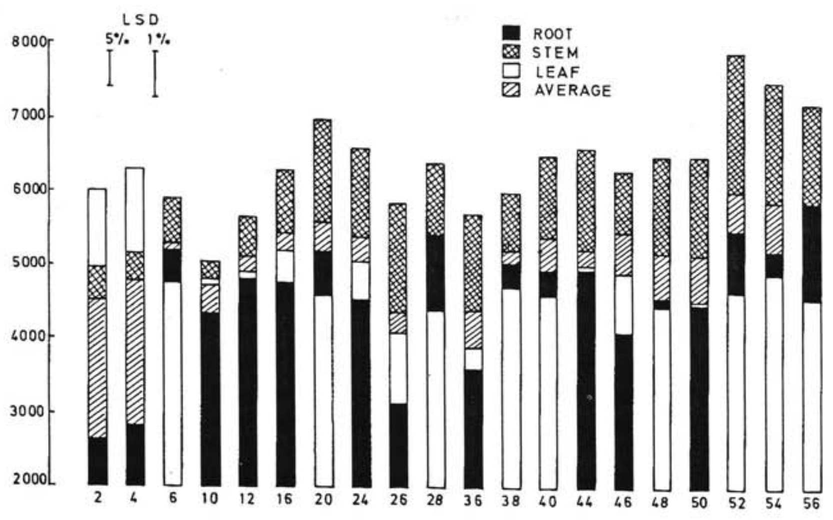
Nitrogen content. The highest average content (Graph. 1) was found in the leaf, then in the root and the lowest in the stem (6765, 3829, and 3462 mg/100 gr of dry matter, respectively). All inbreds examined had highest nitrogen contents in leaves which ranged from 6342 to 7255 mg/100 gr dry matter. However, some inbreds had more nitrogen in the root than in the stem (4, 12, 16, 26, 28, 36) while the others (48, 52, etc). had the opposite situation. The average nitrogen contents for the whole plant ranged from 4388 to 4937 mg/100 gr of dry matter. Diferences in nitrogen content were significant in many cases, i.e., at LSD 1%.

Phosphorus content. The highest average phosphorus content (Graph.2) was found in the root then in the leaf and the lowest in the stem (1067, 975, and 795 mg/100g of dry matter, respectively). Phosphorus content in leaves ranged from 730 to 1687 mg/100 gr of dry matter. Phosphorus contents were exceptionally high in the root and very low in the above–ground 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 1185 mg/100gr of dry matter. In the case of phosphorus content too, there were significant diferences in many cases at LSD 1%.

Potassium content. Highly significant differences were found in the average potassium contents of the stem, leaf, and root (6356, 4797, and 4482 mg/100 gr of dry matter, respectively) (Graph.3). Potassium contents in leaves ranged from 3900 to 6300 mg, in stems from 4950 to 7900 mg and in roots from 2652 to 5800 mg/100gr of dry matter. All inbreds except 1 and 2 had highest potassium contents in stems, inbreds 1 and 2 had highest contents in leaves. However, some inbreds had more potassium in roots (56, 52, 38, 28, 6, etc.) and some in leaves (10, 16, 24, 26, 44). The average potassium content for the whole plant ranged from 4366 to 6000 mg/100gr of dry matter. Significant differences in potassium content were found in a large number of cases for LSD 1% (Graph. 3).



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



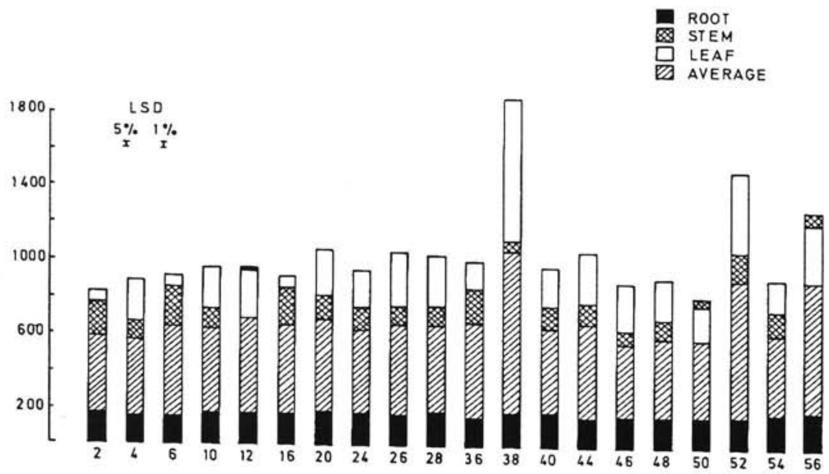
Graph.3 – Concentration of potassium in different plant organs of sunflower inbred lines (mg/100g dry matter)

Calcium content. Outstandingly high calcium contents (Graph.4) were found in leaves, then in stems, and the lowest in roots (1011, 824, and 176 mg/100gr of dry matter, respecitvely). This order for calcium content was found in all inbreds. The content in leaves ranged from 771 to 1898 mg, in stems from 640 to 1294 mg, and in roots from 152 to 199 mg/100gr of dry matter. The average contents for the whole plant ranged from 569 to 1964 mg/100gr of dry matter. Highly significant differences in calcium content were present among the examined inbreds.

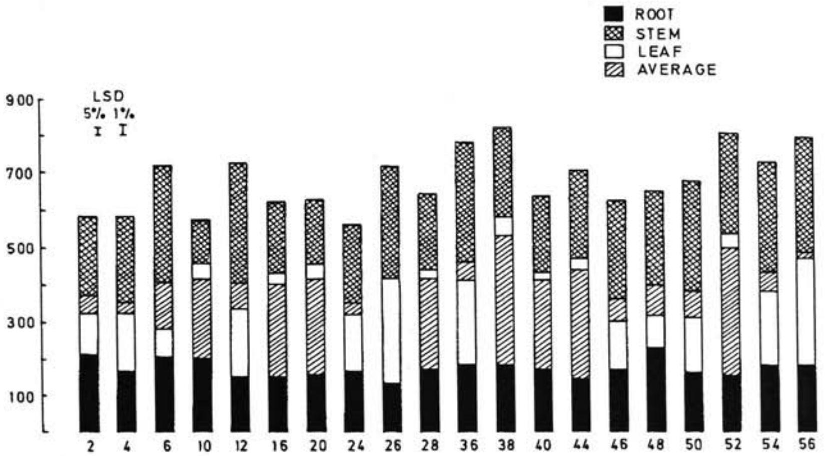
Magnesium content. The higest average magnesium content (Graph.5) was found in stems, then in leaves, and finally in roots (675, 397, and 178 mg/100gr of dry matter, respectively). This order for magnesium content was found in all inbreds. The contents in stems ranged from 285 to 582 mg, in leaves from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

The results indicate the existance of high genotype specitificity 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 highest calcium contents in leaves, then in stems and roots as well as highest magnesium contents in stems, 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 studied less than that of other plant species. Madhok and Walker (1969) were the first to report on this problem. These authors, investigating Mg nutriton with two sunflower species (*H.annuus L.* and *H.bolanderis* Gray *ssp.exilis* Heiser), found that the species show different tolerance to Mg and that they have different contents of this element.



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



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

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 of a relationship between 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 Alcantra and Diaz de la Guradia (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 Škorić (1981), working on the contents of N, P, K, Ca and Mg in 20 sunflower inbreds, reported variations of both element content and element distribution into root, stem, and leaf which depended upon genotype. Kanan (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 among 3 sunflower hybrids. The evidence presented by Sfredo et al. (1985) on phosphorus content in 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 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 investigation show that in sunflower plants there are great differences in requirements of individual genotypes for certain elements of mineral nutrition.

CONCLUSION

We concluded that there was a remarkable specificity in concentration of individual ions in the sunflower inbreds under investigation. Concentration of the elements also depended upon plant organ analyzed (root, stem, leaf). In the 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 show that the genetic specificity of mineral nutrition is manifested not only through different content of mineral elements but also in their distribution into individual plant organs.

REFERENCES

Alcantro, E.Diaz de la Guarda, 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 compostion 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. *Differentes respuested de las lineas, hibridos y variedades de girasol a la nutricion con bajo nivel de calsio*. IX Conferencia internacional del girasol, Madrid, 239–148.

Foy, E.D., Ovellana, R.G., Schwarz, J.W., Eleminy, 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, Dordreet/Boston/Lancaster.

Gericke, S., Kurmics, B. 1952. *Die kolorimetrische Phosphorsäurebestimmung mit Ammonium–vanadat–molybdat und ihre Anwendung in der pflanzen–nalyse.* Z.Pfalnzenernächr, Bodenk. 59, 8.

Kastori, R., Stanković, Ž. 1985. *Ekskrecija korena i sposobnost iskorišćavanja gvožđa različitih hibrida suncokreta* (Root excretion and capacity for iron uptake in some sunflower hibrids). Zbornik Matice srpske 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 ion acquisition of wild species and inbred lines of sunflower). Savremena poljoprivreda, 5, 6.

Luizzi, D., Viega, L., Roverta, A., Schiavo, C. 1985. *Crecimiento y absorcian de nutrientes en dos cultivares de girasol.* Procedings of XI international sunflower conference 10/13 March Mor 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., York, E.T. 1958. *Effect of nutrient deficiencies on growth and fruiting characteristics of peanuts in sond cultivars*. Agronomy Journal 50, 2, 17–63.

Sraić, M.R., Škorić, 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 Haque/Boston/London.

Sarić, M.R., Loughman, B.C. (Eds), 1983. *Genetic aspects of plant nutrition.* Martinus Nijhoff/Dr Junk Publishers, The Haque/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.

Sfredo, G.J., Sarrugi, J.R., Campo, R.J. 1985. *Accumulation of macro nutrients by two sunflower (Helianthus annuus L.) cultivars under field conditions.* Procedings of XI International Sunflower Conference 10/13 March, Mar del Plata, 189–194.

DIVERSIDAD EN CONCENTRACION DE ELEMENTOS EN LINEAS PURAS

RESUMEN

Considerendo el hecho que la diversidad en concentración individual de elementos de la nutrición mineral es un problema importante tanto teórica como prácticamente, se inició una investigación con plantas de girasol.

La especificidad del girasol en la concentración de N, P, K, Ca y Mg fue examinado con 20 líneas puras. Las coleciones de líneas pertenecen al Instituto de Field and Vegetable Crops, Facultad de Agricultura, Novi Sad.

Las líneas se crecieron en una solución nutritiva por el método de cultivo hidropónico, en invernadero durante 25 días. Las plantas fueron examinadas para contenido de N, P, K, Ca y Mg. Se midió también la materia seca de la raíz, el tallo y hoja así como el área foliar.

En base a los resultados obtenidos se pueden extraer las siguientes conclusiones: La concentración de los elementos dependió del órgano de la planta analizado (raíz, tallo, hoja). En todas las líneas examinadas la concentración mas alta de N y Ca se obtuvo en la hoja, después en el tallo y raíz y la concentración mas alta de Mg se encontró en el tallo, y después en la hoja y la raíz. En un gran número de líneas la concentración mas alta de P se encontró en la raíz. La heterogeneidad química mas alta en los diferentes órganos se observó con el K. Todos los resultados muestran que la aspecificidad de la nutrición mineral se manifiesta no solo a través de un contenido diferente de elementos minerales sino también en su distribución dentro de órganos individuales de la planta.

DIVERSITÉ EN ÉLÉMENTS MINÉRAUX CHEZ DIFFÉRENTES LIGNÉES DE TOURNESOL.

RÉSUMÉ:

Etant donné l'importance théorique et pratique de la concentration en éléments de la nutrition minérale nous avons décidé d'étudier ce probléme chez des plantes de tournesol.

La spécificité de la concentration en N, P, K Ca et Mg a été examinée chez vingt lignées. Le matériel utilisé appartient à l'Institute of Field and Vegetable Crops, Faculté d'agriculture de Novi SAd.

Les lignées ont été cultivées sur solutions nutritives selon la technique des cultures hydroponiques, pendant 25 jours en serre. Les concentrations en N, P, K, Ca et Mg ont été déterminées. Les matières séches des tiges, racines, feuilles analysées, et la surface folliaire mesurée.

Sur la base des résultats obtenus nous pouvons tirer les conclusions suivantes:

– les concentrations en éléments sont fonction des organes analysés (racine, tige, feuille),

– chez toutes les lignées étudiées, les plus fortes concentrations en azote et en calcium ont été trouvées dans les tiges puis au niveau des feuilles et enfin dans les racines, et la plus forte concentration en magnesium se trouve localisée dans la tige, puis dans les feuilles et la racine.

– chez un grand nombre de lignées, la concentration la plus élevée en phosphore se situe dans les racines,

– la plus grande hétérogénéité chimique dans les différents organes de la plante a été mise en évidence pour le potassium.

Tous ces résultats montrent que la spécifité génétique de la nutrition végétale est évidente non seulement pour les diffentes concentrations en éléments minéraux mais aussi concernant la distribution de ces éléments dans les différents organes de la plante.