STUDY OF THE MAIN ELEMENTS OF THE FERTILIZATION SYSTEM IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) BY MEANS OF ^{15}N

CR. HERA and I. TONCEA
Research Institute for Cereals and Industrial Crops, 8264 Fundulea (Călărași), Romania

INTRODUCTION

Sunflower has rapidly extended into production due to its multiple uses as human food and animal feeding, as well as a melliferous plant and row material in numerous industrial branches. Its well developed root system provides a high ability of using the water and nutrients supply of the soil. This physiological trait enables sunflower, although a great consumer of nutrients, to react moderately to fertilizer application. Very different results were obtained by mineral nitrogen application. Thus the yield increases achieved after nitrogen fertilization were either very high (Bamdad, 1972; Sarič, 1972; Jočić and Sarić, 1978) or nonsignificant (Horodyski, 1974; Kováčik et al., 1981) or even negative (Coculescu et al., 1969). As regards sunflower reaction to the main elements of the fertilization system: dose, chemical form and fertilizer type, numerous specialized studies pointed out the high efficiency of moderate nitrogen doses (Coculescu et al., 1969; Rollier, 1979; Toncea and Poparlan, 1985) and the nonsignificant effect of the chemical form (Avram, 1970; Hera, 1968).

Under the present circumstances when the fertilizer production and application are more and more expensive, the development of the research regarding nitrogen nutrition in sunflower has become a stringent necessity.

The ^{15}N labelled fertilizers have been used for the first time in the field experiments at the Research Institute for Cereals and Industrial Crops of Fundulea (Hera 1974).

The present paper presents the experimental results regarding sunflower reaction to the nitrogen dose and to the main chemical forms or nitrogen fertilizer types.

MATERIALS AND METHODS

The investigations were conducted for 3 years (1982—1984) in a bifactorial field experiment (N fertilizer types × doses), placed on a cambic chernozem at Fundulea, under irrigation, in a subdivided plot design. Three fertilizer types (ammonium nitrate, urea and ammonium sulphate) and 3 nitrogen levels (0, 100 and 200 kg N/ha) were applied.

In order to enhance the accuracy of the experimental results the ammonium nitrate used as fertilizer was labelled by the stable isotope ^{15}N to each ion separately ($^{15}NH_4$ and $^{15}NO_3$).

In placing the experiment as well as in working out the experimental data, the methodology concerning the organization and evaluation of field experiments with labelled fertilizers has been used *. The other technological elements such as: crop rotation, the cultivated hybrid (Sorem 82), phosphorous fertilization (concentrated superfosphate — 80 kg P_2O_5/ha), soil tillage, seeding, cultivation, crop protection and harvesting works were the same during the whole experimental cycle.

The effect of the factors under study has been considered after several measurement performed during the full maturity stage of plants, on each plant component (seeds, heads, stalks and leaves) as follows:

— seed yield, heads and stalks (dry matter, kg/ha);

— oil content in seeds (%), the method of nuclear magnetic resonance (N.M.R.);

— mineral nitrogen content in seeds, heads, stalks and leaves (% N), by Kjeldahl method;

— isotopic concentration (% atoms ^{15}N) by the mass spectrometry method.

Based on the results of these measurements, we calculated:

— nitrogen quantity exported with the yield (Nt, kg/ha)

$$Nt = \frac{\text{yield} \cdot \% \, N}{100}$$

* "A guide to the use of Nitrogen-15 and radioisotopes in studies of plant nutrition: calculations and interpretation of data". A technical document issued by the International Atomic Energy Agency, Vienna, 1983.

Table 1

The "F" values and their significance corresponding to the variation sources experimented for the main yield elements in sunflower, which can be modified by nitrogen fertilization (Fundulea, 1982—1984)

Resultant variables	Year	Seeds			Heads			Stalks			Leaves		
		Fertilizer type	Dose	Fert. type x dose	Fertilizer type	Dose	Fert. type x dose	Fertilizer type	Dose	Fert. type x dose	Fertilizer type	Dose	Fert. type x dose
Yield (dry matter)	1982	2.09	14.15**	0.77	5.80*	12.44**	1.41						
	1983	0.54	15.27**	0.77	10.58**	24.23**	1.05	4.90*	118.01**	1.62			
	1984	9.61*	22.39**	6.80*	2.12	19.36**	0.49	14.33**	27.64**	6.99**			
Oil content (%)	1983	0.51	7.19**	0.34									
	1984	7.80*	70.95**	4.96*									
Total content of mineral nitrogen (%)	1982	0.83	36.55**	0.51									
	1983	0.65	65.23**	0.64	0.88	23.06**	0.52	0.29	158.73**	1.79	2.11	103.29**	0.97
	1984	1.79	10.75**	0.31									
Nitrogen content absorbed from fertilizer (%)	1982	2.48	95.66**	23.48**									
	1983	17.33*	42.23**	4.74*	19.19**	32.04**	4.60*	16.44**	13.13**	0.86	19.69**	54.48**	5.78*
	1984	24.35**	62.85**	4.87*									

Nitrogen derived from fertilizer (NdfF, %)

$$\% \text{ NdfF} = \frac{X - Xn}{Ex} 100$$

where X is the isotopic concentration, Xn = natural isotopic concentration ($\sim$ 0.365), Ex = excess of ^{15}N from fertilizer (%).

— N quantity absorbed from fertilizer (Nf) and soil (Ns)

$$Nf = \frac{Nt \cdot NdfF}{100}$$

$$Ns = Nt - Nf$$

— fertilizer utilization efficiency (% F.U.E.).

$$\% \text{ F.U.E.} = \frac{Nt \cdot NdfF}{D\,N}$$

where D N is the notrogen rate (N, kg/ha).

The significance of the experimental results was established by means of variance and regression analysis.

RESULTS AND DISCUSSION

The most important factor in sunflower nutrition with mineral nitrogen is the fertilization system, due to the direct action of its elements on absorbtion and on the majority of biochemical processes of crop formation.

As shown by the experimental results with chemical forms and nitrogen rates, obtained at Fundulea during 1982—1984, sunflower yield, regardless of the cropping year and the plant organ under study, was quantitatively and qualitatively influenced by the dose. Thus the calculated value of the ratio between variance of the dose and the corresponding error (F) was in all cases higher than the theoretical one (Table 1), which indicates a very significant influence of the dose on all variables — yield, oil content, mineral nitrogen (total and from the fertilizer).

The type of nitrogen fertilizer has systematically modified the head and stalk production, as well as the nitrogen content absorbed from fertilizer. From the quantitative point of view, the effect of the investigated factors resulted, as illustrated by the graphs of Figure 1, in the following :

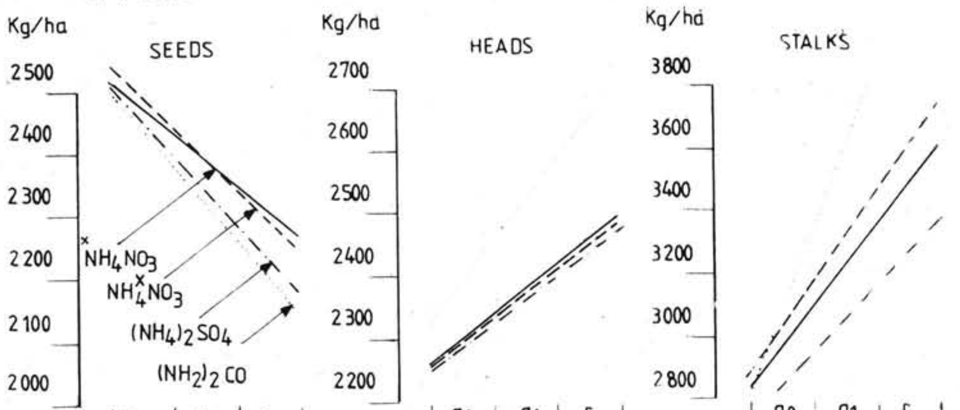
— a significant decrease of the seed yield proportional to the nitrogen rate in the treatments with ammonium sulphate (1.69 kg/kg N) and urea (1.78 kg/kgN) ;

— a significant change of the head yield and the increase of stalk yield corresponding to the nitrogen rate in the treatments with ammonium sulphate (3.18 kg/kg N) and especially urea (8.14 kg/kg N) ;

— various contents of mineral nitrogen depending on the analyzed plant organ (2.70—2.74% N in seeds ; 1.44—1.46% N in heads ; 0.41—0.49% N in stalks and 1.81—1.92% in leaves), as well as nitrogen accumulations proportional to the dose and specific to each plant part ($2.7 \times 10^{-3} - 3.1 \times 10^{-3}$ % N/kg N in seeds ; $1.1 \times 10^{-3} - 1.8 \times 10^{-3}$ in heads ; $3.6 \times 10^{-3} - 5.6 \times 10^{-3}$ in stalks and $2.0 \times 10^{-3} - 3.5 \times 10^{-3}$ in leaves) and fertilizer type ($1.1 \times 10^{-3} - 3.5 \times 10^{-3}$ to NH_4NO_3 ; $1.6 \times 10^{-3} - 3.6 \times 10^{-3}$ to $(NH_4)_2SO_4$ and $1.8 \times 10^{-3} - 5.6 \times 10^{-3}$ to $(NH_2)_2CO$) ;

— positive correlations between nitrogen derived from fertilizer and the two investigated variables, as well as an approximate equal distribution of the nitrogen absorbed from each fertilizer type in all analysed organs. This fact resulted to the treatments with ammonium nitrate in an increase of the nitrogen content

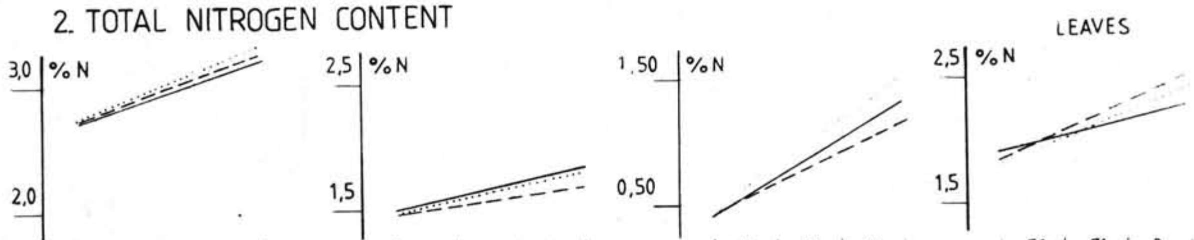
1. YIELD



	Seeds a_0	Seeds a_1	Seeds r	Heads a_0	Heads a_1	Heads r	Stalks a_0	Stalks a_1	Stalks r
ˣNH_4NO_3	2513	-1,27	-0,89	2256	1,18	0,42	2813	4,13	0,97
$NH_4^xNO_3$	2545	-1,51	-0,78	2251	1,17	0,43	2854	4,34	0,92
$(NH_2)_2CO$	2300	-1,78	-0,97	2312	2,02	0,50	2786	8,14	0,99
$(NH_4)_2SO_4$	2511	-1,69	-0,94	2249	1,15	0,43	2715	3,18	0,98

N Kg/ha: 0 100 200

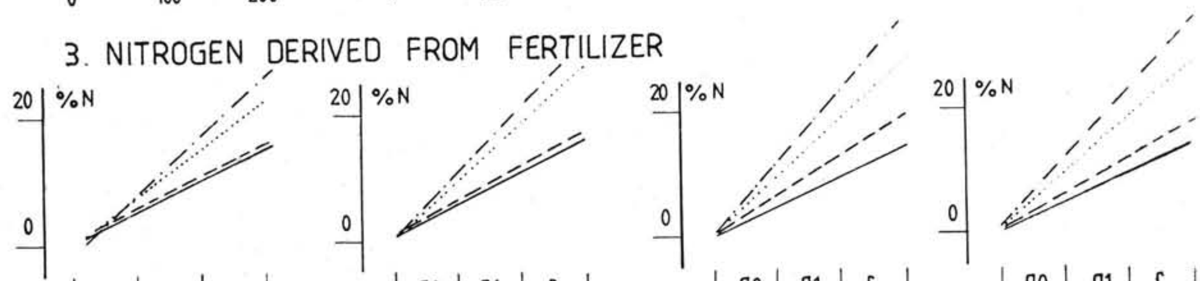
2. TOTAL NITROGEN CONTENT



	Seeds a_0	Seeds a_1	Seeds r	Heads a_0	Heads a_1	Heads r	Stalks a_0	Stalks a_1	Stalks r	Leaves a_0	Leaves a_1	Leaves r
ˣNH_4NO_3	2,70	0,0027	0,999	1,46	0,0016	0,999	0,41	0,0046	0,984	1 92	0.0020	0 740
$NH_4^xNO_3$	2,71	0,0027	0,996	1,46	0,0011	0,999	0,45	0,0037	0,999	1,85	0 0035	0 987
$(NH_2)_2CO$	2,74	0,0028	0,978	1,44	0,0018	0,987	0,44	0,0056	0,998	1 81	0,0032	0 999
$(NH_4)_2SO_4$	2,71	0,0031	0,999	1,46	0,0016	0,999	0,49	0,0036	0,989	1,81	0,0029	0 998

N Kg/ha: 0 100 200

3. NITROGEN DERIVED FROM FERTILIZER



	Seeds a_0	Seeds a_1	Seeds r	Heads a_0	Heads a_1	Heads r	Stalks a_0	Stalks a_1	Stalks r	Leaves a_0	Leaves a_1	Leaves r
ˣNH_4NO_3	0,22	0,076	0,999	0,70	0,077	0,988	0,70	0,073	0,987	0,85	0,071	0,979
$NH_4^xNO_3$	0,59	0,075	0,991	1,60	0,080	0,943	1,00	0,093	0,984	1,18	0 087	0,973
$(NH_2)_2CO$	0,85	0,109	0,991	0,04	0,142	0,999	1,00	0,137	0,992	0,86	0,135	0,994
$(NH_4)_2SO_4$	0,03	0,139	0,999	1,57	0,156	0,985	1,27	0,170	0,992	0,92	0,159	0,979

N Kg/ha: 0 100 200

Fig. 1 — Sunflower seed, head and stalk yield and mineral nitrogen content corresponding to the nitrogen fertilization system (Fundulea, 1982—1984)

Table 2

Influence of dose and type of mineral nitrogen fertilizer on the nitrogen export from soil and fertilizer by sunflower crop (Fundulea, 1982—1984)

N kg/ha	N absorbed from xNH_4NO_3 (kg/ha)			FUE %	N absorbed from $(xNH_2)_2CO$ (kg/ha)			FUE %	N absorbed from $(xNH_2)_2CO$ (kg/ha)			FUE %	N absorbed from $(xNH_4)_2SO_4$ (kg/ha)			FUE %
	Nt	Nf	Ns		Nt	Nf	Ns		Nt	Nf	Ns		Nt	Nf	Ns	
								Seeds								
0	66.9	0.0	66.9	0.0	66.9	0.0	66.9	0.0	66.9	0.0	66.9	0.0	66.9	0.0	66.9	0.0
100	72.9	6.0	66.9	6.0	76.1	7.1	69.0	7.1	73.3	9.9	63.4	9.9	73.1	10.2	62.9	10.2
200	72.0	10.9	61.1	5.5	70.5	10.6	59.9	5.3	69.3	15.2	54.1	7.6	71.1	19.7	51.4	9.9
								Heads								
0	30.8	0.0	30.8	0.0	30.8	0.0	30.8	0.0	30.8	0.0	30.8	0.0	30.8	0.0	30.8	0.0
100	43.2	4.3	38.9	4.3	41.5	5.4	36.1	5.4	46.4	6.6	39.8	6.6	42.4	8.6	33.8	8.6
200	42.0	6.5	35.5	3.3	39.6	6.4	33.2	3.2	45.6	12.9	32.7	6.4	41.4	12.9	28.5	6.4
								Stalks								
0	12.7	0.0	12.7	0.0	12.7	0.0	12.7	0.0	12.7	0.0	12.7	0.0	12.7	0.0	12.7	0.0
100	26.0	2.4	23.6	2.4	28.0	3.4	24.6	3.4	35.3	5.9	29.4	5.9	27.0	5.6	21.4	5.6
200	49.7	7.3	42.4	3.6	43.0	8.0	35.0	4.0	68.8	18.8	50.0	9.4	39.8	13.5	26.3	6.8

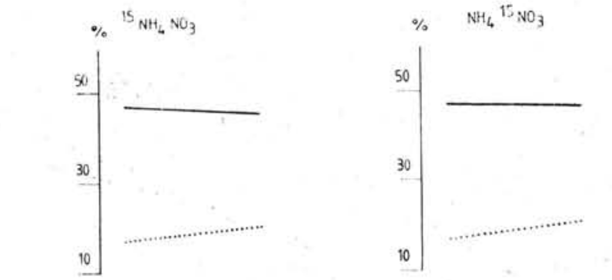


Fig. 2 — Accumulation of useful substances in sunflower seeds, depending on the mineral nitrogen fertilization (Fundulea, 1980—1984)

coming from the ammoniacal fraction by $7.1 \times 10^{-2} - 7.7 \times 10^{-2}$ % N/kg N and by $7.5 \times 10^{-2} - 9.3 \times 10^{-2}$ % N/kg N of the nitrogen from the nitric fraction as well as in an increase of the nitrogen absorbed from urea by $10.9 \times 10^{-2} - 14.2 \times 10^{-2}$ % N/kg N and especially from ammonium sulphate, by $13.9 \times 10^{-2} - 17.0 \times 10^{-2}$ % N/kg N.

The calculations regarding the nitrogen export (Table 2) point out also other traits of sunflower referring to mineral nitrogen nutrition and a certain export differentiation depending on the nitrogen source and the plant organ under study.

Among the nitrogen sources, the highest quantity is supplied by soil (over 75%), a quantity which, as compared to the total nitrogen export, increases in seeds and heads up to a dose of 100 kg/N, while a certain decrease is registered at the maximum dose. The stimulation of the nitrogen export from the soil, as a result of the mineral nitrogen fertilizer application, is correlated with the rate in the case of stalks.

The nitrogen export from fertilizers (Nf) — calculated on the basis of isotopic analyses — is generally lower as compared to that calculated by the classical method of difference and increases proportionally with the nitrogen rate. The chemical form or the nitrogen fertilizer type didn't modify significantly the nitrogen export in any of the analysed sources.

The low utilization of nitrogen from fertilizers by sunflower is expressed also by the utilization coefficient which reaches the maximum value (∾ 25%) at a dose of 100 kg N/ha.

Although the nitrogen coming from fertilizer has been found in the same percentage in all analysed plant parts, the nitrogen utilization coefficient is different : the seeds use maximum 6—10% from the nitrogen quantity applied as fertilizer, the head 4—8,6% and the stalk 3,6—9,4%.

Sunflower nutrition with mineral nitrogen is thus a very complex process, involved especially in the accumulation of useful substances (oil and proteins) in the seeds (Fig. 2).

The mineral nitrogen from fertilizer has negatively influenced the oil content, an effect proportional with the rate and accentuated especially in the treatments with urea.

The contribution of the mineral nitrogen to the increase of protein content is also evident but it depends in a lower degree on the chemical form or the fertilizer type due to the fact that the coefficient of the respective regression varies very little ($1.7 \times 10^{-2} - 1.9 \times \times 10^{-2}$ %).

CONCLUSIONS

Sunflower fertilization with nitrogen represents a more complex process, as compared to other crops. Among the elements belonging to the nitrogen fertilization system, the dose is the most important one. Sunflower crop reacts favourably to doses up to 100 kg N/ha.

The efficiency of nitrogen fertilizers depends on the characteristics of the mineral fertilizer and less on the chemical form of nitrogen. Sunflower makes a good use of the nitrogen existing in the soil and less of that from the fertilizer. The absorbtion of the nitrogen from the supplies existing in the soil is however stimulated by the mineral fertilization, but only when all the elements of the fertilization system are present in optimum.

The nitrogen absorbed from fertilizer is used primarily by seeds, but its presence leads to a decrease of the oil content.

The protein seed content increases constantly in accordance with the applied rate, regardless of the fertilizer type.

REFERENCES

Avram P., 1970, *Effect of different forms of mineral nitrogen fertilizers applied to wheat, maize and sunflower at Oradea* (in Romanian), Analele I.C.C.P.T., XXXVI B, 149—154.

Bamad D. J., 1972, *Effect of NPK ratio and application rate on sunflower seed yield and other characteristics,* Proc. Fifth Int. Sunfl., Clermont-Ferrand, France, 102.

Coculescu G., Isfan D., Hera C., Avram P., Triboi E., Moga I., Popa N., Petrovici P., Sîrbu Maria, Aurora Tutoveanu, 1969, *Fertilizer effect in sunflower on different types of soils in Romania* (in Romanian), Analele I.C.C.P.T., XXXV B, 561—581.

Hera C., 1968, *Aspects regarding the use of nitrogen fertilizer in sunflower,* Analele I.C.C.P.T., XXXIV B, 573—580.

Hera C., 1974, *Experimental results concerning the fertilizer application in sunflower in Romania,* Proc. Sixth Int. Sunfl. Conf., Bucharest, Romania, 505—520.

Horodyski A., 1974, *Recherches sur les possibilités de culture du tournesol dans les conditions climatiques de la Pologne,* Proc. Sixth Int. Sunfl. Conf., Bucharest, Romania, 77—82.

Jočić B., Sarić M., 1978, *Proucivanje ucinke mineralne ishrane suncocreta,* Sovremena Poljoprivreda, 9—10, 5—15.

Kováčik A., Ianovec I., Skaloud V., 1981, *A blueprint for maximizing yield of oil crops, Sixth* coloquium of the Int. Potash Lnstitute, 223—225.

Sarić M., 1972, *The investigation of the effect of different doses and ratios of NPK mineral fertilizers on the seed and oil yield of sunflower.* Proc. Fifth Int. Sunfl. Conf., Clermont-Ferrand, France, 95.

Rollier M., 1979, *Tournesol—fertilisation,* Cultivar, 119—77.

Toncea I., Popîrlan G. G., 1985, *Some aspects concerning sunflower fertilization* (in Romanian). Probleme de agrofitotehnie teoretică şi aplicată, VII, 1, 39—59.

ÉTUDE DES PRINCIPAUX ÉLÉMENTS DU SYSTÈME DE FERTILISATION DU TOURNESOL (*HELIANTHUS ANNUUS* L.) PAR L'UTILISATION DE L'ISOTOPE MARQUÉ ^{15}N

Résumé

La réaction du tournesol aux différentes doses d'azote, ainsi qu'aux types variés d'engrais à l'azote, a été étudiée par l'application d'engrais marqués à ^{15}N.

Cette espèce répond favorablement seulement à des doses allant jusqu'à 100 kg N/ha. L'efficacité de la fertilisation à l'azote dépends des caractéristiques de l'engrais minéral et dans une moindre mesure de la forme chimique de l'azote. Le tournesol utilise mieux l'azote existant au sol et moins intensément celui des engrais. L'absorption d'azote des réserves du sol est, toutefois, stimulée par la fertilisation minérale, mais seulement si tous les éléments du système de fertilisation sont à l'optimum.

L'azote absorbé des engrais est utilisé premièrement par les graines, le coefficient d'utilisation étant de 6 à 10%, néanmoins sa présence est accompagnée par une diminution proportionnelle de la teneur en huile. Le taux de protéines des graines augmente presque constamment, par rapport à la dose d'azote appliquée et indépendamment du type d'engrais.

Les relations entre les rendements en graines, capitules et tiges, correspondant aux systèmes de fertilisation à l'azote sont présentées graphiquement, ainsi que l'accumulation des matières utiles dans les graines de tournesol, en dépendance de la fertilisation à l'azote minéral.

ESTUDIO DE LOS PRINCIPALES ELEMENTOS DEL SISTEMA DE FERTILIZACIÓN DEL GIRASOL (*HELIANTHUS ANNUUS* L.) POR EL EMPLEO DEL ISOTOPO MARCADO ^{15}N

Resúmen

La reacción del girasol a diferentes dosis de nitrógeno, así como a diferentes tipos de abonos con nitrógeno fue estudiada por la aplicación de abonos marcados con ^{15}N.

Esta especie reacciona favorablemente sólo a una dosis de hasta 100 kg N/ha. La eficacia de la fertilización con nitrógeno depende de los característicos del abono mineral y menos de la forma química del nitrógeno. El girasol utiliza mejor el nitrogeno existente en el suelo y menos intensamente, él de los abonos. La absorción del nitrógeno de las reservas del suelo está sin embargo estimulada por la fertilización mineral, pero sólo cuando todos los elementos del sistema de fertilización se encuentran en óptimo.

El nitrógeno absorto de los abonos está empleado primeramente por las semillas, el coeficiente de utilización siendo de 6—10 por ciento, pero su presencia está acompañada por una reducción proporcional del contenido de aceite. El contenido de proteinas de las semillas aumenta casi constantemente en concordancia con la dosis de nitrógeno aplicado e independientemente del tipo de abono.

Están presentados gráficamente las relaciones entre las producciones de semillas, capítulos y tallos correspondientes a los sistemas de fertilización con nitrógeno, así como la acumulación de las sustancias útiles de las semillas de girasol en función de la fertilización con nitrógeno mineral.