T1982AGR32

STUDIES ON UPTAKE OF SOIL AND FERTILISER NITROGEN BY SUNFLOWER USING ^{15}N-TECHNIQUES.

T. VREBALOV, Z. RAJKOVIC, and D. BOGDANOVIC
Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia.

ABSTRACT

^{15}N techniques were used in three-years of field trials on a calcareous chernozem soil to examine soil and fertiliser nitrogen (N) uptake by sunflower plants at different stages of development. The maximum amount of N on the 3-year average in the above-ground plant parts was measured at the stage of seed filling; total uptake was 213 kg N ha^{-1} with 86% originating from soil reserves and only 14% from the fertiliser. The percentage utilization of the freshly applied N fertiliser was about 34%.

INTRODUCTION

Several studies have been conducted on the behaviour of chernozem soil in conditions of the semi-arid climate of Vojvodina using conventional methods of soil testing and ^{15}N techniques. It was found that (i) there is no risk of NO_3-N leaching below the zone of active root system (Rajkovic, 1978; Patwary and Rajkovic, 1979; Patwary and Rajkovic, 1980); (ii) some crops, for example corn, prefer soil N to freshly applied fertiliser N (Upasena, 1977); (iii) there is a poor response to directly applied N fertiliser on sunflower grown in crop rotations in which the other crops receive adequate amounts of N fertiliser (Rajkovic *et al.,* 1980); (iv) sufficient amounts of NO_3-N are mineralized in the course of a vegetative season to supply sunflower plants during the period of the most intensive N uptake (Rajkovic, 1978; Rajkovic *et al.,* 1980).

To be able to give a reliable recommendation for sunflower fertilisation (dose, time, method) in a given crop rotation, we decided to determine the portions of residual N and freshly applied N used in the growth of the sunflower crop. We resorted to ^{15}N techniques which enables accurate and quantitative assessment of the fate of fertilizer N applied to the soil-plant system, although a yield response to the applied N does not occur.

MATERIAL AND METHODS

Field experiments were conducted in 1977, 1978, and 1979 on calcareous chernozem soil using the sunflower hybrid NS-H-26-RM. A latin square design was employed. The basic plots of all fertilisation treatments were subdivided into microplots in which isotopically labelled ^{15}N fertilizer was applied in fall as $(^{15}NH_4)_2SO_4$, and in spring, before planting and for top-dressing, as $^{15}NH_4{}^{15}NO_3$.

All treatments received basal applications of 1 kg ha^{-1} of P_2O_5 and 100 kg ha^{-1} of K_2O. The three nitrogen treatments were: (i) 60 kg/ha of N applied completely in fall; 40 kg/ha in fall and 20 kg/ha before planting; 20 kg/ha in fall, 20 kg before planting, and 20 kg/ha for top-dressing.

Total N (Nt) in biomass was determined after Kjeldahl (Bremner, 1965) and isotopic abundance by photo-spectrometry (NOI-4). Percentage of N derived from fertiliser ($\%N_{dff}$) was calculated by the following equation:

$$\%N_{dff} = \frac{\%\ ^{15}N \text{ excess in sample}}{\%\ 15 \text{ excess in fertilizer}}$$

The amount of ^{15}N in plants was calculated by the following equation:

^{15}N in plant dff (kg ha^{-1}) = N_{dff} x yield of N in plant kg ha^{-1}).

The percentage of utilization of the applied fertilisers was calculated by the following equation:

$$\frac{\%N_{dff} \text{ x yield of N in plant (kg ha}^{-1})}{\text{Rate of fertilizer N application (kg ha}^{-1})}$$

Plant material samples for the determinations of dry matter accumulation (D.M.) and $^{14}N + ^{15}N$ uptake were taken at the 5 stages of development listed in Table 2.

RESULTS AND DISCUSSION

No differences were found between the experimental years or between the fertilisation treatments (Vrebalov *et al.,* 1980; Rajkovic *et al.,* 1980). The only exception was the first stage of growth (two pairs of leaves) which is shown in Table 1 and all the treatments discussed.

Table 1. N uptake of sunflower at the 4 leaf stage of growth.

	N in plants				
Methods of N-fertiliser application	Total N kg/ha^{-1}	N_{dff} kg/ha^{-1}	N_{dfs} kg/ha^{-1}	N_{dff} %	% utilization of applied N-fertiliser
60	0.86	0.08	0.79	9.6	0.14
40+20	0.86	0.03	0.83	4.0	0.06
20+20+20	0.95	0.01	0.94	1.1	0.02

The results obtained at the stage of two pairs of leaves differed considerably from those obtained at subsequent stages. The total N uptake was low — below 1 kg ha^{-1} — while the fertiliser N uptake was insignificant. Still the technique applied enabled us to perceive that the amount of ^{15}N were much larger in the treatments in which the entire N or its major portion was applied in the fall. It should be noted that top-dressing had not been performed at that stage. The results obtained are valuable because they explain fertiliser N uptake at early stages of sunflower growth. The uptake is low because the shallowly applied fertiliser N is distributed slowly in the soil mass.

Table 2 shows the N uptake at subsequent stage, to full maturity.

Table 2. N uptake of sunflower during growth (3-year average).

Stage	D.M. t/ha^{-1}	N %	N_t kg/ha^{-1}	N_{dff} kg/ha^{-1}	N_{dfs} kg/ha^{-1}	N_{dff} %	N_{dfs} %	% utilization of N_f
6 pairs of leaves	0.5	4.2	21	2.5	18.8	11.2	88.8	4.0
Budding	3.5	2.9	100	12.5	87.6	11.6	88.4	18.1
Flowering	8.0	2.1	167	20.6	146.5	12.3	87.6	29.4
Seed filling	14.9	1.4	213	31.5	181.5	14.2	85.8	40.0
Full maturity	12.2	1.5	178	24.3	153.4	12.9	87.1	33.8

The accumulated dry matter and N were highest at the stage of seed filling: 14.9 t and 213 kg ha^{-1}, respectively. Of the total amount of N taken up to that stage, only 14% was derived from fertiliser while 86% was derived from soil. It is interesting to note that the ratio N_{dff}:N_{dfs} was similar at all stages of growth (11 — 14:86 — 89).

The percentage of utilization of freshly applied fertilizer N increased during plant development from 4 to 40% at the stage of seed filling. The percentage was 34% at maturity.

These results explain small effects of increased doses of N on sunflower yields established in long-term permanent field experiments in the region (Table 3).

Table 3. Effect of N on sunflower yield.

Fertilization treatment	Tamis, 1965/75		Rimski Sancevi, 1967/80					
	Seed t ha^{-1}	Response to fertiliser t ha^{-1}	Seed t ha^{-1}	Response to fertiliser t ha^{-1}	oil %	oil t ha^{-1}	N %	Prot. %
No fertiliser	2.39	—	2.4	—	51.2	1.3	1.7	10.6
$N_{50}P_{100}K_{100}$	2.75	+ 0.36	2.8	+ 0.4	49.7	1.5	2.0	12.8
$N_{100}P_{100}K_{100}$	2.77	+ 0.38	2.9	+ 0.5	48.5	1.5	2.4	14.8
$N_{150}P_{100}K_{100}$	2.72	+ 0.32	2.8	+ 0.4	48.1	1.4	2.5	15.7

P = P_2O_5; K = K_2O

Thus, the dose on N should not exceed 50 kg N ha^{-1} even if long-term fertilisation is practiced. Larger doses of N are not compensated by increased contents of N, i.e., crude protein, because of concurrent increases in non-essential amino acids (Robinson, 1979). When considering these results it should not be overlooked that equal doses of N are also added to other crops in a crop rotation (wheat, corn, sugarbeet).

It may be concluded on the basis of the results of this and previously mentioned papers that sunflower uses residual N efficiently. In the case of calcareous chernozem soil in the climatic conditions of Vojvodina, it is possible to increase the amount of residual N in soil.

Sunflower growing is largely affected by N added to the preceeding crop. In Vojvodina, N requirements of sunflower may be satisfied through an adequate fertilisation of preceeding crops. Record yields of sunflower are obtained in plots which were intensively fertilised with N in preceeding years, not in those in which high doses of N are added directly to sunflower. Therefore, amounts of readily available residual N should be increased wherever possible in order to create favorable conditions for sunflower growing.

There are several reasons which make residual N more appropriate than fresh N. First of all, the sunflower plant, especially hybrid cultivars, have a well-developed root system with a strong sorptive power, enabling an intensive uptake of nutrients even from less available soil reserves. Of course, a powerful photosynthetic apparatus of the sunflower plant also helps the activity of the root system.

Residual N is uniformly distributed in the soil mass and thus available to all parts of the sunflower root system (Cooke, 1967, 1975, 1976; Greenwood, 1978). It has been concluded that not only absolute amounts of N but also its distribution in soil play an important role. Deeply placed N is more valuable because the surface layers of soil dry quickly and stay dry longer. Accordingly, the root system develops in the deeper soil layers, i.e., towards water and nutrients.

Abundance of residual N secures a steady supply of N throughout the vegetative season, synchronizing the release of residual N with the growth of plants. The risk of excess nutrients is thus avoided and the plant requirement for slow-release N sources is met.

Highest sunflower yields are obtained on fertile soils in which the residual effects of fertiliser application (in our case, N fertiliser) to other crops in the rotation benefit sunflower.

LITERATURE CITED

BREMNER, J. 1965. Total nitrogen. In: Methods of soil analysis. Part 2. Ed. Black, C.A.ASA.USA. 1149 — 1176.

COOKE, G.W. 1967. The control of soil fertility. Crosby Lockwood Ltd. London.

COOKE, G.W. 1975. Fertilising for maximum yield. Crosby Lockwood Ltd. London.

COOKE, G.W. 1976. Long-term fertiliser experiment in England: The significance of their results for agricultural science and for practical farming. *Annales Agronomiques.* Vol. 27. No 5 — 6, 503 — 536.

GREENWOOD, D.J. 1978. Influence of spatial variability in soil on mircobial activity, crop growth, and agronomic practice. In: *Nitrogen in the Environment.* Vol. 1. Ed.: D.R. Nielsen and J.D. MacDonald. New York. 213 — 222.

PATWARY, S.U. and RAJKOVIC, Z. 1979. Tracer studies on the balance and chemical distribution of applied nitrogen under different moisture regimes using lysimeter. *Plant and Soil* 52, 209 — 217.

PATWARY, S.U. and RAJKOVIC, Z. 1980. Comparative study of nitrate movement in cropped and fallowed soils at different moisture regimes. *Plant and Soil* 57, 471 — 482.

RAJKOVIC, Z. 1978. Fertilisation in intensive maize cultivation. International symposium "Efficient Use in high productive agriculture" (UNIDO & C.I.E.C.), April 27th and 28th, Vienna.

RAJKOVIC, Z., VREBALOV, T. and BOGDANOVIC, D. 1980. Method of nitrogen fertilisation and yield of sunflower NS-H-26-RM. *9th International Sunflower Conference. Torremolinos* (Malaga), June 8 — 13, p. 27.

ROBINSON, R.G. 1978. Production and culture. In: *Sunflower science and technology.* Ed. J. Carter. ASA. U.S.A. p. 116.

UPASENA, S.H. 1977. The effect of different methods of nitrogen fertilisation on the uptake of nitrogen and yield of corn. Doctors Dissertation. Faculty of Agriculture University of Novi Sad, 1 — 177.

VREBALOV, T., RAJKOVIC, Z. and BOGDANOVIC, D. 1980. Dry matter accumulation and nitrogen, phosphorus, and potassium assimilation by sunflower hybrid NS-H-26-RM. *9th International Sunflower Conference, Torremolinos* (Malaga), June 8 — 13, p. 26.