DYNAMICS OF MINERAL NITROGEN IN SOIL AND ITS EFFECT ON YIELD, SEED QUALITY AND NITROGEN TAKING OUT BY SUNFLOWER CROP

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Summary: To examine dynamics of mineral nitrogen from soil and its effect on yield and quality of seed and nitrogen taking out by sunflower crop, long-termed field experiment was conducted. Nitrogen doses were: 0, 50, 100, 150, 200 and 250 kg/ha, with and without ploughing under of harvest residues. Nitrogen fertiliser was applied to a previous crop, but there was no application at sunflower. Dynamics of residual NO_3-N in soil under sunflower has a tendency to reduce in the stage from the beginning of growing to flowering. The highest amount of dry matter was accumulated before flowering, while maximum accumulation was found in the stage of seed forming. The highest nitrogen taking out occurs before flowering while it is most intensive in the period from budding to flowering. Soil which was fertilised for long period with nitrogen amount above 50 kg/ha gave higher yields of seed and oil. Increased amount of residual nitrogen in soil decreased oil content.
Key words: sunflower, residual nitrogen, dry matter, nitrogen content, nitrogen taking out, seed yield, content and yield of oil.

Introduction

In order for us to optimise the exploitation of high genetic yield potential of certain sunflower hybrids, it is of crucial importance to provide optimal conditions of nutrition. Available nitrogen is the key nutritive element in increasing of the productivity plants. It is, therefore, vitally important to control the availability of N content by making sure it is present in the soil and plant during the growing season. The objective behind this paper was to determine the optimal quantity of residual N for maximum oil and seed yields as well as how yields and seed quality are influenced by the dynamics of soil residual N.

Material and method

The dynamics of mineral nitrogen in the soil and its effect on yield and quality of seed and nitrogen taking out by sunflower crop was studied in 1992 and 1993 at stationary field trials applying the increasing doses of nitrogen fertiliser at experimental field of the Institute of Field and Vegetable Crops in Novi Sad. The trial was established in four replications according to random block design. In the period when the study was conducted, the crop rotation included wheat - maize - sunflower. Fertilising variants of preceding crop:

1. 0 kg/ha + HR + 50 kg/ha N every third year
2. 50 kg/ha + HR + 50 kg/ha N every third year
3. 100 kg/ha + HR + 50 kg/ha N every third year
4. 150 kg/ha + HR + 50 kg/ha N every third year
5. 200 kg/ha + HR + 50 kg/ha N every third year
6. 250 kg/ha + HR + 50 kg/ha N every third year
7. 0 kg/ha
8. 100 kg/ha
9. 200 kg/ha

Potassium and phosphorus amounts were same at all variants: 80 kg/ha of P_2O_5 and K_2O. Mineral fertilisers were applied to maize according to exactly determined plan. No mineral fertiliser was applied to sunflower. On the variants 1-6, harvest residues (HR) were plown under and every third year, after wheat, 50 kg/ha of N was added. Harvest residues were removed from the variants 7, 8 and 9. Sunflower hybrid NS-H-45 was used in the trial. The sowing was performed manually at the distance 70 x 30 cm (47619 plants/ha) in the second decade of April. Nitrogen content was observed up to the depth of 120 cm according to layers of 30 cm in the following five phases: before sowing, budding, full flowering, seed forming, full maturity. The concetration of nitrates was measured spectrophotometrically at the UV spectrum 210 nm, by method of *Scharpft and Wehrmann (1977).* We analysed fresh samples, at field moisture level. The samples of plant material, taken at different stages of plant development (budding, full flowering, seed forming, full maturity), were first dried at room temperature and then at 80 °C prior to the analysing. Separate samples were dried at 105 °C for the calculation of absolutely dry matter weight. Total N in plant material was determined by colorimetry on *Kjeldahl* digests. Oil content of seeds was measured on *NMR* analyser.

RESULTS

Dynamics of soil mineral N

The highest amounts of residual mineral N in the soil were found in the period before sowing *(Figures 1 and 2)*. In other words, N applied to preceding crops was partly immobilised into the organic matter of the soil and then intensively mineralised under the favourable conditions of the spring. Similar results were obtained by *Bogdanović (1985)* on the same trial. During the vegetation period, the amount of mineral N was on the decline, due to more intensive uptake on the part of plants and their increasing requirements. This trend was observed for the period between the beginning of vegetation period and antithesis. Highest demands for N were observed in the period between budding and flowering, which is the period of the greatest accumulation of dry matter and the greatest utilisation of soil mineral N. The lowest amount of residual NO_3-N was registered in the period of antithesis, which corroborates the results of *De Georgia et al. (1990)*. After flowering, there came an increase in the amount of soil mineral N, due to reduced plant N requirements. This also validates the results of the above mentioned study. Mineralization was greater than consumption, which brought about an increase in the amount of residual NO_3 in all variants of the trial. Weather conditions were largely influential on the dynamics of mineral N in the period of full maturity. The conditions in 1992 were extremely unfavourable to mineralization, hence a drastic fall in the amount of mineral N. In some of the soil layers of certain trial variants, mineral N was found only in traces, the primary cause of which was soil humidity below the level of permanent wilting. This is in agreement with the results of *Rajković(1978)*, who argues that humidity below that of wilting prohibits microbiological activity. In 1993, conditions more favourable to mineralization produced a tendency towards an increase in the amount of soil mineral N in the period from flowering to full maturity.

Dynamics of dry matter accumulation

The dynamics of dry matter accumulation proved to be variable and dependant on the phase of development and amount of soil residual N (*Fig 3*). On average, 23,9% of the total amount of dry matter was formed in the budding stage. The greatest amount of dry matter was accumulated in the period between emergence and flowering. In this period, 90,1% of the total amount was accumulated, most intensively from budding to flowering. The latter period accounted for 66,2% of the total amount of dry matter. In our researches, the maximum amount of dry matter was formed in the phase in which forming of seeds takes place. The amount of dry matter accumulated from flowering to this phase was low, averaging 9,9%. In the period of full maturity, the reduction in the total amount of accumulated dry matter averaged 20% Reduction in the total above-ground plant mass in the same period is the result of drying and falling of leaves, the extent of which is such that this organ is hardly present during the harvest. In full maturity, stem accounts for 37,1%, head without seeds for 21,15 and seeds for 41,8% of the total amount of dry matter. The stem and leaf reach the maximum of dry matter accumulation in flowering.

Dynamics of nitrogen absorption in sunflower crops

Nitrogen content was shown to be dependant on: plant age, plant organ and mineral nutrition. Throughout the vegetation period, N content decreases in all plant organs apart from seeds. Our results show the highest N content to be in the budding phase. In the flowering phase, in contrast, all plant parts signal a significant decrease in N content. The most intensive accumulation takes place from budding to flowering. In this period, due to the dilution effect, plant tissue registers a decrease in N content. In the same period, the highest N content can be observed in the leaf, then, the head and, finally, the stem, which has the lowest content. Leaf N content in this phase falls within the lower and upper limits of sufficient N supply for this phase of growth described by *Kadar and Vass (1988)*. The lowest N content was registered in the seed forming phase, which is also when the production of organic matter reaches the maximum and the dilution effect can be clearly observed. Similar results were obtained by *De Giorgio et al.(1990)* and *Sfredo et al. (1985)*. In full maturity, there is a further decrease in N content in all organs except for the seed. The highest content of N was registered in seeds, after that, in the leaf and, then, in the head without seeds. The stem had the lowest content. Regarding all plant organs in the vegetation period, the highest N content can be found in the leaf in the budding stage, whereas the lowest is with the stem in full maturity. From the beginning of the vegetation period to this latter phase, N content in the leaf and stem is on the decline. In the period of intensive growth, this is caused by diluted N in plant tissue; afterwards, the reason is the transfer of N from vegetative organs into the seed.

Dynamics of N uptake from the soil by sunflower crops

The dynamics of N uptake was dependant on the phase of growth and variant of nutrition (*Fig 4*). The lowest N uptake was observed in the budding phase. From emergence to budding, the plant develops at a slower rate, since most assimilates are used for the development of the root system. An increase in soil residual N increases total N uptake. The highest amount of N is taken up by the stage of flowering. As the

N amounts added to the preceding crop rose, so did the N uptake on the part of crops. The period between budding and flowering is when dry matter, and by virtue of this N itself, accumulates most intensively. N uptake reaches the maximum in the seed forming phase. In this phase, in contrast to budding and flowering, the highest amount of N is found in the head, which must be a result of the transport of assimilates from the stem and leaf towards the head. In full maturity, various losses produce a considerable decrease in the amount of N. Accumulation of N in the stem and leaf begins with their formation and peaks in flowering. In these organs, the most intensive N uptake takes place between budding and flowering. As a result of the transport of N towards the seed, there is a significant decrease in the amount of N in these organs. *Merrien(1986)* as well as *Rodriques et al.(1992)* point out that leaves are the source of 70% of N in mature seeds. At the end of the vegetation period, nevertheless, the stem is the organ with the lowest N content, whereas the highest can be found in the seed.

Seed and oil yields in sunflower

Seed yields increased significantly with an increase in the quantity of soil residual N. The lowest yields were observed in the non-fertilised variants (*Table 1*), and all those fertilised before sowing had significantly higher seed yields. In the first year of the experiment, 100 kg/ha of N applied to the preceding crop significantly increased the seed yield. In the second year, the same was achieved with 50 kg/ha. Our researches are a complete confirmation of the results by *Merrien (1986)*,showing that sunflower supplies itself with N primarily from the soil reserves. Where these were present, mineral fertilisers were not applied; yet, the seed yield remained very high. This confirms the chernozem soil type's great capacity to provide crops with available N not only in the phases of its most intensive uptake but throughout the entire vegetation period as well. Our results also affirm sunflower's great ability to utilise N soil reserves. Finally, N nutrition increases oil yield, the maximum being with those variants of nutrition with which the maximum seed yield is also produced.

Oil content in the sunflower seed

The content of oil was also shown to be contingent on the variant of nutrition and year of examination (***Table 1***). Non-fertilised trial variants had significantly higher oil content. Incorporation of harvest residues, however, did not significantly affect the content of oil, which was not the case with weather conditions in the seed forming and seed filling stages, when any deficiency in water decreases the content of oil. This latter characteristic depends largely on the intensity of assimilation after flowering *(Blanchet and Merrien, 1982)*. Weather conditions in the post-flowering period led to a decrease in oil content.

Conclusion

Dynamics of residual NO_3-N in soil under sunflower has a tendency to reduce in the stage from the beginning of growing to flowering. In the stage from flowering to full maturity it has increasing tendency. The highest reduction of residual NO_3-N in soil occurs in the period of the most intensive production of dry matter, i. e., in the period from budding to flowering. The highest quantity of plant mass was found in the variants with the highest content of residual nitrogen in soil. The highest amount of dry matter was accumulated before flowering, while maximum accumulation was found in the stage of seed forming. Total nitrogen has a tendency to be reduced from the beginning of growing to full maturity in all plant parts, but not in seed in which nitrogen increases from the beginning of seed forming to its full maturity. Nitrogen taking out reaches maximum in the stage of seed forming. The highest nitrogen taking out occurs before flowering while it is most intensive in the period from budding to flowering. Seed is a part which takes out the highest amount of nitrogen in the stage of full maturity. The effect of residual N from the soil reserves on seed and oil yields turned out to be variable, depending on the amount of N fertilisers applied. The soil fertilised over a long period of time with N amounts in excess of 50 kg/ha gave higher yields of seed and oil. Non-fertilised trial variants produced the highest oil content. Increased amounts of soil residual N were proven to decrease oil content in the seed.

Fig. 1 and 2. Dynamics of residual nitrogen under sunflower in 1992 and 1993

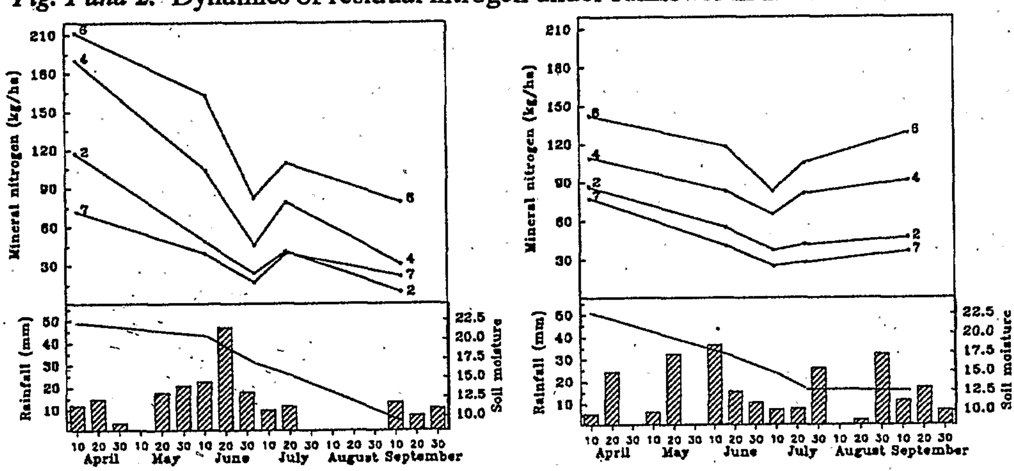

Fig. 3. Dynamics of dry matter accumulation

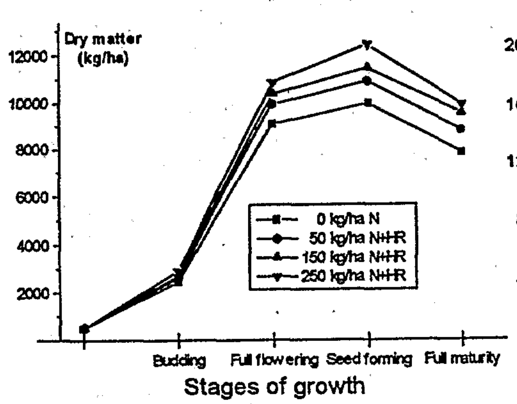

Fig. 4. Dynamics of N uptake from the soil by sunflower crops

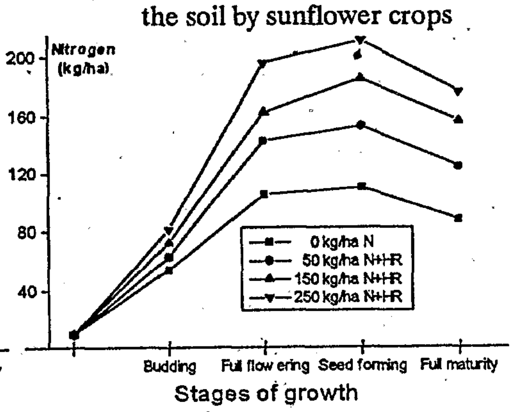

Table 1. Seed and oil yields and oil content in sunflower

Nitrogen doses	Seed yield (kg/ha)		Oil content (%)		Oil yield (kg/ha)	
	1992	1993	1992	1993	1992	1993
1. 0+HR+50 kg/ha N	2861	3437	47,52	44,51	1316	1356
2. 50 kg/ha N+HR+50 kg/ha N	3442	3978	47,30	43,79	1449	1550
3. 100 kg/ha N+HR+50 kg/ha N	4025	3914	45,16	42,25	1617	1472
4. 150 kg/ha N+HR+50 kg/ha N	4315	4039	45,10	42,40	1731	1524
5. 200 kg/ha N+HR+50 kg/ha N	3954	3943	45,38	41,79	1597	1467
6. 250 kg/ha N+HR+50 kg/ha N	4353	4077	44,58	41,99	1728	1524
7. 0	2822	3227	47,90	44,76	1203	1286
8. 100 kg/ha N	4018	3823	46,21	42,28	1652	1440
9. 200 kg/ha N	4305	3891	45,28	41,07	1736	1423
Average	**3788**	**3813**	**46,05**	**42,76**	**1559**	**1449**
LSD 5%	*321*	*161*	*1,70*	*1,04*	*114*	*73*
LSD 1%	*433*	*218*	*2,29*	*1,40*	*154*	*98*

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