Influence of N,P K nutrition on sunflower plants
3. Accumulation and transformation of sugars, proteins and oil in developing seeds

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SUMMARY

Highly productive hybrids NS-H-43 and NS-H-52 were grown in the field. The effect of NPK nutrition under specific conditions of long-term application of certain combinations of mineral nutrients was investigated. Dynamics of dry matter accumulation and transformation of sugars, proteins, and fatty acids in seed were studied.

The amount of carbohydrates initially increases then decreases, while oil concentration increases in seed during seed filling, indicating sugars as main precursors of oil synthesis.

Sucrose, as the predominant sugar, deserves special attention.

Nitrogen applied in high doses, individually and in combination with phosphorus and potassium, inhibits transformation of sugars into fatty acids and oil, causing lower oil concentration in seed of both hybrids. Effect of NPK nutrition on the dynamics of protein accumulation in seed seems to be negligible.

Effect of NPK nutrition on grain yield and oil concentration can vary significantly, depending on the genotype, dose and ratio of nitrogen, phosphorus, and potassium in the fertilizers applied. The higher grain yields in the former hybrid suggests a more efficient utilization of NPK nutrients for the synthesis of metabolites and their transformation into oil and proteins in seed.

INTRODUCTION

Numerous studies have been conducted on mineral fertilizers doses and ratios suitable for sunflower. Considering the dependence of the results obtained in these studies on local agroecological conditions, the data obtained elsewhere cannot be directly applied, before passing a thorough check.

In our country, the importance of determining optimum doses and ratios of mineral fertilizers for various crops has been recognized and it has received due attention. However, the number of investigations dealing with sunflower fertilization is rather limited. Earlier investigations, those of Madjarić and Budišić (1960), Marković and Stojanović (1966), Stojković-Džodan (1967), had indicated a significant reaction of sunflower to increased doses of mineral fertilizers, from 25% to 75%. More recent investigations (Sarić et al., 1972; Žeravica, 1972; Vrebalov, 1977; Jocić and Sarić, 1978;

Čurić, 1988) exhibited a considerably lower effect of mineral fertilizers. This was obviously due to an increased general level of soil fertility, which in turn resulted from intensive mineral fertilization, especially in the public sector, which was pursued for a long period.

Considering the importance of the problem studied, primarily from the standpoint of economy of sunflower production, we resumed the investigation started in 1967 but including in it new sunflower hybrids.

Material and Method

Experiment were conducted in a stationary field trial established in 1966 at the experiment field of the Institute of Field and Vegetable Crops at Rimski Šančevi. The trial was organized on a chernozem soil with favorable physical and chemical properties. The soil layer 0-30 cm had 0.190% total nitrogen, 20 mg/100 g soil available phosphorus and about 30 mg/100 g soil available potassium.

Certain plots in the trial, in which sunflower, wheat, sugarbeet, and maize were rotated, received fixed doses of mineral nutrients, 50, 100, and 150 kg/ha, indexed 1, 2, and 3, respectively. After 20 years of the trial, considerable changes occurred in the contents of mineral nitrogen and available phosphorus, a small change in the content of available potassium, and a negligible change in the content of total nitrogen. Plot size for each crop was 2 ha. After each season, seed yield was registered for each nutrition variant and each sunflower hybrid. Oil concentration was analyzed on an NMR analyzer, total sugar on a HPLC liquid chromatograph, using an OPTILAB 5931 HSRI detector. In certain years, seed and oil yields per unit area were treated by the analysis of variance on the basis of the LSD test at 1% and 5%.

Results and Discussion

1. Effect of N,P, and K dose and ratio on seed and oil yield and oil concentration

Seed yield - Seed yield depended on nutrition variant, hybrid, and year. Considering the application of individual nutrients, only nitrogen affected positively the yield of both hybrids (Table 1). The importance of nitrogen fertilizer becomes clearly evident when it is combined with the other fertilizers, especially phosphorus. Potassium fertilization did not bring positive effects, no matter if applied individually or in combination with the other fertilizers. This finding was in agreement with our previous results (Ćupina and Jocić, 1972).

Table 1 - Effect of NPK doses and ratios on seed yield, oil concentration and oil yield in 1991

Nutrition rate and ratio	Seed yield (t/ha)				Oil conc. in seed		Oil yield (t/ha)			
	NS-H-43		NS-H-52		NS-H-43	NS-H-52	NS-H-43		NS-H-52	
	t/ha	%	t/ha	%	%	%	t/ha	%	t/ha	%
0	2.70	100	2.58	100	50.38	50.39	1.36	100	1.30	100
N2	3.13	116	2.74	106	50.06	50.31	1.57	115	1.38	106
P2	2.88	107	2.68	104	50.36	52.72	1.45	107	1.41	108
K2	2.71	100	2.65	103	48.09	52.02	1.30	96	1.38	106
N1P1K1	3.06	113	2.91	113	48.62	50.96	1.49	110	1.48	114
N2P1K1	3.34	124	2.81	109	48.30	51.49	1.61	118	1.45	112
N2P2K2	3.71	137	3.12	121	48.43	48.14	1.80	132	1.50	115
N3P3K3	3.49	129	3.01	117	47.09	47.78	1.67	123	1.44	111
Average	3.26		2.89		48.62	49.73	1.59		1.43	
LSD 5%	0.27		0.28							
LSD 1%	0.36		0.37							

Considering the effect of increased doses of fixed ratios of fertilizers (e.g., variants 8, 13, and 20), the hybrid NS-H-43 maintained its seed yield at the same level while NS-H-52 suffered a reduction. Different doses of phosphorus and potassium at the fixed level of nitrogen did not affect seed yield.

Regarding the reaction of the hybrids to fertilizer application, NS-H-43 was more responsive than NS-H-52; the maximum yield increases were 38% and 24%, respectively, both in fertilization variant 8. The hybrids also differed in the extent of yield reduction due to increased fertilization dose (variants 8 vs. variant 20); the former hybrid had a small reaction, the latter a considerable one, 105 kg/ha and 395 kg/ha, respectively.

Oil concentration - Oil concentration in sunflower seed depended on nutrition variant and hybrid (Table 1). The highest concentrations were obtained in the check variant, 59.96% and 50.17% for the respective hybrids. The application of individual fertilizers tended to reduce oil concentration, especially nitrogen.

In the fertilized variants, highest oil concentrations were registered in the variants with lowest nitrogen doses, irrespective of the doses of the other two elements (Variants 1, 9, and 10).

Oil concentration decreased with the increase in fertilizer dose.

On the average for all fertilization variants, NS-H-43 had a higher oil concentration than NS-H-52, by 1.71%. As the corresponding difference in the check plot was

negligible, it was evident that fertilizer application affected oil concentration more in NS-H-52 than in NS-H-43. In 1991, however, the former hybrid had a higher oil concentration than the latter, which indicated that the increased humidity stimulated oil synthesis in NS-H-52.

2. Dynamics of sugar and oil transformation during sunflower seed forming and filling

As a result of high intensity of photosynthesis, sunflower leaves form sugars which are transported into seeds. During seed forming and filling, these sugars are transformed into oil (Chopovick, 1974). According to Popov (1967), the amounts of mono- and disaccharides go down and oil synthesis intensifies as sunflower seeds mature. To synthesize 1 g of oil, 3 g of sugar are needed.

The graph (Figure 1) shows the dependence of sugar transformation into oil during seed forming and filling on the dose and ratio of N,P, and K nutrients. The dynamics of sugar transformation was followed after pollination, at 7-day intervals (on July 23, July 30, August 6, August 13, August 20, August 27, and September 3, 1990), in the fertilization variants shown in Figure 1.

Conclusions

The results obtained showed that the high nitrogen doses inhibited the sugar transformation into oil in sunflower seeds. Nitrogen stimulates the synthesis of nitrogen-based compounds (proteins) but inhibits the synthesis of oil. Furthermore, the results indicated that the high nitrogen doses delayed the total transformation of sugars into oil to 4-5 weeks after pollination. The individual application of phosphorus or potassium tended to intensify sugar transforamtion into oil. It was observed that the transformation did not commence immediately after pollination but some time later. It is an indication that constituting compounds of seed cells are first to be formed and reserve compounds follow.

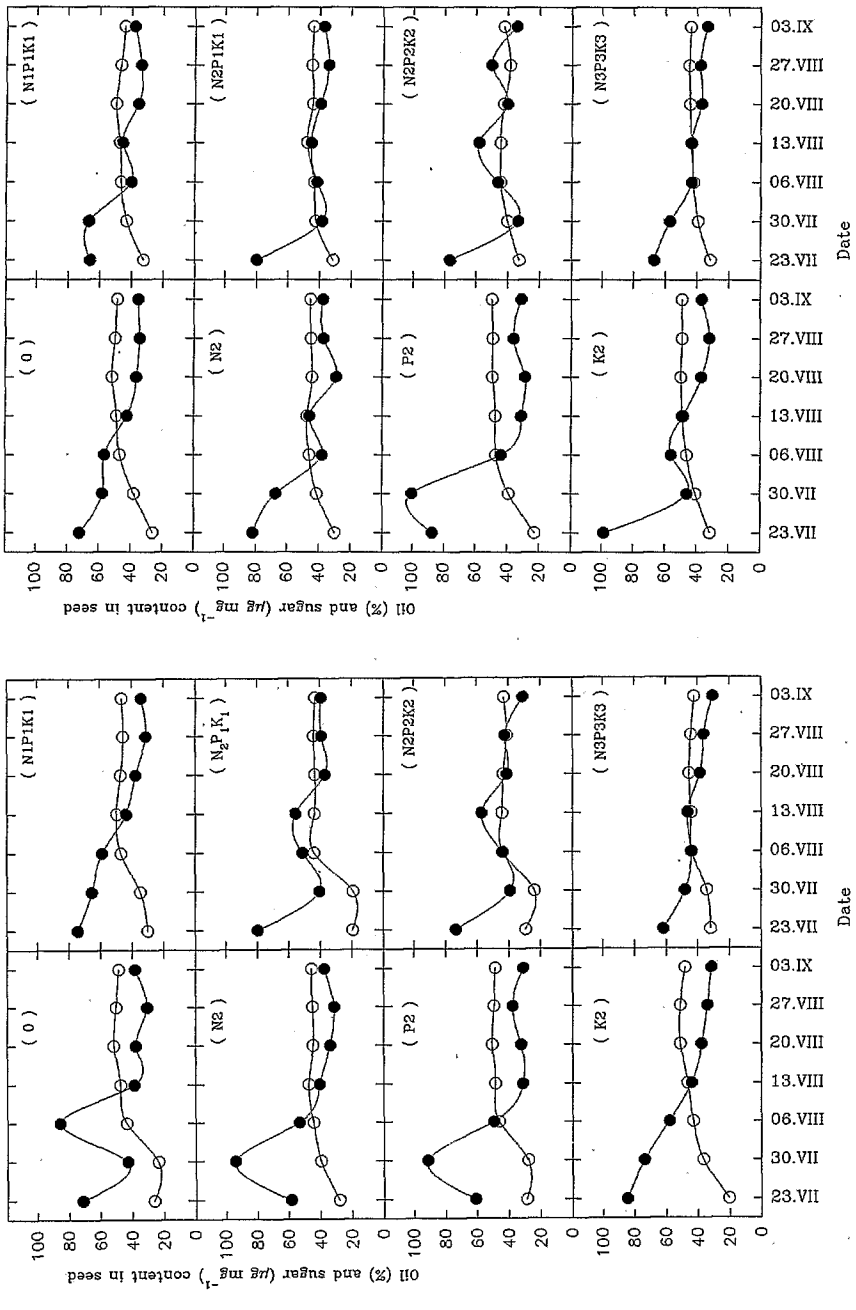

Figure 1. Oil (○ , %) and sugar (● , $\mu g\ mg^{-1}$) content as a function of mineral nutrition for NS-H-43 (A.) and NS-H-52 (B.) hybrid.

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