Influence of N,P,K nutrition on sunflower plants.
2. Transport and accumulation of assimilates in the ageing leaves.

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SUMMARY

The effect of N,P and K nutrition on sunflower (*Helianthus annuus* L.) hybrids NS-H-43 and NS-H-52 was studied. Plants were grown in the field under specific conditions of mineral nutrition, established by the long-term application of defined combinations of mineral nutrients.

Contents of total carbohydrates as well as the most abundant components (sucrose, glucose, fructose, raphinose etc.) were measured in ageing sunflower leaves, during the reproductive stage of plant growth by the HPLC method. The most significant changes were observed in 25th leaves at the stage of anthesis for both examined hybrids. The lowest level of carbohydrates was observed in leaves sampled from plants that were grown on the soil deprived of NPK nutrition (control). The application of N1P1K1 combination of mineral nutrients had the most favourable effect on carbohydrate content in analyzed leaves and on seed yield of both hybrids.

INTRODUCTION

Nitrogen deficiency usually limits growth of crops under field conditions, but the precise mechanism of this process is not clear. In general, N deficit reduces leaf area development to a greater extent than the rate of photosynthesis in leaves (Watson, 1952).

Some authors suggest that the initial effect of nitrogen stress upon growth may act through a change in water relations rather than through its effect on photosynthesis (Radin and Boyer,1982).

There are two components of growth reduction by N stress, first is a reduction in leaf elongation, second is a decline in the rate of dry matter accumulation, as described for other plant species that were stressed by N and P deficiency (Watson,1952)

In this work we investigate the influence of N, P and K nutrition on dry mass of plants and accumulation of carbohydrates in the ageing leaves of sunflower hybrids that were grown in stationary field experiment.

Material and methods

Plant culture : The object of investigation were two NS-sunflower (*Helianthus annuus* L.) genotypes :hybrids NS-H-43 and NS-H-52.

Experimental conditions :Plants were grown in the field under specific condition of mineral nutrition, established by the long-term application of defined combinations of mineral nutrients. There were 19 combinations of 3 mineral nutrients (N, P_2O_5, and K_2O) in four concentrations (0, 50, 100, and 150 kg ha^{-1}) In this experiment plants were sampled from eight trial plots (230 m^2 each) with the following nutrient combinations applied: control (0), 100kg N/ha (N2), 100kg P_2O_5/ha (P2); 100kg K_2O/ha (K2); 50kg N, 50kg P_2O_5, and 50kg K_2O/ha (N1P1K1); 100kg N, 50kg P_2O_5, and 50kg K_2O/ha (N2P1K1); 100kg N, 100kg P_2O_5, and 100kg K_2O/ha (N2P2K2); 150kgN, 150kg P_2O_5, and 150kg K_2O/ha (N3P3K3). Dry mass of plants and separately, of leaves, stems, receptacles and seeds was determined in air-dried samples, in five stages of plant development: 10-12 leaves stage, flower bud stage, flowering stage, milk maturity and stage of physiological maturity. Separately, samples of 20th and 25th leaf counting from the base were collected and analyzed for the content of soluble carbohydrates in several stages of plant development, starting from the stage of flower bud (Sakač et al, 1992).

Carbohydrate analysis : Quantitative and qualitative composition of carbohydrates were determined by the HPLC method (HPLC system OPTILAB 5931 with an HSRI detector) (Van Riel, 1986; Tecator Application Note, 1982-83). Samples of plant material, leaf discs (10 cm^2) were cut, immediately frozen in liquid nitrogen, and homogenized with Polytron PT 36 homogenizer. After homogenization, the extract was centrifuged (2,500g, 10 min.) and the supernatant was injected into the HPLC, after the appropriate filtration through MILIPORE 0.45 μm filter. The results are expressed on leaf area basis.

Results

Content of soluble carbohydrates, as the most abundant photo-assimilates in leaves, depends on the genotype, leaf position and on the N, P and K availability (Fig. 1). Content of total and most abundant soluble carbohydrates was higher in the examined leaves of NS-H-43 than in corresponding leaves of NS-H-52 plants, in control and nutrient supplied plants during the generative phase of plant development. The highest values and most significant changes in the amount of soluble carbohydrates in 20th and 25th leaves were observed at the stage of flowering (90 days after sowing) in both hybrids (Fig. 2). At this stage higher concentrations of carbohydrates were detected in 25th leaves of nutrient supplied plants than in corresponding 20th leaves of both genotypes. At the stage of physiological maturity the difference is even more pronounced (results not shown). The lowest level of soluble carbohydrates was measured in the leaves sampled from the plants that were not supplied with nutrients (control). Under the influence of nitrogen nutrient (N2) carbohydrate content was increased in 25th leaf of NS-H-52 and NS-H-43 by approximately 75% and 41% respectively. Phosphorus (P2) and potassium (K2) exhibited smaller effect on carbohydrate content of leaves than nitrogen (N2). Under the influence of N1P1K1 combination carbohydrate content in 20th and 25th leaf of NS-H-52 plants increased by about 80%, N2P2K2 and N3P3K3 combinations supplied to NS-H-52 plants showed similar stimulatory effect; with NS-H-43 plants the increase in carbohydrate content in 25th leaf was smaller in N3P3K3 supplied plants (42%) than in N2P2K2 (50%) and in N1P1K1 supplied plants (73%). It is interesting to note that combined nutrients in high concentration (N3P3K3) did not affect significantly the content of soluble carbohydrates in analyzed leaves in relation to the leaves from plants that were supplied with nitrogen only (N2). It was shown that the application of N1P1K1 combination of mineral nutrients had the most favourable effect on the carbohydrate content in analyzed leaves of both hybrids.

The effect of single and combined nutrients on dry mass of leaves, stem, receptacle and seeds in the course of NS-H-43 and NS-H-52 plants development is presented in Figure 3 . In all examined cases dry mass of individual organs of NS-H-43 plants was higher compared to NS-H-52 plants. However, the increase in dry mass of plants and most organs under the influence of applied nutrients was more pronounced in NS-H-52 than in NS-H-43 plants. The exception was seed yield of NS-H-43 plants which was increased to a greater extent under the influence of applied mineral nutrients than that of NS-H-52 plants.

Discussion

The activities of carbon and nitrogen assimilatory processes are closely related to the rates of plant growth and development. Disruption in the supply of either of the nutritients can result in marked change in the assimilation of the other. Nitrogen stress involved two distinct changes in carbon utilization: starch accumulation in leaves (Radin and Eidenbock, 1986; Wilson,1975) and translocation of a large portion of available carbohydrates from leaves into the root system (Brouwer,1962), which imply a general decline in carbohydrate utilization efficiency within the leaf canopy.

Strong positive correlations have been found between the photosynthetic capacity of sunflower leaves and their nitrogen content, most of which is used for synthesis of components of the photosynthetic apparatus (Blanchet et al, 1986).

Our results show stimulatory effects of N and NPK nutrients on photosynthetic rate and photosynthetic efficiency of the examined leaves of both hybrids, especially of NS-H-43 plants (Plesničar et al, 1992). The accumulation of soluble carbohydrates in the leaves followed the pattern of photosynthesis, with most intensive accumulation in 25th leaves at the flowering stage (Panković et al, 1991) under the influence of combined NPK nutrition. Stimulatory effect of NPK nutrition, especially N1P1K1, on the content of soluble carbohydrates in the analyzed leaves was more pronounced in NS-H-52 than in NS-H-43 plants. In accordance to that dry mass of plant parts above the ground was increased under the influence of mineral nutrition, more in NS-H-52 than in NS-H-43 plants.

Observed differences in carbohydrate content between the analyzed leaves of NS-H-52 and NS-H-43 plants are partly caused by the difference between the number of leaves on NS-H-52 plant (in average 31.9) and on NS-H-43 plant (in average: 28.6). This indicates the possibility of apparently "younger" leaves (20th & 25th) of NS-H-43 plants behaving more like sinks, while "older" leaves (20th & 25th) of NS-H-52 plants behave more like sources of assimilates (Huber, 1989). In all cases, however, seed yield was higher in control and more so in nutrient supplied NS-H-43 plants than in corresponding NS-H-52 plants. This suggests better utilization of mineral nutrients by NS-H-43 plants on one hand, and more efficient transport and transformation of photoassimilates into the oils and proteins of NS-H-43 seeds on the other (Ćupina et al, 1992).

CONCLUSIONS

- The content of soluble carbohydrates was higher in ageing 25th leaves (0.2 - 0.9 mg/cm^2) than in corresponding 20th leaves (0.1 - 0.7 mg/cm^2) in control and nutrient supplied NS-H-43 and NS-H-52 plants. Maximum carbohydrate content in leaves was detected in both hybrids at the stage of plant anthesis.
- Carbohydrate content and dry mass of leaves and other plant parts were higher in NS-H-43 plants than in NS-H-52 plants in all examined cases.
- The increase in carbohydrate content of leaves and dry mass of plants under the influence of applied nutrients was more pronounced in NS-H-52 than in NS-H-43 plants. Content of soluble carbohydrates in leaves was the highest in plants supplied with different NPK combinations.
- The application of N1P1K1 combination of mineral nutrients had the most favourable effect on carbohydrate content in analyzed leaves and on seed yield of both hybrids.

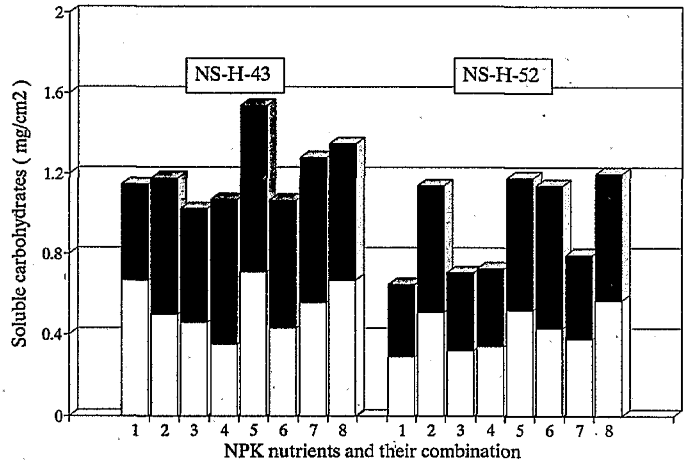


Figure 1. The effect of N,P and K availability on the content of soluble carbohydrates in the 20th (white) and 25th (black) leaf of NS-H-43 and NS-H-52 hybrids.

1-Control; 2-N2; 3-P2; 4-K2; 5-N1P1K1; 6-N2P1K1; 7-N2P2K2; 8-N3P3K3

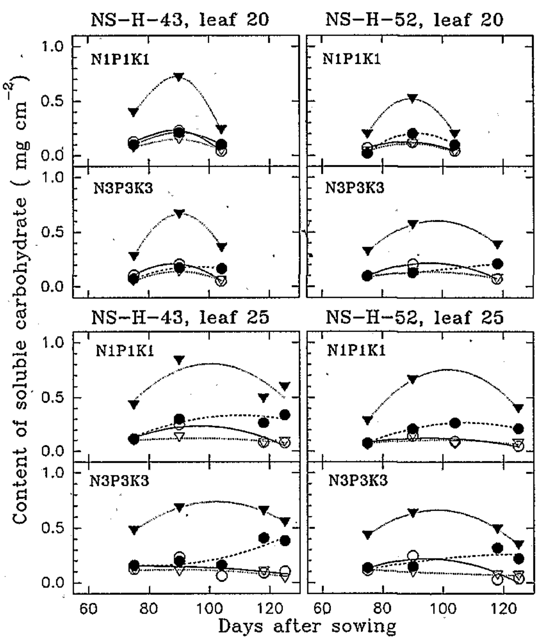
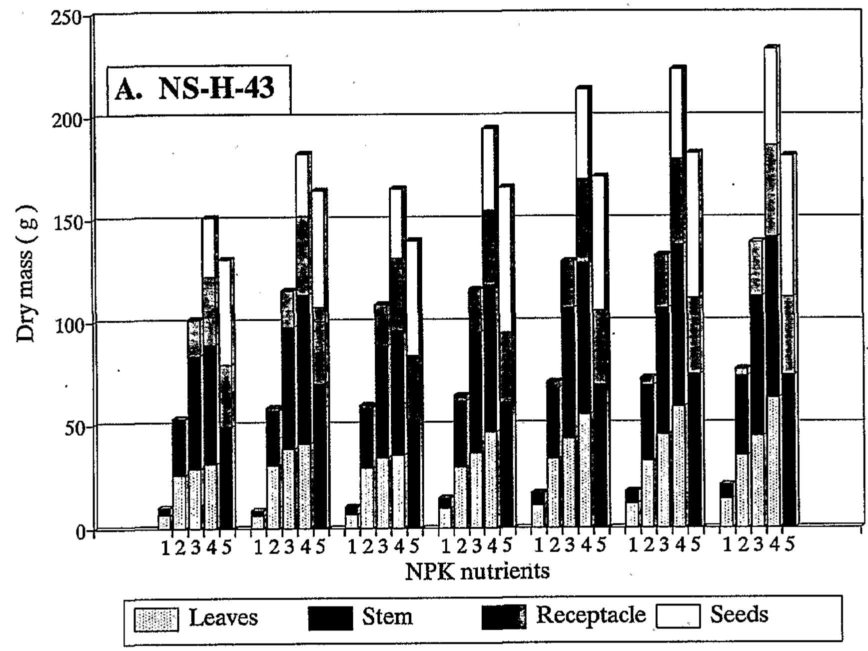


Figure 2. Influence of N,P,K nutrition on the content of total soluble carbohydrates (▼), glucose (●), sucrose (▽) and fructose (○) in the 20th and 25th leaf of NS-H-43 and NS-H-52 hybrids in several stages of plant development.



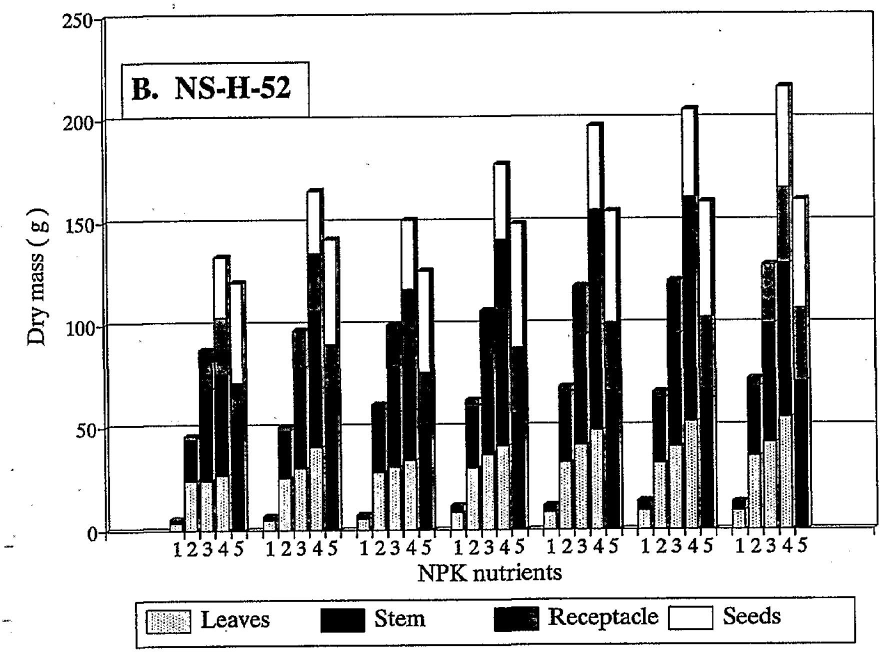


Figure 3. The effects of N,P,K nutrients on dry mass of leaves, stem, receptacle and seeds in several stages of plant development (1-5; see Material and Methods).

A. NS-H-43; B. NS-H-52.

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