Dynamics of dry matter accumulation in sunflower

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ABSTRACT

This paper deals with the effect of sowing density on dynamics of dry matter accumulation in sunflower. The experiment was established on the chernozem soil, in a six-crop rotation system, in the two-factorial split-plot design. The main plots were three sunflower hybrids: NS-Dukat, NS-H-111 and NS-H-103. The subplots were six densities: 30000, 40000, 50000, 60000, 70000 and 80000 plants per hectare. The dynamics of dry matter accumulation and the distribution of dry matter among the various plant organs were dependent on competition between the plants. The largest amount of dry matter was accumulated by the flowering stage, while the peak of accumulation occurred 30 days after the flowering. The period of the most intensive dry matter accumulation was from budding till flowering.

Key words: dry matter – stand density – sunflower.

INTRODUCTION

Since sunflower hybrids differ in plant height, number, size and position of leaves, lodging and disease resistance, vegetative space, nutrient and water uptake as well as photosynthetic activity, it is necessary to establish optimal plant density for each hybrid. Different sunflower hybrids react differently to the environmental conditions. This leads to a different realization of yield potential.

Control of dry matter distribution between different plant organs is the basis for crop yield (Wardlaw, 1990). Special conditions for nutrient uptake, its distribution between different organs, and photosynthesis efficiency are created under the influence of different vegetative space and plant number. This is one of the causes of differences in sunflower yield in the same agro ecological conditions (Hall et al., 1990). Villalobos et al. (1992) found that, in order to create a model of crop growth, it is necessary to have a knowledge of assimilate distribution between plant parts and how the environment affects dry matter distribution and yield.

It was found that semi-dwarf sunflower hybrids had a higher dry matter content in head and a lower one in the stem, when compared with the hybrids with the standard height (Maid and Schneiter, 1988). No differences were observed in total dry matter accumulation in the hybrids of different heights, although taller hybrids formed a larger amount of dry matter.

There is increased competition between plants at high stand densities. As the competition between plants should be decreased in order to promote efficient use of water, nutrients and sunlight, it is necessary to determine optimal plant density in order to maximize the expression of the yield potential.

The aim of this experiment was to determine optimal plant densities for sunflower hybrids with a high yield potential which differ significantly in their growing habits.

MATERIALS AND METHODS

Field experiments were conducted at the Rimski Sancevi experiment field of the Institute of Field and Vegetable Crops, Novi Sad, Serbia, for three years. The experiment was established on a chernozem soil, in a six-crop rotation, following a two-factorial split-plot design. The main plot contained three cultivated sunflower hybrids: NS-Dukat, NS-H-111 and NS-H-103.

NS-Dukat is an early hybrid that matures in 90 to 95 days. The average stem height is 145 to 155 cm, the genetic potential for seed yield 4 t ha^{-1}, and the seed oil content from 47 to 49%. The hybrid is genetically resistant to downy mildew, broomrape and the sunflower moth. It is recommended for late sowing (15 May to 15 June) in fields that could not be sown before for some reason.

NS-H-111 is a medium early hybrid that matures in 105 to 115 days. The stem is firm, 165 to 185 cm tall on average. The genetic potential for seed yield is 5 t ha^{-1}, the seed oil content from 48 to 50%. The hybrid is genetically resistant to downy mildew, rust, broomrape and the sunflower moth, and tolerant to *Phomopsis*. The hybrid is adaptable to a wide range of agroecological conditions.

NS-H-103 is an experimental hybrid that matures in 120 to 130 days. The stem is firm, 90 to 100 cm tall on average. The genetic potential for seed yield is 4 t ha^{-1} and the seed oil content ranges up to 50%. The hybrid is genetically resistant to downy mildew, rust, broomrape and the sunflower moth.

The experiment subplots were six stand densities: 30,000, 40,000, 50,000, 60,000, 70,000 and 80,000 plants per hectare. Manual planting was done in early April, by placing 3-4 seeds per hill. At the stage of 1-2 pairs of leaves, the stand was thinned to one plant per hill, to obtain the desired number of emerged plants. Timely cultural practices were performed, applying the conventional technology. The experiment was conducted in four replications. The elementary plots consisted of six 10-meter rows.

Dynamics of dry matter accumulation during vegetative period of sunflower plants was observed at the main stages of the plant development:

1. 6 pairs of leaves
2. budding
3. flowering
4. seed forming
5. 30 days after flowering

Samples were taken from 12 plants (3 plants from each repetition) from the following variants: 30000, 80000 plants/ha in all three hybrids; 60000 plants/ha in NS-Dukat, 50000 plants/ha in NS-H-111 and 70000 plants/ha in NS-H-103. Average sample for each variant was used for the determination of dynamics of dry matter accumulation. Each sample was dried at 105° C, and dry matter percentage in different plant parts was determined.

RESULTS AND DISCUSSION

Dry matter accumulation dynamics varied depending on the development stage, plant density and the hybrid.

Dry matter accumulation at the stage of 6 pairs of leaves was low, and the plant density did not have any effect on plant dry matter production (Fig. 1). A higher proportion of total dry matter content in leaves compared to the stem was observed at this stage, especially in the hybrid NS-H-103 (Fig. 2). This is in accordance with the results of Horie (1977), who found predominance of assimilative distribution in the leaves at this stage.

Sunflower plants developed slower and accumulated less dry matter till the budding stage. Merrien (1986) explained this phenomenon by the fact that until the budding, most of the assimilates produced in the leaves are transported towards the root, which develops intensively during that stage. Bud appearance causes the inversion of the main direction of assimilate transportation. At that moment, the capitulum becomes the main assimilates consumer. In hybrids NS-Dukat and NS-H-111, the capitulum had a higher dry matter content than the leaves. According to Villalobos et al. (1994) and Trapani et al. (1994), this is the direct consequence of the increased competition between plants caused by increase in stand density. In contrast to NS-Dukat and NS-H-111, hybrid NS-H-103 dry matter content was higher in the leaves than in the capitulum.

The relationship between dry matter accumulation per plant and per acreage in different stand densities changed significantly at the budding stage. The highest dry matter content per plant was obtained at the lowest stand density, while the lowest dry matter content was recorded at the highest stand density. This was not the case with the dry matter accumulation per acreage, where the opposite trend was observed. Relations between dry matter production per plant and per hectare at the different stand densities are affected by competition between plants. Competition between plants starts at the stage of the intensive growth. The competition starts at the 13-14 pair of leaves stage, first in the stands with a higher number of plants, and, at the later stages of the development, in the stands with the lower plant densities. Percentage of dry matter formed at the budding stage increased with the increase in the plant density in all three tested hybrids.

The highest quantity of dry matter was accumulated from emergence till the flowering stage. Similar results were obtained by Merrien (1986). Dry matter accumulation was most intensive between budding and flowering, which is in accordance with the results of De Giorgio et al. (1990) and Sfredo et al. (1985).

Competition between plants for light, water and nutrients was more evident at the flowering stage. Till flowering, relations between plants were such as to enable the development of each plant even at higher stand densities, i.e. the plants developed faster and formed a larger quantity of dry matter at the stages of development in which the competition between plants was lower.

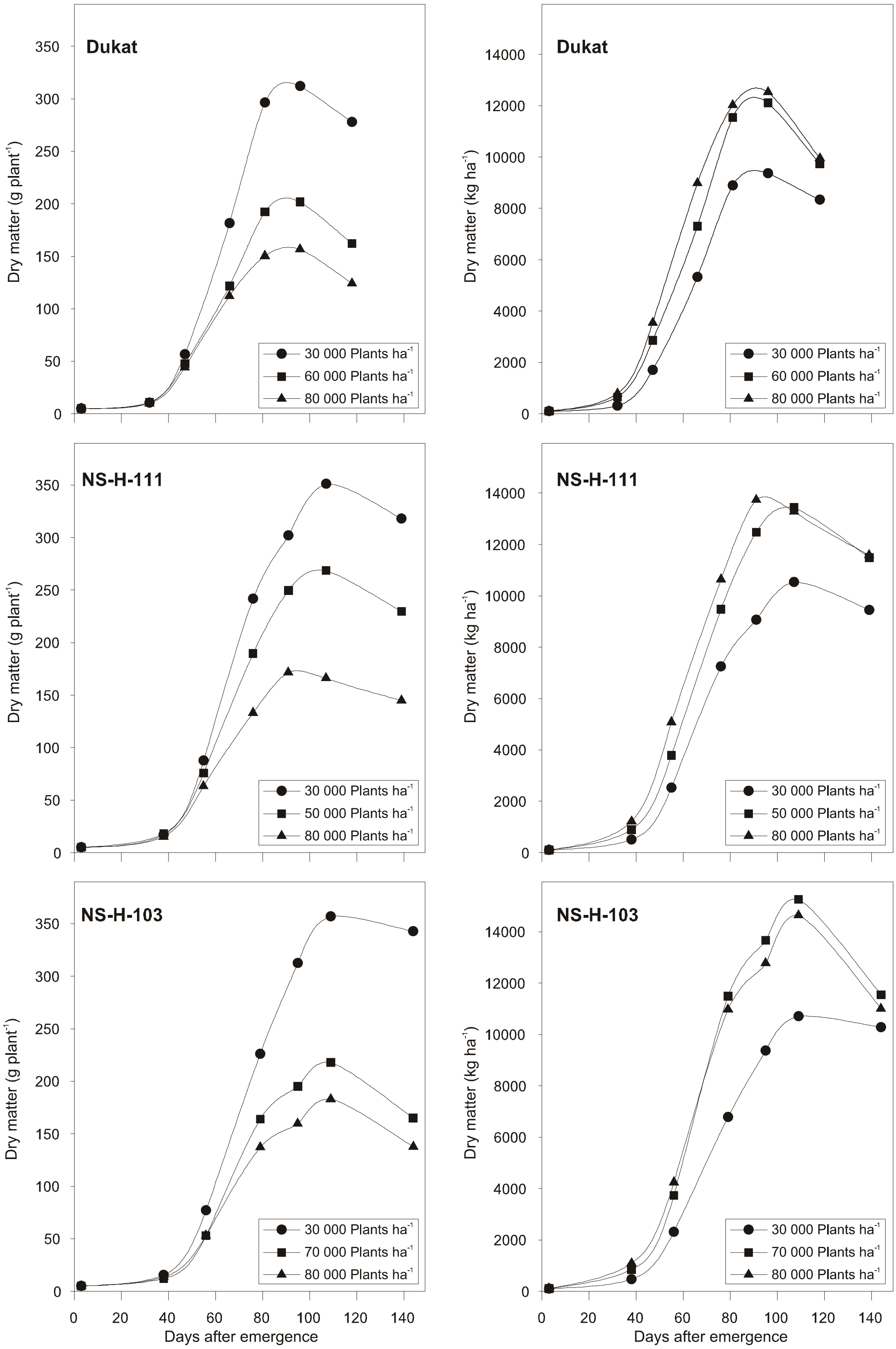

Fig. 1. Dynamics of dry matter accumulation during vegetative period of sunflower plants at different plant densities.

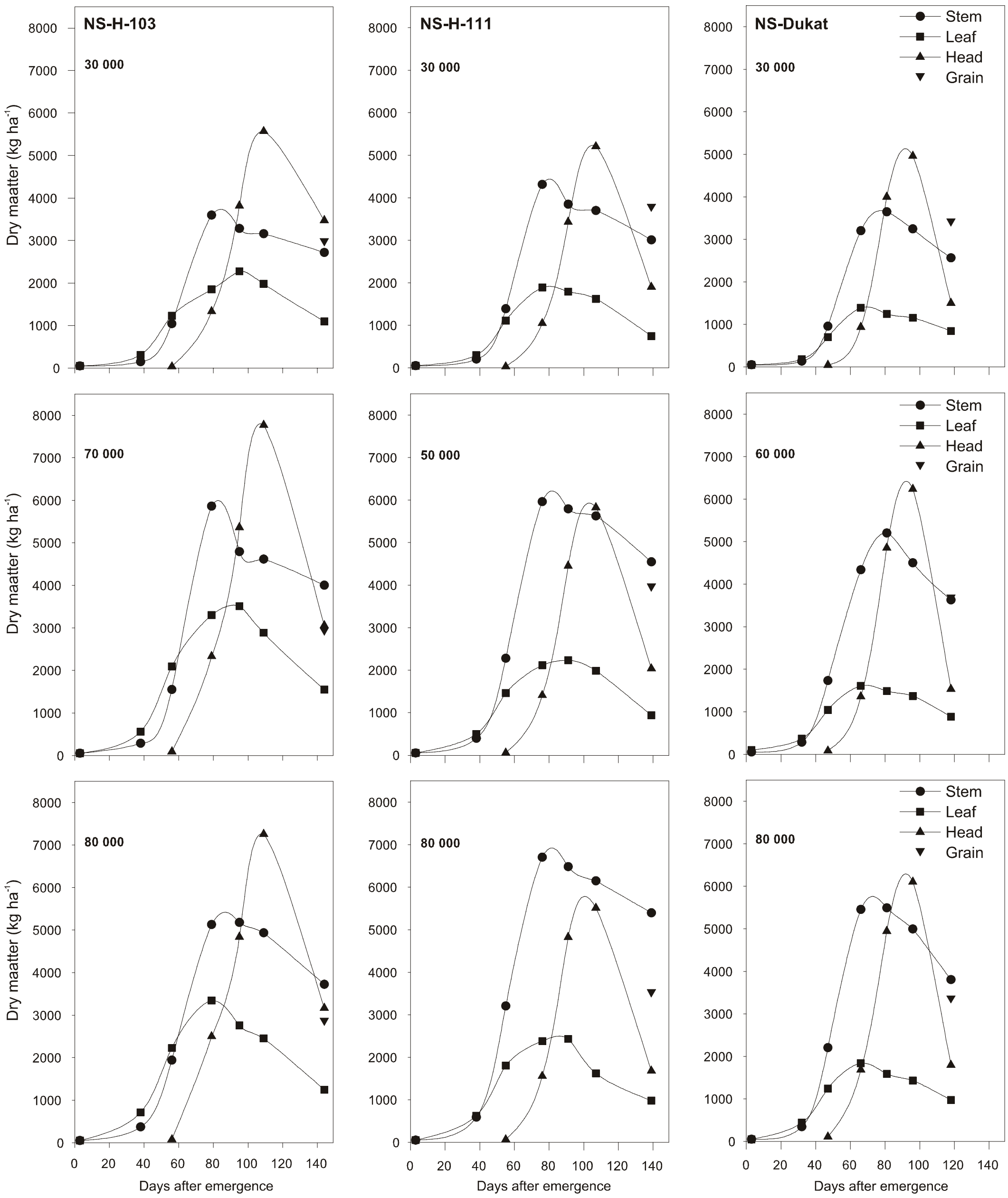

Fig. 2. Dry matter distribution between plant organs of sunflower plants at different plant densities.

Similar results were obtained by Blanchet et al. (1988). At this stage, in all three tested hybrids, the highest dry matter content was found in the stems, followed by the dry matter content in the leaves. In hybrids NS-Dukat and NS-H-111 dry matter content increased in the stem and decreased in the leaves with the increase in plant density. This is in agreement with the results of Horie (1977), Villalobos et al. (1994) and Trápani et al. (1994). In NS-H-103, the opposite trend of dry matter accumulation was observed. According to De Giorgio et al. (1990) and Sfredo et al. (1995), when there is no competition between plants caused by the size of vegetative space, the highest dry matter content can be found in the leaves, followed by the dry matter content in the stems.

Intensive dry matter accumulation continued from flowering till 30 days after flowering. This was especially the case of the hybrid NS-Dukat, in which, due to its growing habit, dry matter accumulation was not that much affected by competition. Proportion of stem in total dry matter content was still significant, but lower compared to the flowering stage. Significant decrease in dry matter, compared to the flowering stage, was observed in leaves as well. Proportion of head in total dry matter content increased significantly at the expenses of assimilates from stem and leaves, as well as current assimilation. Similar results were obtained by De Giorgio et al. (1990). Proportion of stem in total dry matter content increased with the increase in stand density, while the proportion of leaves and capitulum decreased.

Maximal dry matter content was observed at the stage of 30 days after flowering. This is in accordance with the results of Vrebalov et al. (1983). Dry matter distribution between plant organs had the same tendency as in the previous developmental stage. Similar to the results of Sfredo et al. (1985), the proportion of dry matter of stem and leaves in total dry matter content decreased, and the proportion of dry matter in the capitulum increased.

The highest dry matter content in the stem was observed in NS-H-111 at all stages of the development. The other two tested hybrids had similar dry matter content in the stem, although it was non-significantly higher in NS-Dukat. Hybrid NS-H-103 had the highest dry matter content in leaves, NS-H-111 being the second and NS-H-Dukat the third.

In our work, we have found that the dynamics of dry matter accumulation and dry matter distribution between different sunflower plant organs depended on the competition between plants, which started from the budding stage. Dry matter content per plant decreased and dry matter per acreage increased with the increase in stand density. At the initial stages of the dry matter accumulation, leaves had priority in dry matter distribution. At the later stages of the development, that priority was derived to the stem till flowering, and later on to the capitulum. In all tested hybrids, the maximum dry matter accumulation was at the stage of 30 days after flowering. The most intensive period of dry matter accumulation was from budding till flowering stage.

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