T1976PHY11

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SUNFLOWER PRODUCTIVITY IN RELATION TO COMPETITION BETWEEN PLANTS

Plant density greatly affects the realization of the potential productivity of plants. For example, increasing of densities of sunflower variety Peredovik from 5,000 to 57,000 per hectare resulted in a reduction of seed yield per head by over 3 times under conditions of ample moisture stocks in soil in 1966 and by 5 times in the arid year of 1969 (Fig. 1). However, seed yield per hectare increases with plant density up to a certain level due to a more productive utilization of the growth area resources under conditions of competition between plants. Thus, by its physiological state the optimal sunflower phenotype considerably differs from the maximum one. In particular, under minimum competition at 5000 plants/ha (area of nutrition 140 x 140 cm) the yield was almost equal through seasons differing in precipitation, while the moisture level of the soil affects the yield as plant densities increase. Hence, variation in environmental conditions and consequently managerial practices affect the yield level mainly by the change of competitive relationships between plants. Studies of these relationships are therefore also necessary for better understanding of principles of interaction between genotype and year.

Unlike other properties susceptible to competition, the reaction of sunflower stalk length to density qualitatively changes depending on which of the environmental factors is in its minimum. Though competition for illumination increased with greater densities in 1966 and 1969, the stalk length increased only in the humid year (Fig. 1). Under draught conditions with higher plant densities competition for water becomes stronger thus hampering the stalk growth. That is why the

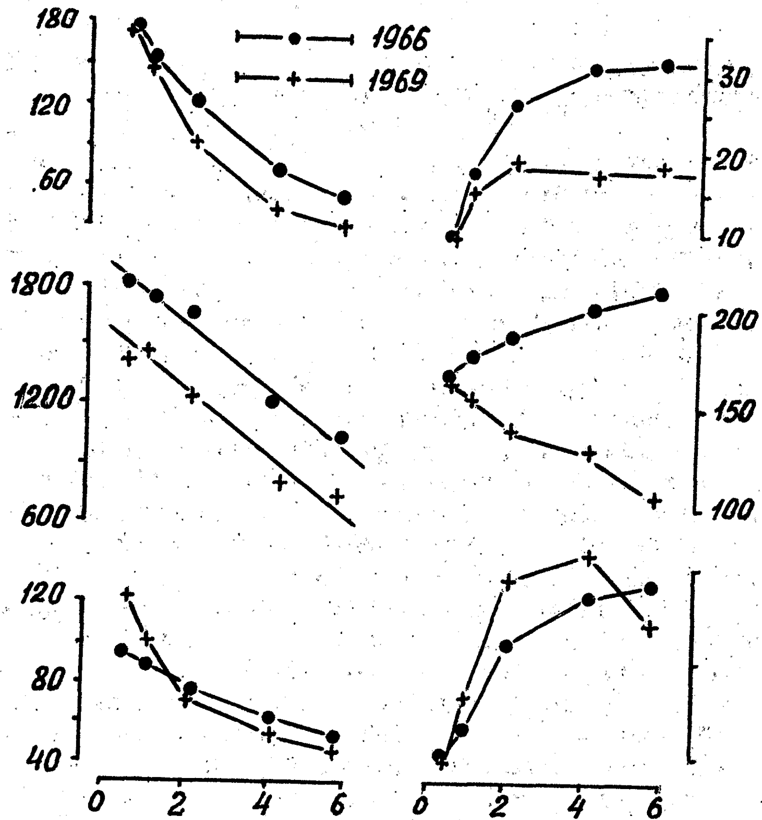

Fig. 1. Response of a sunflower plant o the Peredovik variety to heavy seeding under moist (1966) and arid (1969) conditions

length of internodes of the stalk represents an important factor in analyzing competitive situations on sunflower fields.

Table

Seed Yield of Sunflower (g per plant) in Different Seasons, Peredovik Variety

Factor	Seasons		
	1966	1973	1969
Precipitation in May - August, mm	517	261	137
Yield at plant density of 40,000 plants/ha	72.8	68.5	41.9
Yield at optimal density	53.8	68.5	89.6
Optimal density, thousand plants/ha	57	40	20

It might seen at first glance that under unfavourable conditions competition becomes stronger. But that is observed only at unchangeable plant densities (Table). However, different plant densities are optumal for different conditions. If we compare the mean productivity of plants in optimal densities we can see that a genotype is the most effectively realized under the most unfavourable conditions due to a lower rate of mutual depression between plants. This means, in particular, that at optimal densities yield increases owing to irrigation and fertilization are limited not by the genetic potential of plant productivity, but by a more intensive competition for other environmental factors as competition for water and nutrition decreases. The search for means of increasing sunflower productivity therefore necessitates an analysis of particular situations of competition in different conditions of cultivations.

When studying situations of competition it is important to find out for which factors the plants compete first of all, for the deficiency of these particular factors mostly determines the yield level. As an example we can take competition for light, water and available soil nitrogen in sunflower crops grown without fertilization and irrigation in the year of 1971, which is typical for the Krasnodar Territory in terms of precipitation. Before budding the mean LAI of the crops increased from 0.6 at a density of 2 plants/sq m to 1.06 at a density of 2 plants/sq m, that is illumination of the leaves even in very dense crops was never below the zone of light saturation of photosynthesis. However, the net photosynthetic productivity dropped in proportion to the leaf area in the fourth power, i.e. it was practically independent of the leaf area (Fig. 2). A similar pattern was observed during the period from budding to flowering when the mean LAI varied from 1.2 to 1.7 sq m/sq m. Hence, under studied conditions an abrupt reduction of photosynthetic productivity with an increased plant density cannot be explained by competition for light.

Competition for water between the plants' root systems is clearly observed at the phase of 13-14 leaves even at such densities when there are no differences in leaf areas and in biological masses of individual plants. With plant doubling per square meter the quantity of sap per one stalk decreased three times. Following the reduction of density the general quantity of sap for 1 sq m of the crop increased and was proportional to the soil moisture level determined at the level of 0-30 cm at points equally distanced from the neighbouring plants (Fig. 3). Even at this time, therefore, at optimal density the active absorption of water by sunflower roots was determined by the presence of available water in the soil. Only at the density of 2 plants/m^2

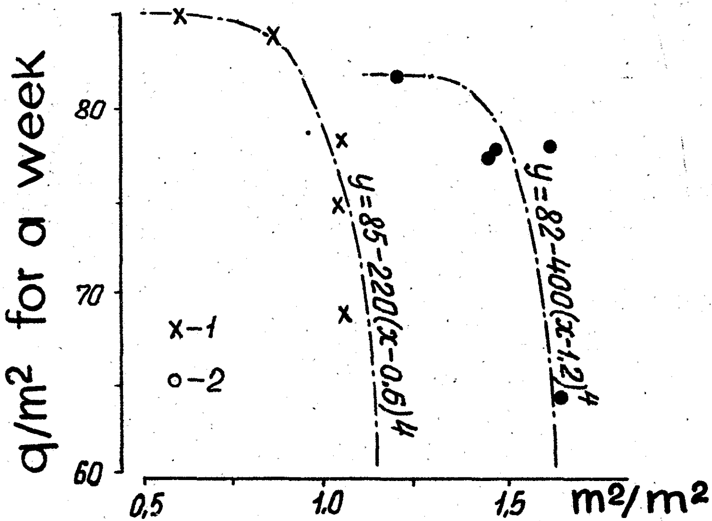

Fig. 2. Correlation between leaf area index (X, m^2, m^2) and photosynthesis pure productivity (y, g/m^2 of leaves per week) in sunflower crop during periods: 1 - before bud formation: 2 - from bud formation up to flowering

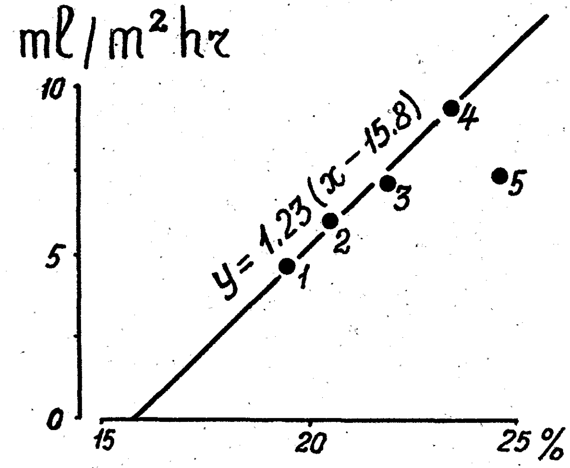

Fig. 3. Secretion of bleeding sap by sunflower roots (ml/m^2 per hour) depending on soil moisture content (%) at a stage of 13 - 14 leaves
Number of plants per 1 m^2:
1 - 11.11; 2 - 8.16; 3 - 6.25; 4 - 4.00; 5 - 2.04

the intensity of water uptake by root systems was 50% higher on average per plant than that at the plant density of 4 plants/m^2. Obviously, by that time the roots of two plants per square meter had not yet completely occupied their respective volumes of soil, and for this reason the respective point on the graph (Fig. 3) deviates from the regression line. A steadily exacerbated competition for water was observed at the budding and flowering phases.

There is an opinion that on the Kuban chernozem sunflower requirements for nitrogen are rather well satisfied, and there be no considerable competition for this element in crops of optimal density. Direct determinations have shown, however, that at the densities of 2 plants/m^2 and more nitrogen absorption calculated to full maturity in grams per plant is inversely proportional to the plant density (Fig. 4). Hence, the total nitrogen uptake from unit area of the optimal density crop is not determined by the sum of plant requirements, but by the presence of available nitrogen forms in the crop. This means, that in the available conditions competition between plants for nitrogen greatly affects the formation of yield by sunflower plants in the field. Detailed studies have shown that plants begin to compete very early for nitrogen and for water; at an optimal density plants uptake available nitrogen before the start of a critical period - flowering and embryo development, thus providing an effective utilization of soil fertility for yield formation.

Thus, under studied conditions competition for light between seedlings is less important for yield formation than competition for water and nutrients. In the majority of sunflower producing regions sunflower plants are not better provided with water than in the Krasnodar Territory. In this case it is impossible to eliminate competition for nitrogen by fertilization because this increases transpiration and therefore intensities competition for water. This situation is apparently typical for sunflower cultivated without irriga-

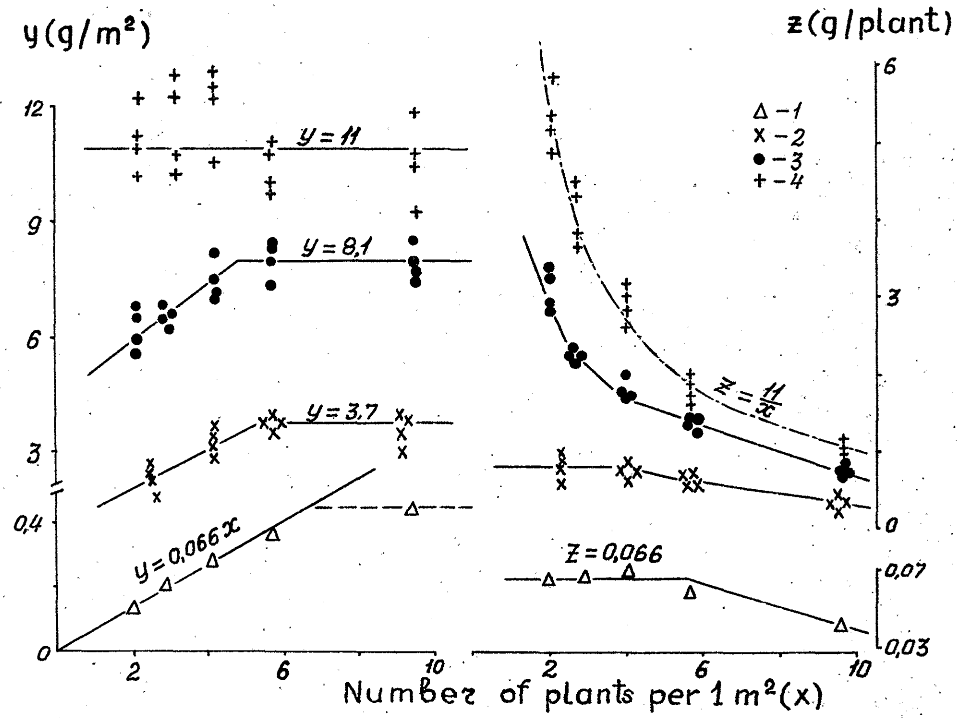

Fig. 4. Removal of nitrogen per 1 m^2 of crop (y) and per plant (z) depending on sowing density (x) at stages
1 - 13-14 leaves; 2 - bud formation; 3 - flowering; 4 - complete maturity

tion. This must be taken into account not only in developing methods of cultivation, but also in designing the ideal sunflower type for breeding. Obviously, an ideal type of plant with short and erect leaves, as proposed for rice and wheat following studies of their competition for light, cannot be considered as ideal for sunflower. But we have found that for productive sunflower genotypes those properties are obligatory which are favourable for effective utilization of absorbed nitrogen for the seed yield formation.