PHYTOTRON TEMPERATURE CONDITIONS AS A SELECTION BACKGROUND IN SUNFLOWER BREEDING FOR EARLY MATURING AND DROUGHT RESISTANCE

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SUMMARY

Phytotron study of different sunflower cultivars and hybrids response to constant and varying temperature conditions in the period of growth was undertaken.

Optimization of the temperature conditions in the phases of plant development has been made. Breeding material was assessed against the background of the effective heat sum necessary both in the periods of plant development interphases and for the whole period of plant growth.

Donors of early maturing can de developed through selection of sunflower genotypes less responding to the effective heat sum in the interphase periods of plant development.

INTRODUCTION

As it follows from the recent concepts of plant physiology, each environmental factor posesses its own variation range within the limits of which a plant manifests its potential abilities.

Study of an environmental factor should, from one side, be conducted so that to avoid its interaction with other factors, or, at least, changing its values should be made at the background of the unchanged values of the other factors, whereas, from the other side, effects of any such factor on sunflower plant development should be examined in combination with other factors.

Such studies can be conducted only in controlled environment conditions.

Not only different species, but even varieties and cultivars of one and the same species are known to need different temperature conditions and change of optimum day by night temperatures in particular.

MATERIALS AND METHODS

Study of sunflower plants response to different temperature conditions is of both, theoretical and practical significance, since 2 to 3 extra generations of especially valuable breeding

material are grown in phytotron at VNIIMK in autumn-winter--spring period.

Growing valuable seed is greatly dependent on light and temperature conditions in phytotron greenhouses and chambers.

The studies conducted are described below:

Experiment 1. Sunflower plants (cv.Peredovik) were grown in three climate chambers. The objective was to study the influence of different temperatures within a daily cycle on sunflower growth, development and performance. The following regimes were maintained: photoperiod (day) - 16hrs; night - 8hrs; irradiance from DRLF-400 lamps - 200 W/m^2; illuminance - 50klx.

Plants were grown in vegetative pots at uniform optimum nutritive and soil moisture conditions. Relative air humidity in chambers was 60-70%, temperature conditions (day/night, °C): 1) 27/22; 2) 27/27; 3) 22/22.

Experiment 2. The objective was to study sunflower growth and development in conditions of higher temperatures. Sunflower plants (cv.Peredovik) were grown in two climate chambers at uniform optimum nutritive and soil moisture conditions and irradiance (120 W/m^2). Air temperatures in chamber 1 (25/20°C) were maintained automatically within the whole period of plant growth. In chamber 2, air temperature was maintained at 40°C for 6 hours in day time, from the phase of three pairs of true leaves to the end of growth period.

Experiment 3. Plants were grown at high temperatures from the flower bud stage. Preliminarily, these sunflower plants (cv.Peredovik) were grown in conditions of uniform lighting 16/8hrs (day/night), nutrition and soil moisture, at 25/20°C. At the flower bud stage they were transferred into climate chambers with set 35/20°C temperatures.

Experiment 4. The objective was to study the influence of high temperatures in the period from flowering stage to initiation of maturing. The experiment was conducted in 4 variants with due account of soil moisture, and at known seed oil fatty acid composition (52-54% of linoleic and 30-32% of oleic acid).

Fatty acid analysis was made with 1/8 part of seed. The rest seed with embryo was then sown into vegetative pot.

The experiment was conducted in climate chambers at uniform irradiance 140 W/m^2 and 16/8hrs of day and night periods.

The first two variants involved the study of influence of optimum 25/20°C and maximum 40/30°C temperatures at the same optimum soil moisture. In two others the objective was to study the influence of the abovementioned temperatures at soil moisture defficiency (55% FWC).

Plants grown in natural conditions at 55 and 70% FWC and 21°C of average daily temperature in the period from flowering to start of maturing were used as check.

RESULTS

Effect of constant daily temperatures of 22°C was displayed in pronounced variations in growth and development of sunflower plants. As compared to other experiments, mass plant budding was observed here 6 days later (effective heat sum 697°C).

However, in these conditions the period of budding to flowering lasted only 11 days at the least effective heat sum of 187°C, whereas at constant daily temperature 27°C it lasted for 17 days at 332°C effective heat sum (Table 1).

Table 1

Effective heat sums (A) and duration in days (II) of different interphase periods of sunflower plant development at various conditions of daily thermoperiodism

Air temperature day/night, °C	Emergence to budding		Budding to flowering		Flowering to maturing		Total for vegetation period	
	A	II	A	II	A	II	A	II
27/27	683	35	332	17	605	31	1620	83
27/22	770	35	440	20	616	28	1826	83
22/22	697	41	187	11	510	30	1394	82

Subsequent development of plants in time by stages (flowering, maturing) was about the same in all the variants.

Different temperature conditions produced pronounced effect on plant growth pattern.

Plants grown at constant temperature 27°C demonstrated more extended internodes and were of 192cm height, whereas those grown at constant temperature 22°C were more compact and had 133cm height. Plants grown in conditions of daily thermoperiodism occupied the intermediatory position by their height value (175cm).

Phenological observations showed that sunflower plants start their generative development, viz. flowering and fruit setting at certain definite time, independent of presence or absence of daily thermoperiodism. However, qualitative and quantitative manifestation of this generative process bears a certain relationship to temperature conditions in this period (Table 2).

Table 2

Performance of sunflower plants, grown under different temperature conditions

Temperature day/night, °C	Effective heat sum for the growth period, °C	Amount of, (pcs/plant) flowers	Amount of, (pcs/plant) seeds	Seed weight, g/plant, %	Weight of 1000 seeds, g	Seed germinating force, %	Seed germination, %	Seed oil content, %
27/22	1619	1805	1189	59	50	83	93	46.8
27/27	1826	2402	1090	37	34	74	93	38.6
22/22	1394	1798	1174	44	38	54	85	44.9
LSD_{05}				9.9				

In the experiment where high temperatures were set in the phase of three pairs of true leaves, sunflower plants responded by decreased seed weight calculated on a per plant basis.

Experimental results showed that high temperature in combination with higher relative air humidity produced negative effect on pollen fertility. As compared to check, it decreased by 42.8%.

The experiment conducted with the objective to examine the influence of high temperatures at the stage of budding on subsequent growth and development of plants showed the following:

Air temperature day/night, °C	25/20	35/20
Number of seeds, pcs/plant	1034	1112
Weight of seeds, g/plant	52	25
Seed oil content,%	54.1	43.7

Fatty acid composition of oil, % :		
palmitic	5.1	4.6
stearic	5.4	3.7
linoleic	42.7	36.3
oleic	46.8	56.4

As it is observed in this case, rise of air temperature in the day period by 10°C results in two times less seed yield and decrease of seed oil content by 10.4%.

A regularity has been revealed showing that high temperatures promote decrease of linoleic and increase of oleic acid content in oil.

DISCUSSION AND CONCLUSION

Constant day and night temperature of 27°C produced the most favourable effect at initial stages of yield formation, i.e. when flowers were formed in sunflower plant heads.

The highest effective heat sum was recorded in this experiment both in interphase period and within the whole period of plant growth.

Average per head 2402 flowers capable to set fruits were counted in this experiment. Later, these temperature conditions showed to be not so favourable as the number of plump seeds in the head made up only 45%. Significant high weight of plump seeds (average 59g/plant) obtained in conditions of daily thermoperiodism is to be stressed. The seeds were large and demonstrated better seeding qualities as compared to those obtained in other variants without thermoperiodism.

Data from Experiment 1 show that temperatures varying within a day are more favourable for fruit setting and less favourable for vegetative growth in sunflower crop.

Daily thermoperiodism provides also better temperature conditions for oil-forming process in sunflower seeds. This is supported by the following oil percentages presented by variants of Experiment 1 and amounting to 46.8; 38.6; 44.9, correspondingly.

The fact that the highest content of saturated fatty acids was obtained in conditions of daily thermoperiodism needs special mentioning as well.

Daily thermoperiodism is not an obligatory condition for

sunflower growth and development, since at both, varying and constant daily temperatures sunflower plants form reproductive organs: they flower and bear fruits.

However, in the period of sunflower seed forming and maturing, optimum day temperatures followed by somewhat lower ones in night time created more favourable conditions for increase of plant productivity and improvement of seed quality.

High temperatures retarded sunflower growing processes even at sufficient moisture conditions and produced negative effect in the period of intensive oil accumulation, thus resulting in decreased plant productivity. Weight of 1000 seeds reduced from 60g at 25/20°C to 40g at 40/30°C; seed oil content lowered, correspondingly, from 50 to 43%.

High temperatures in combination with deficient soil moisture produced the most negative effect on plant growth.

Number of leaves per plant decreased in this variant to 15, their area, - to 4208 cm^2. Weight of 1000seeds lowered from 47 to 37g, seed oil content, correspondingly, from 48 to 39%.

High temperatures at deficient moisture in soil in the period of intensive oil formation process in sunflower plants (floral initiation to start of maturing) promoted more intensive synthesis of oleic acid (71.2%).

For designing phytotronic method of evaluation and selection of early maturing sunflower forms, tolerant to cold, with the objective of developing initial breeding material, lower temperature limit was taken as 5 to 10°C basing on literary and our research data.

This method allows to select plants in climate chambers at modelled temperature conditions. The first three selections of plants are made in the chamber with low 5-10°C temperature, the fourth one, - in the stage of budding, at temperature 15°C, the fifth, - in the period of flowering, in vegetation climate chambers at 25°C.

So, about 100 sunflower lines and accessions are examined in phytotron, annually.

Selected through this method, sunflower lines, having been evaluated by their resistance to pathogenes (broomrape, downy mildew and rots) are transferred then to Sunflower Breeding Department and to Regional Experiment Stations.