Danish scientific journal
DSJ

№39/2020
ISSN 3375-2389
Vol.2

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STRESS RESISTANCE OF ZUCCHINI PLANTS AT DIFFERENT TERMS OF SOWING IN THE CONDITIONS OF UKRAINE

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Abstract

The results of research on the influence of different sowing dates on the stress resistance of zucchini plants are presented. It was found that depending on the sowing date, the formation of the crop is influenced by weather conditions. At earlier sowing dates the plants are better provided with moisture compared to later dates. The duration of interphase periods decreased with each subsequent sowing period. The shortest interphase periods were detected during the sowing period of the third decade of May, which is 3-5 days shorter compared to the sowing period of the third decade of April. Early sowing dates contribute to the formation of larger biometric parameters. Thus, the area of leaves during the sowing period of the third decade of April in the phase of technical maturity was 14.5 thousand m^2 / ha, while during the sowing period of the third decade of May – 6.8 thousand m^2 / ha. It is also established that early sowing of zucchini has a positive effect on yield. In the Forest-Steppe Right Bank, the highest yields were obtained during the sowing period of Dec. 3. April at the level of 69.6 t / ha.

Keywords : stress resistance, zucchini, timing, biometrics, yield.

In the process of growing crops, plants are often exposed to various environmental stressors: low temperatures, drought, soil acidity, pests and diseases that significantly reduce their productivity. Thus, the relative decrease in yield caused by abiotic factors (from the potential under ideal growing conditions) can be from 60 to 82 %, depending on the culture [*21*].

The greatest crop losses are caused by droughts, soil acidity, salinization, extreme temperatures and imbalance of mineral nutrition of plants. At least 60 % of cultivated soils worldwide are deficient in vital nutrients. Combining eating disorders with abiotic and biotic stresses leads to significant losses in crop productivity [*21*].

Each crop has its own genetic potential laid down by breeders, ie the highest yield that it can provide under optimal growing conditions. Stress causes physiological depressions in the plant, which slow down growth, impair quality and reduce yields. It is estimated that the damage to plants from stress is greater than the damage from diseases and pests. To get out of physiological depression, the plant spends part of the energy to restore metabolic processes. Yield loss directly depends on the amount of energy spent on it [*6*].

Influence on plants of extreme temperatures is one of the most widespread abiotic adverse factors. In 40 % of the temperate climate of the Earth, plants are exposed to high stress temperatures. At a qualitatively new level, studies of adaptation mechanisms began after elucidating the general principles of stress signaling in plant cells, the identification of genes and the specific proteins encoded by them, involved in the development of resistance [7, 10, 22, 24, 25].

After prolonged exposure to such temperatures, external symptoms of damage develop and the body dies [13]. Even a slight decrease in temperature, which does not lead to visible damage to heat-loving plants, can cause a drop in their productivity by up to 50 %. Such plants include zucchini.

Zucchini is one of the promising vegetable crops. Zucchini belongs to the family Pumpkin (Sucurbitaceae), which combines more than 100 genera and about 400 species. Three cultivated species are grown in Ukraine : large-fruited pumpkin – Cucurbita maxima Duch.; hard-skinned pumpkin – Cucurbita pepo L. (which includes zucchini, as its bush form), nutmeg – Cucurbita moschata Duch. ex. Poir., And the other two (Cucurbita ficifolia – Pumpkin fig; Cucurbita mixta Pang. – Pumpkin mixed) are grown in other countries [5, 17, 20].

Among vegetable pumpkins, zucchini is the most resistant to cold, but it is demanding to heat. Zucchini seeds begin to germinate at a temperature of +8 ° C, + 9 ° C, and the optimum temperature for seed germina-

tion and subsequent plant growth is + 22 – + 25 °C, the minimum for growth and development +12 °C – +15 °C [4]. Zucchini plants can withstand short-term drops in temperature to + 6–10 °C, but do not tolerate frost [1]. Zucchini are plants of short daylight, grow faster at 10-12 hours a day. Shading delays plant development, yields are reduced and therefore co-sowing with shading plants or between rows of orchards is not recommended [3, 23].

Since zucchini requires high soil moisture (not less than 80 % HB) during the period of intensive growth of plants and fruits, at the beginning of the growing season and during ripening maintain moderate soil moisture (70 % of the lowest moisture content) [18]. Zucchini seeds require 48–50 % moisture to swell and germinate [2].

Studies to study the stress resistance of zucchini plants at different sowing dates were conducted in 2018–2019 in Ukraine. Field experiments were performed (randomized blocks). During the research, the scheme of the experiment was developed according to the methodology of the research case, as well as observations, accounting, calculations [8, 14, 15, 16].

Variants of the experiment were sowing dates : III decade of April, I decade of May, II decade of May and III decade of May. Option I of the decade of May was chosen for control, as it is recommended by Ukrainian scientists for this growing area. The experiment was repeated four times. The area of the accounting area is 40 m^2. The Sorcerer variety was used in the experiment.

In field experiments, the predecessor of zucchini plants was carrots. The standard technology of zucchini cultivation was used for research [12]. During the growing season, the soil was loosened and weeds were destroyed. Fertilizers were applied under fallow plowing according to the norms recommended for the growing zone : nitrogen (30–45 kg / ha), phosphorus (45–60 kg / ha) and potassium (30 kg / ha).

The direction of the rows was from north to south. At each accounting site, 10 experimental plants were marked, for which phenological observations were made, biometric measurements were performed, and so on. Field, statistical and laboratory research methods were used in the experimental work.

Conducted phenological observations, biometric measurements, accounting and analysis. Phenological observations : the beginning and mass appearance of seedlings, the appearance of the first, third and fifth true leaves, budding, the beginning of fruit formation, the beginning of technical maturity and the end of fruiting of zucchini plants. The beginning of each phenological phase was considered the time when it entered 15 % of plants, and sometimes the mass phase – when it occurred in 75 % of plants. The vast majority of observations were performed visually.

During the growing season, biometric measurements were performed: the length of the stem was determined using a ruler, the thickness of the stem was measured with a caliper, the number of leaves by counting [11], leaf area was determined using a ruler, measuring the length and width of the leaf and applying the coefficient of leaf shape according to the method of V. I. Kamchatnuy, G. A. Sinkovets [9].

Harvesting was carried out as the fruit was formed 3-4 times a week in accordance with the requirements of the current standard – “Fresh zucchini. Technical conditions – DSTU 318 – 91” [15]. The weight of the fruit from each section was determined separately by weighing, the diameter of the fruit was measured using a caliper. The yields obtained in the experiments were processed by the method of analysis of variance [19].

The timing of sowing influenced the onset of phenological phases of zucchini development (table 1). According to the calendar terms, single and mass seedlings were previously celebrated during the sowing period of the third decade of April, which is 9 and 7 days earlier than the control. In this version, the 1st, 3rd and 5th true leaves started to appear earlier. Later, single, mass seedlings and the appearance of the first, third and fifth true leaves were noted in the sowing period of the third decade of May, which is 18 days (mass seedlings) and 17 days (appearance of the 5th leaf) later than control.

Table 1

Dates of phenological phases in plants of the zucchini variety depending on the sowing date (average for 2018–2019)

Sowing period	Seed seedlings		Leaf formation		
	single	mass	1th	3th	5th
III decade April	5.05	9.05	14.05	19.05	23.05
I decade May (control)	14.05	16.05	21.05	26.05	29.05
II decade May	23.05	26.05	29.05	3.06	7.06
III decade May	31.05	3.06	6.06	11.06	15.06

Studies have shown that the timing of sowing of squash variety Chaklun had an impact on the duration of the interphase periods (table 2).

Table 2

The duration of interphase periods in plants of the squash variety Chaklun depending on the sowing date (average for 2018–2019)

Sowing period	Days from sowing to		Leaf formation, days from the stairs		
	single seedlings	mass germination	1th	3th	5th
III decade April	10	14	5	9	14
I decade May (control)	9	11	5	9	13
II decade May	8	11	3	8	12
III decade May	6	9	3	8	11

When sowing zucchini seeds at a later date, there was a reduction in interphase periods. Thus, during the sowing period of the third decade of April, the duration of the period from sowing to single and mass seedlings was 10 and 14 days, respectively, while in the control these periods were 1 and 3 days shorter. If we compare the sowing dates of the third decade of April and the third decade of May, the interphase periods were reduced by 5 days – mass germination and 3 days – the formation of the 5th leaf. For a more detailed analysis of the studied sowing dates of zucchini, biometric measurements were performed in the phase of three true leaves (table 3).

Table 3

Biometric indicators of squash plants of the Chaklun variety in the phase of three true leaves (average for 2018–2019)

Sowing period	Height of plants, cm	Thickness of stem, mm	Area of leaves, thousands m^2/ha
III decade April	14,7	4,5	80,0
I decade May (control)	13,8	4,3	64,7
II decade May	12,4	4,1	42,3
III decade May	11,9	3,8	37,6

According to the obtained data, the largest length of the stem had plants sown during the sowing period of the third decade of April – 14.7 cm, which is 0.9 cm more than the control (first decade of May). Plants sown during the sowing period of the third decade of May had the shortest stem length – 11.9 cm, which is 1.9 cm less than control and 2.8 cm less than plants sown in the third decade of April. The sowing period of the third decade of April contributed to the formation of the greatest thickness of the stem and the area of the leaves. Thus, the thickness of the stem was 4.5 mm, leaf area – 80.0 cm^2 / plant, which is 0.2 mm and 15.3 cm^2 / plant, respectively, more control.

To better study the biometric parameters of zucchini plants, biometric measurements were performed in the flowering phase of plants (table 4). Zucchini plants sown during the sowing period of the third decade of April had a longer stem length and thickness relative to the control – 64.3 cm and 25.7 mm, which is 0.7 cm and 0.1 mm more. Plants of this variant were characterized by the largest number of leaves – 24.7 pieces / plant and their area – 9.4 thousand m^2 / ha, which is 1.2 pieces / plant and 1.3 thousand m^2 / ha, respectively, more.

Table 4

Biometric indicators of squash plants of the Chaklun variety in the flowering phase depending on the sowing period (average for 2018–2019)

Sowing period	Height of plants, cm	Thickness of stem, mm	Number of leaves, pieces /plant	Area of leaves, thousands m^2/ha
III decade April	64,3	25,7	24,7	9,4
I decade May (control)	61,6	25,8	23,5	8,1
II decade May	56,6	23,9	22,8	6,9
III decade May	50,0	22,8	21,0	4,8

The sowing dates of the second and third decades of May were characterized by slightly lower biometric parameters compared to the control variant. Thus, the length and thickness of the stem were the smallest in the variant for the sowing period of the third decade of May – 50.0 cm and 22.8 mm, which is 11.6 cm and 3.0 mm, respectively, less than the control variant. The number of leaves and their area also differed significantly and was 2.5 pieces / plant and 3.3 thousand m^2 / ha less than the sowing date of the first decade of May (control).

The study of phenological phases of development of zucchini plants showed that the timing of sowing has an impact on their onset (table 5). According to the calendar terms, earlier the budding phase was observed during the sowing period of the third decade of April – 23.05, while in the control period – 29.05, which is 6 days later. At the latest, this phase was observed in the variant for the sowing period of the third decade of May – 14.06, which is 16 days later than the control variant. The same pattern was observed in the subsequent phenological phases.

The fastest zucchini products were started on the sowing period of the third decade of April – 19.06, which is 4 days earlier than the control and 11 and 18 days earlier than the sowing dates of the second and

third decades of May. The end of the growing season was later marked by the sowing period of the third decade of April and the first decade of May (control) – 15.09. Earlier, the end of the growing season was marked by the sowing period of the third decade of May – 9.09.

Table 5

Dates of phenological phases in plants of the zucchini variety depending on the sowing date (average for 2018–2019)

Sowing period	Budding	Flowering female flowers	The beginning of fetal formation	The beginning of technical maturity	The end of the growing season
III decade April	23.05	12.06	16.06	19.06	15.09
I decade May (control)	29.05	17.06	20.06	23.06	15.09
II decade May	8.06	24.06	27.06	30.06	12.09
III decade May	14.06	1.07	3.07	7.07	9.09

Thus, in the early sowing stages the phases of zucchini development occurred a little earlier than in the later sowing dates, but the end of the growing season came much later.

To better study the timing of sowing, the duration between the phase periods of zucchini plants was determined (table 6.). The shorter period of mass germination – the beginning of fruit formation was characterized by the sowing period of the third decade of May – 31 days, which is 4 days shorter than the control. This period was the longest in the sowing period of the third decade of April – 38 days, which is 3 days longer than the sowing period of the first decade of May (control). The interphase period of the beginning of fruit formation – technical maturity between the studied variants did not differ significantly and was 3 – 4 days.

An important indicator that affects the formation of the crop is the duration of fruiting. The longest period of fruiting was during the sowing period of the third decade of April – 88 days, which is 4 days longer than the control and 23 days longer than the sowing period of the third decade of May.

Table 6

The duration of interphase periods in plants of the squash variety Chaklun depending on the sowing period, days (average for 2018–2019)

Sowing period	Mass seedlings – the beginning of fruit formation	The beginning of fruit formation is technical maturity	Duration of fruiting
III decade April	38	4	88
I decade May (control)	35	4	84
II decade May	32	3	74
III decade May	31	3	65

Thus, the studied sowing dates influenced the interphase periods of development of zucchini plants. Early sowing dates contributed to the lengthening of interphase periods and increased duration of fruiting, later sowing dates contributed to a reduction between interphase periods, as well as a reduction in fruiting duration.

Biometric measurements in the phase of technical maturity showed that the timing of sowing zucchini had a significant impact on plant growth (table 7). The greatest length and thickness of the stem of the zucchini plant had during the sowing period of the third decade of April – 78.7 cm and 29.9 mm, while in the control these indicators were at the level of 72.7 cm and 28.4 mm, which is 6.0 cm and 1.5 mm respectively less.

The most leafy in this phase were the plants of the sowing period of the third decade of April – 27.8 pcs / plant, which is 1.1 pcs / plant more than the control variant. The sowing period of the third decade of April was also characterized by the largest leaf area – 14.6 thousand m2 / ha, which exceeded the control by 1.1 thousand m2 / ha.

Table 7

Biometric indicators of squash plants of the Chaklun variety in the phase of technical maturity depending on the sowing date (average for 2018–2019)

Sowing period	Height of plants, cm	Thickness of stem, mm	Number of leaves, pieces /plant	Area of leaves, thousands m^2/ha
III decade April	78,7	29,9	27,8	14,6
I decade May (control)	72,7	28,4	26,7	13,5
II decade May	63,2	23,9	23,8	8,4
III decade May	58,5	21,6	19,4	6,9

The sowing period in the third decade of May was characterized by the lowest biometric indicators both in terms of control and in relation to other studied options.

One of the main indicators in the assessment of the studied element of technology is the yield (table 9).

Table 9

Commodity yield of fruits of a squash of the Chaclun grade depending on term of sowing

Sowing period	Yield capacity, t/ha			± before control
	2018 p.	2019 p.	average	
III decade April	76,1	63,3	69,7	+6,5
I decade May (control)	65,5	60,8	63,2	0
II decade May	54,4	44,9	49,7	-13,5
III decade May	39,5	27,3	33,4	-29,8
HIP_{05}	2,6	3,2	–	

During the years of research, the sowing period of the third decade of April was characterized by the highest yield. Thus, on average, this figure was 69.7 t / ha, and the increase relative to control was 6.5 t / ha. The significance of this difference is confirmed by the results of analysis of variance. Significantly lower yields were obtained at later sowing dates of the second and third decades of May – 49.7 and 33.4 t / ha, which is 13.5 and 29.8 t / ha less than the control.

When growing a crop, an important condition for harvesting is its quality and biometric parameters. The largest number of fruits was observed during the sowing period of the third decade of April – 18.8 pieces / plant, which is 1.9 pieces / plant more than the control. The lowest number of fruits was observed during the sowing period of the third decade of May – 7.6 pieces /plant, which is 9.3 pieces /plant less than in the control (table 10).

Table 10

Biometric indicators of zucchini production depending on the sowing date (average for 2018–2019)

Sowing period	Number of fruit, p/plant	Weight of fruit, g	Fruit diameter, cm
III decade April	18,8	314	5,1
I decade May (control)	16,9	317	5,0
II decade May	12,4	322	5,2
III decade May	7,6	375	5,3

Plants sown during the sowing period of the third decade of May had the largest weight of fruit – 375 g, and in control – 317 g, which is 58.0 g less. The lowest weight of fruits was noted during the sowing period of the third decade of April – 314 g.

The diameter of the fruits did not differ significantly between the variants of the experiment. However, it was the largest during the sowing period of the third decade of May – 5.3 cm, and in the control – 5.0 cm, which is 0.3 cm less.

Studies have shown that the cultivation of zucchini in the early stages of sowing helps to prolong the interphase periods, but has a positive effect on the biometric performance of zucchini plants. Thus, studies have shown that the weather conditions that developed during the cultivation of zucchini plants at different times had an impact on growth, development and crop formation. The reaction of plants to certain growing conditions provided different levels of yield. It was found that the early sowing dates contributed to the prolongation of the interphase periods and the formation of the best biometric parameters of plants. While the late dates led to a reduction in interphase periods and the formation of smaller plant parameters. The combination of different sowing dates provides an extension of the period of receipt of zucchini products. It is established that early sowing of zucchini has a positive effect on yield. Thus, in the Forest-Steppe Right Bank the highest yield was obtained during the sowing period of the third decade of April at the level of 69.7 t / ha.

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Vol.2

№39/2020

ISSN 3375-2389

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