Evaluation of Bulgarian varieties Valencia-type peanut (*Arachis hypogaea* L.) under moderate drought conditions in the early stages of flowering and saturation of the nuts

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Abstract

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The influence of short-term drought during the phenophases beginning of flowering and saturation of the nuts on Bulgarian peanut varieties selection was tested. Changes in water exchange indices, some morphometric indicators, relative chlorophyll content and seed and fruit yields in 10-day induced drought were reported. Correlations between the researched indicators were found. The results show that the studied peanuts varieties do not use soil water efficiently, but although they are under moderate stress they do not decrease fruit and seed yields. The most effective use of soil water is observed in the Kremena variety.

Keywords: peanuts; drought stress; physiological reaction; seed yield

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) are grown predominantly in semi-drought areas of the tropics where rainfall is irregular and insufficient, causing unpredictable stress (Wright and Nageswara Rao, 1994; Reddy et al., 2003). In such areas, the volume of rainfall is often unpredictable, making planning for production difficult. Even peanuts grown with irrigation they may experience water shortages due to limited irrigation options or water quantities that are insufficient for optimal plant growth. Improving access to water and its management is practically difficult as water is a scarce resource. The climatic regions of Bulgaria where peanuts are grown, the situation with irrigation at the moment are identical. Farmers in the country very often can not determine the time of irrigation and the amount of water needed for the irrigation and irrigation regime of the culture. Despite the adaptation to the environment, peanut production is endangered when plants are subject to uneven watering during the flowering and saturation of nuts. In drought tolerant plants, this effect is reduced by physiological and biochemical changes to avoid dehydration, such as root system enlargement, reduction of leaf leaching potential, obstruction of the stomata, and osmotic regulation (Gruber et al., 2005; Kottapalli et al., 2009; Furlan et al., 2012; Padmavathi and Rao, 2013). The practical inability to fully control the irrigation process often leads to excess water. Water stress causes the accumulation of soluble sugars and increases the free maintenance of proline (Babita et al., 2010). Sugars act as osmotic compounds protecting the plants during droughts to stabilize the cell membrane (Streeter et al., 2001). However, the accumulation of carbohydrates depends on the individual responses of the plant species. Exposure to water stress is the production of reverse oxidation systems (ROS), which promotes various oxidative actions in plants (Azevedo Neto et al., 2010; Pereira et al., 2012). According to Nemeskéri et al. (2012), oxidative damage in plant tissues is alleviated by the concerted action of both enzyme and non-enzyme antioxidant mechanisms. Furthermore, in order to minimize the damage caused by the inverse oxidative action, the cells activate a neutralization process led by antioxidant enzymes that modulate their activity depending on the level of plant tolerance (Sankar et al., 2007; Akcay et al., 2010; Pereira et al., 2012). The level of damage caused by water deficiency is determined by the intensity and duration of stress as well as the phenological stage of the plant (Chaves and Oliveira, 2004).

The aim of the experiment was to evaluate the physiological response and variation of the yield of peanut varieties to the conditions of moderate stress (delayed watering).

MATERIALS AND METHODS

Plant material

Bulgarian peanut varieties created in IPGR-Sadovo for a period of 40 years have been tested to reaction to moderate stress during a two-year period. The varieties tested are Sadovo 2609, Kalina, Kremena, Orphey and Tsvetelina.

Staging of field trial

The plants of each variety were planted in 2 m wide bedding. In this way, 25-26 plants of variety were harvested in each of the variants. The control plants were regularly irrigated, with normal MPH maintained until the end of the crop's vegetation. In the so-called stressed version, in two drought-critical phenophases - the beginning of flowering and saturation of the nuts, the plants dried for a period of about 10 days. The analytical methods were applied in the two critical phases of plant development.

Analytical methods

Determination of fresh weight (FW), dry weight (DW) and relative water content (RWC) of the leaves is performed using an analytical balance. The dry weight is determined by drying the samples at 104°C for 4 hours or by reaching constant weight in three consecutive measurements (Beadle, 1993).

The leaf area (LA, cm^2) is calculated according to the formula: S = L x H x 0.60, where: L - maximum leaf length, H - maximum leaf width, 0.60 is a specific peanut leaf index.

The specific leaf area (SLA, cm^2/g^{-1}) is defined as a leaf area to a leaf biomass unit: SLA = LA/DW where: LA is the leaf area; DM is the biomass of the leaves.

The relative water content (RWC, %) is determined as percentage, according to the formula RWC, % = (FW-DW)/(TW-DM) x 100, % (Turner, 1981).

The calculation of the transpiration rate of individual leaf in mg $H_2 0/cm^2$ LA/min was made according the method of rapid towing (Georgiev and Vulchev, 1991; Kumar and Sharma, 2007).

The damage index (Id, %) of plasmalemmas in the leaf cells was determined by conductivity according to the formula:

Id = [1- (1-T1 / T2) / (1-C1/C2)] x 100,

where T1and T2 are the values recorded before and after autoclaving for stressed plants, for control (unstressed) plants C1 and C2 values (Blum and Ebercon, 1981; Premachandra et al., 1992, Kocheva et al., 2009).

Hand held digital infrared (IR) thermometer was used to measured canopy temperature depression : CTD = t^0 air – t^0 leaf, according to Blum et al. (1982), Amani et al. (1996). The analysis is carried out in a clear and quiet weather, at the same time taking data on the leaf surface temperature and the air temperature.

Relative chlorophyll content in leaf are determinated as chlorophyll content index by apparatus CCM-200 plus manufactured by ADS, Opti Science, England.

The fruit yields and seed yields by variants and varieties were reported.

RESULTS AND DISCUSSION

Beginning of flowering phase

The results of morphometric indicators and water exchange were shown in Table 1 and Table 2. The fresh weight (FW) in stressed plants ranges from 0.2214 g in Sadovo 2609 to 0.2691 g in Tsvetelina. In plants growing at optimum soil moisture, this indicator is lowest again at Sadovo 2609 – 0.2598 g and highest in Kremena - 0.3068 g. Stressed plants respond with a decrease in fresh mass compared to unstressed. The highest reduction of fresh mass showed Kremena - 38.9%, and the lowest is in variety Tsvetelina – 1.3%.

The value of dry weight (DW) in the control plants ranges from 0.0654 g in Sadovo 2609 to 0.0718 g in Kremena. Logically, stressed plants react with a decrease in dry weight, but this reaction is not the same in all varieties, Tsvetelina and Or-

Table 1. Results for water exchange, leaf morphometry and analytical methods for unstressed plants of peanut in beginning of the flowering phase

Variety	FW g	DW g	RWC %	WC g	g H_20/ g DW	Transpiration mg/cm^2/min	L cm	W cm	LA cm^2	cm^2/ g DW	g H_20/ cm^2	CTD °C	CCI
Kremena	0.3068	0.0718	90.7	0.2342	3.40	0.172	5.20	3.01	9.49	137.04	0.0250	-3.97	25.12
Tsvetelina	0.2727	0.0658	92.2	0.2068	3.19	0.153	4.86	2.91	8.50	131.29	0.0244	-3.63	23.01
Sadovo 2609	0.2598	0.0654	89.7	0.1944	3.06	0.211	4.68	2.93	8.36	131.12	0.0237	-3.31	23.75
Orphey	0.2786	0.0679	92.6	0.2108	3.25	0.141	4.87	2.94	8.66	133.37	0.0245	-3.22	24.11
Kalina	0.3042	0.0710	91.3	0.2332	3.39	0.160	5.11	3.10	9.82	142.55	0.0238	-3.04	19.48

Table 2. Results for water exchange, leaf morphometry and analytical methods for stressed plants of peanut in beginning of the flowering phase

Variety	FW g	DW g	RWC %	WC g	g H_20/ g DW	Transpiration mg/cm^2/min	L cm	W cm	LA cm^2	cm^2/ g DW	g H_20/ cm^2	CTD °C	CCI
Kremena	0.2209	0.0566	91.79	0.1644	2.96	0.164	4.57	2.61	7.14	128.52	0.0230	-4.87	26.02
Tsvetelina	0.2691	0.0674	90.99	0.2017	3.06	0.177	4.79	2.81	8.18	125.84	0.0244	-5.16	22.25
Sadovo 2609	0.2214	0.0567	88.17	0.1647	2.99	0.144	4.24	2.68	6.84	124.07	0.0243	-5.12	22.05
Orphey	0.2615	0.0688	89.26	0.1927	2.90	0.163	4.76	2.90	8.33	125.43	0.0230	-4.77	25.10
Kalina	0.2550	0.0658	87.79	0.1892	2.92	0.141	4.69	2.91	8.32	127.78	0.0229	-4.94	22.95

pheus do not reduce their dry weight. On the other hand, Kremena variety has the strongest reduction-26.8%, but it is not the lowest dry weight. The lowest dry weight was reported for Sadovo 2609.

The average results for obtained for relative water content (RWC) of the leaves in the two water regimes do not indicate a difference between varieties as well as between variants of irrigation regime. The variant of reduced water supply does not lead to a high-water deficit in all varieties. However, the Sadovo 2609 variety, which showed the lowest fresh and dry leaf weight, had also the lowest RWC in both irrigation variants.

The water content (WC) in the leaves of the stressed plants was highest in Tsvetelina – 0.2017 g, and lowest in Kremena – 0.1644 g. The water content of regularly irrigated plants varies from 0.2342 g in Kremena to 0.1944 g in Sadovo 2609. Logically, the reduction of this indicator is the highest in Kremena (42.3%) and the lowest in Tsvetelina (2.54%).

The water ratio per unit of synthesized dry matter gives a clear picture of the leaf moisture compared to the absolute value of the water content. For control plants, the value is over 3.00 g, as the highest value was in Kremena (3.40 g), and the lowest was in Sadovo 2609 (3.06 g). In the case of stressed plants, only Tsvetelina variety exceeds the limit of 3.00 g, with less variation in varieties. The highest is the reduction in Orphey variety (16.0%), and the lowest was in the least watered variety Sadovo 2609.

The transpiration rate is the lowest for Kalina (0.141 mg/cm^2/min), and the highest for Tsvetelina (0.177 mg/cm^2/min) of stressed variants. In regular irrigated plants, this indicator is the lowest for Orphey (0.141 mg/cm^2/min), and the highest for Sadovo 2609 (0.211 mg/cm^2/min). In regard to comparison of the transpiration rate of both varied experiments, with the most stable reaction are Kremena variety. The most severe reduction presents the Sadovo 2609 variety.

For stressed plants, the leaf length (L) at Tsvetelina is the biggest (4.79 cm), and the smallest is for Sadovo 2609 (4.24 cm). In moisture-protected plants the leaves of Kremena are the longest, and they are the shortest again for Sadovo 2609. The reduction in leaf length is the smallest for Tsvetelina (1.57%) and the highest for Kremena (13.82%). The smallest leaf width (W) in the stressed plants has Kremena – 2.61 cm, and the largest has Kalina – 2.91 cm. In the variant with optimal soil humidity, the Tsvetelina variety is with the smallest width, and the largest variety is Kalina. The reduction in leaf width is the smallest for Orphey.

In the stressed plants Sadovo 2609 is with the smallest leaf area (LA) – 6.84 cm^2, and Orpheus is with the largest LA – 8.33 cm^2. In the regularly irrigated plants the smallest leaf area is again for Sadovo 2609 – 8.36 cm^2, and the highest is for Kalina – 9.82 cm^2. The decreased in leaf area is most pronounced in the Kremena variety and reaches 33.04%, and the lowest decreased at Orphey – 3.92%. The reduction in the leaf area indicator in stressed plants is higher than the reduction of length and width of the leaves.

The specific leaf area expresses the ratio of dry mass accumulated per leaf surface unit (cm^2 LA/g DW). In this respect in stressed plants Sadovo 2609 accumulates the most quantity dry mass on the smallest surface area – 124.07 cm^2/g, i.e. it has the thickest leaf. The least dry mass per unit surface area accumulates Kremena 128.52 cm^2/g. We note a lower variation of this parameter in varieties compared to the regular watering option. In this variant, all varieties are characterized by an increase in the ratio of the area to the dry matter compared to the no irrigated plants. That is, water contentment leads to its inefficient use in unstressed plants. This ratio is the highest for Kalina – 142.5 cm^2/g, and it is the lowest for Sadovo 2609 – 131.1 cm^2/g.

The water content to leaf area ratio ranges from 0.0229 g H_2O/cm^2 for Kalina to 0.0244g H_2O/cm^2 for Tsvetelina in the stress variant. In the control variant, the Kremena variety has the largest amount of water per unit area, consequently, in this variety, the reduction in the value of this indicator is greatest but does not exceed 10.0%.

From these results were formulated following conclusions:

• The Kremena variety significantly reduces the fresh and dry mass during drought in the beginning of flowering phase. The variety preserves high leaf moisture in stress conditions and high levels of transpiration.

• In conditions of stress, variety Orphey reduces least the fresh and dry mass, despite the low levels of transpiration.

• In normal soil moisture conditions, the highest level of fresh and dry mass has Kremena variety, and it is the lowest for variety Sadovo 2609.

• The intensity of transpiration in regular soil irrigation is highest at Kremena again.

• The largest leaf area in stressed plants is characteristic of Tsvetelina, and it is the smallest in Sadovo 2609. In regularly irrigated plants, the leaf area is largest in Kremena, and it is smallest again in Sadovo 2609.

• The reduction in the length of the leaves is largest in Kremena, and it is smallest in Tsvetelina.

• The width of leaf reduces is lowest in Orphey.

• In irrigated plants, water is used inefficiently. For this fact indicates the specific leaf area parameter. The plants of Kalina variety are the most inefficient.

As a result of the study it was found that under the applied drought conditions the plasmalemas damage index can not be used as a stress indicator. All dried varieties have equal or similar values for this indicator.

The mean value for canopy temperature depression (CTD) for the two-year study is negative in both variants of water supply. In dried plants, this value has a higher negative. The leaves of Tsvetelina are the most stressed (-5.16°C) and in Orpheus CTD is the highest (-4.77°C), with a very small difference. In control plants, the difference from the highest negative temperature to the lowest is also low, it does not exceed 1°C. In this case, we assume that the difference between CTD of controls and CTD of stressed plants is more important for the study. Kremena variety has the smallest difference in CTD values in both tested variants (0.9°C), that is, Kremena cooled most effectively its leaves and preserves the vital processes best. By this indicator the greatest difference in temperature are in Kalina and Sadovo 2609.

In both variants of the experiment with the largest amount of chlorophyll is Kremena variety with highest chlorophyll content index (CCI), followed by Orphey. The lowest amount of chlorophyll was reported for Kalina variety in the control variant and the Sadovo 2609 variety in the stress variant. Typical for the hand–held reading of the total chlorophyll content is that the comparison of the varieties performance is only made in the tested variations.

From these results following conclusions were formulated:

• The variety Kremena has best preserves of its vital functions and best leaf area cooling. Kalina variety reacts with the increase of its leaf area in drought condition compared to other varieties and inhibits its vital functions.

• The highest chlorophyll content in both optimal irrigation and delay irrigation showed Kremena.

At an optimal level of soil moisture, it is evident that there are proven positive correlations between fresh weight, dry weight, RWC and water content in the leaves. A significant negative relationship between RWC and transpiration rate and positive but no significant relationships of same indicators with a water quantity per unit of dry weight was reported in the regularly irrigated plants.

It is completely logically that the morphometric indices of the leaves correlate positively with the parameters of water exchange, fresh and dry weight as well as between them. Positive, but not proven, is their correlation with the amount of water per unit of dry matter. Also, the intensity of transpiration does not increase with increasing the leaf area, even exsist a negative proven dependence with on the length of the leaf. Unstressed plants are characterized by a positive relationship of bigger density of leaves (cm^2/DW) with more fresh and dry weight. In control plants, there is no proven correlation between distance reading indices CTD and relative amount of chlorophyll with all other indicators as well as between them. An exception is the significant positive relationship between CTD and transpiration, demonstrating the cooling role of the evaporation of water from the leaves. From the obtained results calculated from correlation analysis of unstressed plants, it can generally be concluded that water is not a limiting factor and is not fully absorbed due to its sufficient quantity in the soil.

For stressed plants, significant positive relationships between water exchange, fresh and dry weight is calculated, these ratios are presented in control plants. There are also some differences, the first being that there is no significant relationship between dry weight and RWC, also there is a proven negative relationship between dry mass and water quantity per dry mass unit. The efficiency of the transpiration increases in the direction of biomass synthesis, and this is expressed by a positive association of the transpiration with with the above mentioned indicators.

As in control plants, morphometric indicators correlated positively with water exchange indicators, dry and fresh mass, as well as between them.

With transpiration rate and water quantity per unit of dry mass, there are no significant correlation. Unlike control plants, the specific leaf area has no effect on most indicators except for dry weight. There is a strong positive relationship with the indicator content of water per unit of dry matter. The water quantity per unit area is in positive correlation with the other parameters of the water exchange, except for the low negative correlation with the dry mass. In control plants, this relationship has been shown to be positive. Also, compare to control plants, the remotely sensed CTD indicator which is indicative for stress has been positively proven by most parameters such as fresh weight, RWC, water quantity and leaf morphometry. The CTD indicator has positive, but it is not statistically significant relationship with dry mass and with water quantity per dry mass unit. Of this result we can conclude about the presence of plant stress in this variant of water-supply. For the CCI index, which shows amount of total chlorophyll, as well as controls, low and insignificant relationships with other indicators are calculated.

The results obtained show that available soil moisture leads to increased leaf biomass and increased relative water content in leaves. Stressed plants react with reduce of leaf biomass, in these grow conditions they only increase leaf area. Reduced water content in the soil leads to a danger of increased leaf canopy temperature and hence to risk of life-threatening impairment. Effectiveness of transpiration is enhanced in stressed plants.

Phenophase of fruiting

The results of the measurements of morphometric indicators are shown in Table 3 and Table 4. Fresh weight (FW) value decreases compare to the beginning of flowering phase in the stressed plants. It increases only in Kalina and Kremena varieties. This parameter ranges from 0.2134 g in Sadovo 2609 to 0.2591 g in Kalina. While in the first phase leaves of Kremena and Sadovo 2609 have the smallest and the same fresh mass, in the phase of fruiting for Kremena variety 10% more fresh mass was estimated. In optimally irrigated plants the fresh mass is higher in Kalina, which repeats its good result from the first phase. The reduction of fresh mass in this phase is the highest in Kremena (19.3%).

Logically, stressed plants respond with a decrease in a dry weight (DW). The lowest dry weight was recorded for Sadovo 2609 and Kremena, and it was highest for Kalina. This result repeats the obtained data during the first phase. Kalina variety shows a higher dry mass than the control plants. Dry mass reduction is the highest in Kremena and Tsvetelina - up to 18.0%.

Relative water content of the leaves in the dried plants decreases, as the highest RWC have Tsvetelina and Kremena, and it is the lowest for Kalina. In the irrigated control, this indicator changes minimal, with the results for the most watered and these with high water deficit being analogous to those of the stressed plants. In general, it can be summed up that Kalina variety reacts the most sensitively and has the highest water deficit, and all other varieties show a similar reaction.

The water content (WC) of leaves retains its character from the earlier stage, especially for the varieties of Sadovo 2609 and Kremena. The reduction of this indicator is the strongest in Kremena – 19.9%, followed by Tsvetelina – 17.6% and the lowest in Sadovo 2609 – 1.8%.

During this phase, transpiration rate is more intense in stressed variants than in the first phase, with transpiration rate being the lowest at Sadovo 2609, and it is the highest at Tsvetelina. In regular irrigated plants, this parameter is the lowest for Kremena – 0.157 $mg/cm^2/min$, and the highest for Sadovo 2609 – 0.210 $mg/cm^2/min$.

The quantity of water per dry matter decreases during the phase of fruiting, as for the varieties Sadovo 2609 and Tsvetelina it is the lowest. For Orphey, this ratio is the highest. The reduction for all varieties is very low - up to 3%, which is an indicator of applied low stress. This fact also is confirmed from calculated results for the RWC.

In irrigation variants, Kalina variety was with the largest leaf length (L) of leaves and Sadovo 2609 was with the smallest leaf length. This arrangement is the similar with the stressed plants in the first phase of the study. The reduction in the average length for varieties does not reach more than 10%, as the largest value is calculated for Kalina.

The leaf width (W) does not exceed 0.5 cm in controls, and 0.25 cm for stressed plants. Kalina variety has the widest leaves in both variants, and from the dried variants Sadovo 2609 and Tsvetelina were with the narrowest leaves. The results for the reduction do not give a clear difference, which had somewhat in the first phase. Even in the Kremena and Sadovo 2609 varieties it has a slight increase.

Table 3. Results for water exchange, leaf morphometry, analytical methods and yield for unstressed plants of peanut in the fruiting phase

Variety	FW g	DW g	RWC %	WC g	g H_20/ g DW	Transpiration mg/cm^2/min	L cm	W cm	LA cm^2	cm^2/ g DW	g H_20/ cm^2	CTD °C	CCI	Yield kg/da
Kremena	0.2856	0.0722	89.21	0.2134	3.00	0.156	5.46	2.61	8.56	120.7	0.0251	-3.18	32.61	505.11
Tsvetelina	0.2835	0.0746	89.14	0.2089	2.82	0.173	5.10	2.78	8.57	116.4	0.0242	-4.23	23.35	315.18
Sadovo 2609	0.2205	0.0590	87.47	0.1614	2.76	0.210	4.80	2.41	7.05	121.7	0.0226	-2.23	22.98	303.53
Orphey	0.2775	0.0708	89.17	0.2067	2.97	0.187	5.34	2.73	8.77	125.8	0.0235	-4.52	31.34	375.11
Kalina	0.3142	0.0825	86.89	0.2317	2.88	0.188	5.61	2.91	9.96	125.0	0.0231	-2.73	21.58	366.69

Table 4. Results for water exchange, leaf morphometry, analytical methods and yield for stressed plants of peanut in the fruiting phase

Variety	FW g	DW g	RWC %	WC g	g H_20/ g DW	Transpiration mg/cm^2/min	L cm	W cm	LA cm^2	cm^2/ g DW	g H_20/ cm^2	CTD °C	CCI	Yield kg/da
Kremena	0.2304	0.0594	88.53	0.1710	2.93	0.224	5.11	2.66	8.17	133.65	0.0218	-2.46	29.25	724.96
Tsvetelina	0.2343	0.0621	88.77	0.1722	2.77	0.245	4.78	2.53	7.32	119.02	0.0235	-3.18	27.99	370.07
Sadovo 2609	0.2134	0.0574	86.88	0.1586	2.75	0.204	4.64	2.56	7.19	128.46	0.0220	-2.59	24.96	274.68
Orphey	0.2468	0.0632	88.44	0.1836	2.94	0.237	5.09	2.63	8.09	130.02	0.0226	-4.47	35.32	490.79
Kalina	0.2591	0.0693	84.61	0.1897	2.80	0.212	5.14	2.79	8.67	128.40	0.0219	-3.81	25.25	515.11

Leaf area (LA) is a function of the previous indicators and the classification of varieties by final reaction is the same. Kalina variety has the largest leaf areas in both variants, and Sadovo 2609 has the smallest. The largest variations were for the varieties Tsvetelina and Kalina, while in the first phase this variety was Kremena.

The reported specific leaf area per unit dry leaf weight during this phase is more for the stressed than controls, while in the first phase the controls had higher values. In controls, the Orphey variety has the highest value, while the Tsvetelina variety is the smallest. In the stressed plants, Kremena and Sadovo 2609 are classification respectively. The results for the Kremena and Sadovo 2609 varieties are repeated for the stressed variants during the first phase.

In the control plants, with the largest amount of water content of leaf per unit leaf surface is Kremena variety and with the least amount is Sadovo 2609. In no irrigated the results for Tzvetelina and Kremena are the same order. From these results, Kremena variety is expected to be with the largest reduction, but it does not exceed 15.0 %.

As the result in the first phase, the mean value of canopy temperature depression (CTD) is negative in both water supply regimes. Unlike, in the beginning of flowering phase, not all varieties have a higher negative CTD value in the reduced water supply variant compared to the controls, namely only the varieties Sadovo 2609 and Kalina show a stronger stress response. These two varieties react in this way also during the first phase. In absolute value the lowest stress in the stressed variant is observed in Kremena (-2.46°C), and the most stressed are the leaves of Orpheus variety (-4.47°C). But at Orpheus variety there is no difference between control and stress variants and therefore it can not be considered that it is the most stressed variety.

As regards to relative content of total chlorophyll, in both variants of the experiment Orphey variety was with the largest amount of chlorophyll, followed by Kremena variety. The advantage on this indicator is repeats for the same varieties of the first phase. Also, as in the first phase, the lowest content of chlorophyll was reported for the Kalina variety in the control variant and for the Sadovo 2609 variety in the stress variant. The difference in the total content of chlorophyll in these varieties reaches to 30 % compared to the total content of chlorophyll reported in Orphey variety.

The results of the experiment found that under conditions of moderate stress the majority of varieties did not reduce fruit yield. There is an exception only for the oldest of the tested varieties – Sadovo 2609. This variety decrease its yield, while the others react with an increase in yields subjected to moderate stress. This fact can be explained by the smaller number of fruits, but well-fed fruit compared to the optimal humidity variant. The obtained yield kernel is higher in stressed plants, with values difference reach 10.0% in Kremena (Table 5).

The results obtained show that Kremena variety preserves high water content of the leaves under stress conditions. In conditions of optimal soil moisture, Kalina variety has the highest levels of fresh and dry weight, and Tsvetelina variety has the lowest. The transpiration rate in moisture plants in regular irrigation varieties is the highest in Kalina.

In control plants, the correlation between the morphometric parameters - fresh mass, dry mass, leaf length, leaf width and leaf area, RWC, water content and water content per unit area are positive and significant up to 1%. The water content per unit dry mass is in positive relation to most of the listed indicators except for dry mass. Expected transpiration rate is positively significant with RWC and CTD, as CTD parameter not significantly correlated with other indicators. The other remote readings parameter CCI has a significant positive relationship only with the water content per unit area. From the plant correlated dependents in the irrigation variant, we can conclude that there is no stress situation during the mass flowering and fruiting phase and that the indicators used in the study are sufficient to characterize this crop.

The calculated correlations in stressed plants do not differ significantly than those in the previ-

Table 5. Grain yield for the tested variants

Variety	Grain yield, %	
	control	stressed
Kremena	56,0	66.0
Tsvetelina	67.1	67.5
Sadovo 2609	63.5	65.9
Orphey	62.6	65.2
Kalina	60.4	65.9

ous phase. The morphometric parameters are in one direction, with the differences being low correlate between dry mass and RWC, RWC and leaf width, water content per unit dry weight and leaf area. There are stronger connections between the water content per dry mass unit and the other parameters, but a negative relationship with dry mass means that the water has no limiting role. No remarkable and strong correlations have been obtained from the distance readings parameters, except for the average negative correlation between CTD and CCI, which may lead us to the conclusion that there is ineffective transpiration with only a cooling effect.

The analysis of dependences shows that the yield of fruit in moderately stressed plants is positively influenced by the accumulation of vegetative mass. Any increase in the size of vegetative organisms leads to an increase in yield. At the same time, transpiration does not affect the yield value. In the control variant, however, the increase in the size of the vegetative organ does not lead to a noticeable increase in yield. Transpiration affects negatively to its magnitude, this fact indicated of inefficient use of available water.

CONCLUSIONS

After analyzing the results, the following conclusions were made:

• Plants which throughout their development period grow in accessible soil moisture are ineffective, as they increase vegetative mass at the expense of their generative organs;

• Transpiration is effective only at moderate moisture deficiency;

• All measured parameters of water exchange have a direct positive relationship to peanut fruit production. This fact suggests that a longer drought impact on plants will lead to an inevitably reduction in yield.

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