

Evaluation of relative water content (RWC) at four barley (*HORDEUM VULGARE* L.) genotypes in response to microwave treatment

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Abstract From the electromagnetic spectrum (EM) three different wavelength regions can be used to provide information on vegetation characteristics: the Visible to Short Wave Infrared, the Thermal Infrared and the Microwave regions. The relative water content (RWC) of the plants is used as a measure of the water status. Vegetation status is an indicator of the degree of stress experienced by plants in their environment. The aim of our investigation was to determine the effect of microwave treatment of barley seeds, we were preseted morphological parameter: relative water content (RWC) for 4 different winter barley genotypes. RWC compares the water content of a leaf with the maximum water content at full turgor. Values of RWC for leaves of the studied genotypes ranged from 88.07 at Cardinal variety to 97.8 at the Sistem variety, under irradiation of the microwave conditions and is observed a good correlation between Cardinal, Maresal and Dana genotypes, in different the power and time of exposure of the microwave.

Key words

barley, RWC, microwave

From the electromagnetic spectrum (EM) three different wavelength regions can be used to provide information on vegetation characteristics: the Visible to Short Wave Infrared, the Thermal Infrared and the Microwave regions. The relative water content (RWC) of the plants is used as a measure of the water status.

Visible to Short Wave Infrared (0.40 - 2.50 μm). Vegetation reflectance in this of the spectrum provides information on vegetation biophysical parameters such as chlorophyll, physiological structure and leaf cellular water content [15]. Chlorophyll absorbs the red and blue elements of the EM spectrum; internal leaf structure affects the near infrared and leaf cellular water absorbs the short wave infrared.

Thermal Infrared (6.0 - 15.0 μm) and **Microwave** (0.1 - 100 cm). Emittance in these portions of the EM spectrum provides information on the thermal properties of vegetation cover such as sensible heat. Sensible heat is used to estimate evapotranspiration of vegetation canopies, which is closely related to water stress [11].

Today, active and passive microwave approaches have been developed to sense soil water content, which can be highly relevant to vegetation monitoring [5]. Passive microwave sensors provide information on the thermal properties of water [13]. Active microwave sensors provide information on the dielectric constant, which may be related to vegetation water content [10].

The estimation of chlorophyll content or the degree of drying (curing) is an alternative to the estimation of vegetation water content and also to the estimation of vegetation water content is an alternative the estimation of vegetation status. A number of studies are based on the relation between chlorophyll and water content. There are methods wich calculated relations between vegetation indices and water content information [2, 3, 12].

Vegetation status is an indicator of the degree of stress experienced by plants in their environment [9]. Vegetation stress can be defined as any disturbance that adversely influences growth [7, 16]. This stress can be due to many factors, one of which is a lack of water that restricts transpiration, inducing closure of stomata and resulting in less water evaporating from the leaf surface. Because less cooling occurs due to water evaporation, the temperature of the leaf increases.

The aim of our investigation was to determine the effect of microwave treatment of barley seeds. Selected parameters (for example, plant growth and biochemical parameters related to oxidative status) were measured but in this paper we were preseted only morphological parameter: relative water content (RWC). RWC compares the water content of a leaf with the maximum water content at full turgor. The results indicate that application of a suitable dose of microwave radiation to seeds can enhance some parameters of barley seedlings.

Materials and Methods

The influence of microwave irradiation on barley seeds has been investigated before. A magnetron MWG20H with a frequency of radiation of 2.45GHz and maximum output power of 800W, according to supplier's data, has been used as microwave source. The maximum density of irradiation has been estimated at 40kW/m³.

The experiment was conducted in the laboratories of the Faculty of Horticulture and Forestry, Timisoara. Four barley genotypes were used in the experiments – Maresal, Sistem, Dana and Cardinal, differing in their reaction to microwave irradiations. The seeds were obtained from the Fundulea Agriculture Research Station.

The seeds were initially treated with 1,5% sodium hypochlorite for 15 min. The residual chlorine was eliminated by thorough washing of the seeds with distilled water. The seeds for the experiment were distributed in two variants (V1-720W and V2-400W) with three times of exposure and 3 replicates, each containing 25 seeds each. The seeds have been exposed to the microwave radiation for 0s (control-M), 10s, and 20s, with two modifications of output powers of the magnetron – 400W and 720W, corresponding intensities – 20kW/m³ and 36kW/m³ respectively, have been applied. The seeds were then germinated on filter paper in Petri dishes, in growth chamber, under laboratory conditions (the natural light cycle was 9 h of light / 14 h of darkness and the daily temperature was 21 ± 2 °C, night temperature 15 ± 2 °C).

In order to estimate the influence of the microwave treatment were determined: relative water content (RWC) in the leaves of the plants. The leaves were placed in polythene bags and transported to the laboratory as quickly as possible in order to minimize

water losses due to evaporation. The relative water content was evaluated from the equation:

$$RWC (\%) = [(FW-DW)/(TW-DW)] \cdot 100$$

where FW is the fresh weight of the leaves, TW is the weight at full turgor, measured after floating the leaves for 4 hours in water in the light at room temperature and DW is the weight estimated after drying the leaves for 24 hours at 60°C or until a constant weight is achieved.

Experimental data obtained were statistically processed by calculating the mean and coefficient of variation [4] and were statistically interpreted using Principal Component Analysis method (PCA).

Results and Discussions

Relative water content of leaves is strongly associated with cell volume and can express more precisely the balance between leaf water supply and transpiration rate [14].

The RWC is a good indicator of plant water-status [14] relative to their fully turgid condition. This indicator can be easily determined and is applicable in large populations manifesting genetic variability [1]. High values of this indicator are associated with positive effect of the microwave an first stage of development, plant growth, and adequate levels of production with positive impact on economic efficiency of agricultural farmers [8].

The data in Table 1 show the influence of microwave treatment is described by characteristic – relative water content (RWC) from 14 days. I can be noticed that the highest results for RWC have been obtained after barley seeds were treated with the microwave output power of 400 W for Sistem, Dana and Maresal genotypes.

Table 1

Results regarding relative water content (RWC) from 14 days

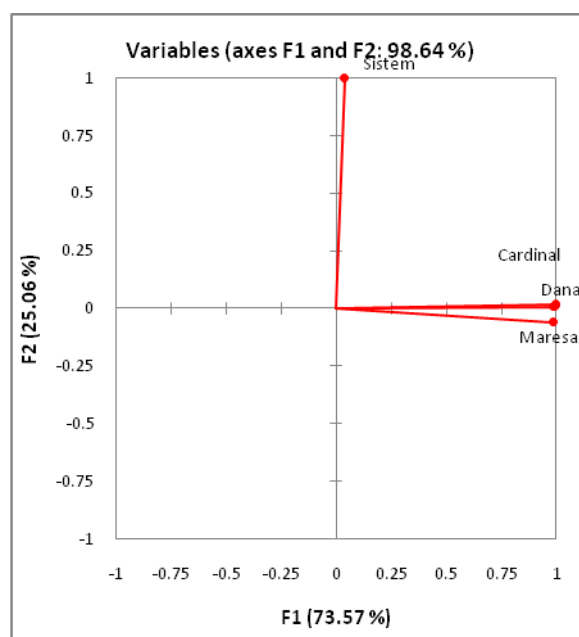
Genotype	Variant	14 days								
		$\bar{x} \pm s_x$			s^2			CV (%)		
		Time of exposure (s)			Time of exposure (s)			Time of exposure (s)		
		0	10	20	0	10	20	0	10	20
Sistem	V1	92.92±0.84	87.21±2.71	92.93±0.77	1.18	3.83	1.09	1.27	4.39	1.17
	V2	92.92±0.84	94.77±2.35	97.8±1.92	1.18	3.32	2.71	1.27	3.5	2.77
Maresal	V1	82.76±8.5	96.27±0.44	94.23±0.10	12.02	0.62	0.14	14.52	6.46	1.57
	V2	82.76±8.5	94±2.23	95.97±0.37	12.02	3.15	0.53	14.52	3.35	0.55
Dana	V1	91.95±0.11	93.41±0.02	96.52±0.18	1.41	0.03	0.26	1.52	0.03	0.26
	V2	91.95±0.11	95.15±1.85	95±0.52	1.41	2.61	0.73	1.52	2.74	0.77
Cardinal	V1	76.55±3.56	88.5±2.62	87.67±7.25	5.03	3.71	10.25	6.57	4.19	11.69
	V2	76.55±3.56	90.25±4.23	88.07±3.04	5.03	5.98	4.30	6.57	6.63	4.88

Table 2

Principal Component Analysis (PCA)

Correlation matrix (Pearson (n)):

Variables	Maresal	Sistem	Dana	Cardinal
Maresal	1	-0.022	0.977	0.955
Sistem	-0.022	1	0.053	0.041
Dana	0.977	0.053	1	0.981
Cardinal	0.955	0.041	0.981	1



Graph 1. Biplot graphic of principal components for RWC at the studied barley genotypes

This indicator presented values (Table 1) ranging between 92.92% in genotype Sistem and 76.55% in cultivar Cardinal, with a variation amplitude of 16.37%, in case of plants cultivated in normal conditions.

In irradiation with microwave conditions studied genotypes ranged between 88.5% in genotype Cardinal and 96.27% in genotype Maresal, with a variation amplitude of 7.77%, for exposure time of 10s at 720W power of the microwave (V1). For exposure time of 20s genotypes ranged between 96.52% in genotype Dana and 87.67% in genotype Cardinal, with a variation amplitude of 8.85%. At 400W power of the microwave (V2) and exposure time of 10 s, genotypes ranged between 90.25% in genotype Cardinal and 95.15% in genotype Dana, with a variation amplitude of 4.90%; for exposure time of 20s genotypes ranged between 88.07% in genotype Cardinal and 97.8% in genotype Sistem, with a variation amplitude of 9.73%. For the coefficient of variation it was observed that for most genotypes relative water content had a low variability.

Values of dehydration capacity for leaves of the studied genotypes ranged from 88.07 at Cardinal variety to 97.8 at the Sistem variety, under irradiation of the microwave conditions (Table 1).

From Correlation matrix Pearson is observed a good correlation between Cardinal, Maresal and Dana genotypes, in different the power and time of exposure of the microwave (Table 2). The results indicate that application of a suitable dose of microwave radiation to seeds can enhance some parameters of barley seedlings.

Conclusions

The highest relative water content in genotypes is observed at Dana, Sistem and Maresal genotype in different power and time of exposure of the microwave. The lowest relative water content in genotypes is observed at Sistem genotype.

High values of this indicator are associated with positive effect of the microwave an plant growth and adequate levels of production with

positive impact on economic efficiency of agricultural farmers.

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