EFECTUL TRATAMENTELOR CU FRUCOL ASUPRA FLORESCENTEI CLOROFILEI LA SOIURILE DE MAR JONATHAN ŞI IDARED

FRUCOL PRODUCT EFFECTS ON CHLOROPHYLL FLUORESCENCE PARAMETERS MEASURED FOR JONATHAN AND IDARED APPLE CULTIVARS

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Abstract

Chlorophyll fluorescence is a non-invasive approach to energetics of the photosystem II (PSII). Light energy transfer to quantum chlorophyll acceptor (QA) and its conversion into photochemical and non-photochemical energy is characterized by some chlorophyll fluorescence parameters measured under the experimental framed conditions. Literature data has shown the chlorophyll fluorescence parameters are certainly influenced by plant water provisions (Lenham, 1994, Oogren, 1990), frost and mineral nutrition (Mohamed et al., 1995) and light intensity (Groninger et al., 1996). Sometimes the entire photosystem II (PSII) equilibrium is significantly upset by many environmental factors, as well as by the foliar applied fertilizers and growth control chemicals. Consequently, chlorophyll fluorescence, as an applicative method might be used to acknowledge the response of plant to foliar treatments as a perturbation factor in chlorophyll photosynthesis. The experimental plan concern the application of Frucol product as poly-functional foliar fluid (nutritive, growth enhancing and fungicide biological effects). Six experimental variants were set up in linear blocs with three repetitions. Three main factors were considered in the development of experiments: Factor A - apple cultivar (a1-'Jonathan', a2-'Idared'); Factor B – foliar treatment (b1 blank – untreated, b2 – 4 treatments with Frucol 1 0.5% over the entire vegetation period with the first treatment after fruitlets abscision and the next 3 treatments at 20 days interval, b3 - 3 treatments with Frucol 2 0.5% over the entire vegetation period with the first treatment after fruitlets abscision and the next 2 treatments at the same 20 days interval, b4 - 5 treatments with Frucol 1 0.5%, first after fruitlets thinning and the next 4 treatments every 20 days, b5 – 3 treatments with Frucol 2 0.5% over fruits growth period at 14 days intervals, b6 – 2 treatments with Frucol 2 0.5%, the first 10 days before harvesting and the second in the day of harvest); and Factor C - the days when the measurements were made: c1 - 30 July, c2 - 5 August, c3 - 17 August, c4 - 24 August, c5 - 13 September. Duncan test was applied for statistical confidence computation of the results. For the treated Jonathan plots, according to the factor B variation, namely variant b5 and variant b6 were exhibiting significant differences against blank in the Fv/Fm ratio in epicarp fruit area. These differences grew very slowly but significantly up to 20 August and then with rising rate until full fruit ripening, accounting for Frucol 2 product capacity to accelerate the chlorophyll degradation to anthocyanins. More intensive effects of the Frucol 2 products were noticed in the case of Idared cultivar. For both cultivars the Fv/Fm ratio in foliage was poorly affected by all the applied treatments. Nevertheless, the loss in chlorophyll synthesis rate due to foliage senescence over the August-September interval was as usually higher for Jonathan cultivar and much more intense due to the applied treatments.

Cuvinte cheie: îngrăşăminte foliare, pigmenţi, senescenţă
Keywords: foliar fertilizer, pigments, senescence

1. Introduction

Chlorophyll fluorescence is an indicator of light energy conversion in the photosynthesis process. New technologies provide means for straight data collection from the field measurements and the computation of fluorescence parameters associated with the photosystem II (PSII). These parameters serve to quantify the photochemical energy changes into chemical energy. As far as it is known, chlorophyll fluorescence parameters are certainly influenced by plant water supply (Lenham, 1994, Oogren, 1990), frost, mineral nutrition (Mohamed et al., 1995) and light intensity (Groninger et al., 1996). As non destructive method (Greaves et al. 1991), the chlorophyll fluorescence can be measured rapidly in 20-30 seconds, with convenient accuracy, on lighted samples, after 10-30 minutes of sample dark adaption. Moreover, many of the fluorescence parameters are very sensitive to the common environmental stress factors. According to the literature, the chlorophyll fluorescence parameters might be considered as key indicators of: fertilizers application time response and effects on plant physiology, plants stress response to the drought, frost and heating weather periods, photoinhibition and shadowing

during circadian rhythm, and senescence of the leaves and fruits (Baker, 2008, Henrique, 2009). This paper concerns the result of apple tree treatments with products Frucol 1 and Frucol 2 in order to increase the rate of chlorophyll degradation to antocyanines and to improve the intensity and extent of colored area on the apple fruit skin. The response of Jonathan and Idared cultivar to the treatments was evaluated on the basis of chlorophyll fluorescence measurements.

2. Material and methods

Frucol products have been designed as a poly-functional foliar fluids (nutritive, growth enhancing and fungicide biological effects). Due to their composition (table 1), the products may induce higher rate in chlorophyll degradation to antocyanines and eventually fruit color intensification and extent of colored area on the peel of apple fruit. The experiments were set up on an apple plantation placed on the third Arges river terrace. The substrate was the cambic soil (former eutrophic cambisols) with loamy luvic or loamy clayey texture up to 80 cm and sandy-clayey in depth. This soil provides little supplies of nitrogen and phosphorus and medium supplies of potassium. All the experiments concern 'Jonathan' and 'Idared' apple cvs. Dynamic chlorophyll fluorescence measurements were made with fluorometer (Opti-Sciences). Following indicators of the leaves and fruits epidermis were collected: Fo, minimal fluorescence level, measured on the dark adapted leaves (minimum 15 minutes), when all the light collecting antennas are open; Fm, maximal fluorescence level, recorded after light exposure to saturation flux, when all light collecting antennas are closed; Fv/Fm is the maximum quantum yield of PSII. Chlorophyll fluorescence variance consists in the displacement of fluorescence intensity from the minimum to maximum level. This variation, as an indicator of the maximum efficiency of the excitation energy transfer, is computed with formula Fv/Fm = (Fm-Fo)/Fm. When leaves are healthy and properly dark adapted the ratio Fv/Fm is always equal to 0.8 for all plant species. Lower levels than 0.8 are hinting some changes in PSII due to the environmental or treatments plant stress. In the case of fruits, the chlorophyll fluorescence variation is associated with chlorophyll degradation, as well as with fruit senescence during shelf life.

Six experimental variants were set up in linear blocks with three repetitions. The experiment was randomized according to the following factors:

Factor A - apple cultivar with gradations: a1 'Ionathan' and a2 'Idared'; Factor B – foliar teatment with gradations: b1 blank – untreated (variant V1), b2 – 4 treatments with Frucol I, 0.5% over the entire vegetation period with the first treatment after fruitlets abscission and the next 3 treatments at 20 days interval (variant V2), b3 - 3 treatments with Frucol 2 0.5% over the entire vegetation period with the first treatment after fruitlets abscision and the next 2 treatments at 20 days interval (variant 3), b4 - 5 treatments with Frucol 1 0.5%, first after fruitlets drop and the next 4 treatments at 20 days interval (variant V4), b5 – 3 treatments with Frucol 2 0,5% over fruits growth period at 14 days intervals (variant V5), b6 – 2 treatments with Frucol 2 0.5%, the first 10 days before harvesting and the second in the day of harvest) (variant V6), and Factor C – the days the measurements were made: C1 - 30 July, C2- 5 August, C3- 17 August, C4- 24 August, C5- 13 September. Duncan test was applied for the statistical confidence computation of the results (computation level α=0.05).

3. Results and discussions

Analysis of the Frucol foliar products application on the apple leaf conforming with the experimental variants unveiled the specific effect of these products on the chlorophyll fluorescence ratio Fv/Fm measured on the fruit epicarp in 'Jonathan' cv. (Fig. 1) and respectively, on the 'Idared' cv. leaves (Fig. 7), as well as on the fruit epicarp in Idared cv. (Fig. 4) and respectively, on the Idared cv. leaves (figures 10). All the measurements made during the periods encompassing the fruit growth and maturation between 30 July and 17 August were displaying little effect on maximum quantum yield of PSII (Fv/Fm) variation measured on the fruit epicarp in both apple cultivars (Fig. 1 and 4). Significant changes in maximum quantum yield of PSII (Fv/Fm) took place after 17 August in all the variants excepting the variant V1 (blank) and V3 (the only one in which there were no treatments during ripening period). The higher drop in maximum quantum yield of PSII (Fv/Fm) was recorded for the variant V4 in both the cases of 'Jonathan' and 'Idared' cultivars epicarp. This is explained by the maximum number of applied doses with Frucol 1 (five) and their best timing. Because the results are complaining with the Duncan's test of confidence, we can conclude the Frucol 1 treatments applied during ripening stage leads to higher raise in chlorophyll degradation over the epicarp of both cultivars under survey. Frucol 2 treatments, in both ways they were applied over ripening stage, according to the variants V5 and V6, have resulted in significant drops in maximum quantum yield of PSII (Fv/Fm), and therefore, in substantial increase in chlorophyll degradation yields for epicarp area of 'Jonathan' apple cv. (Fig. 1). In the case of 'Idared' cv. only the variant V5 seems to be reasonable as yield of chlorophyll degradation and apple peel color extent and intensity (figure 4). Also, from the figure 6 comes out clearly the idea the treatment with Frucol 2 just before harvesting has no effect on chlorophyll degradation and extension in colored area on 'Idared' cv. apples (variant 6). May be, 'Idared' cv. has to be treated with Frucol 2 in the same way the treatment

was done with Frucol 1 in variant V4. Anyway, a sustained foliar nourishment of the 'Idared' cv. over the entire maturation and ripening stages might help to reach the purpose the Frucol was formulated – enlarging the area of colored peel in both apple cultivar. But, under any of the treatments ways under trial the response of the 'Jonathan' cv. to the Frucol product actions is far away stronger than 'Idared' cv. response (Fig. 3 and 6). At 'Jonathan' cv., from figures 2 and 3 is apparent the continuous trend of degradation of fruit epicarp chlorophyll, slow to 20 August and faster after that data. Over time, the ratio Fv/Fm of fruit epicarp chlorophyll fluorescence were decreased (figure 5 and 6) at 'Idared' cv., but not as pronounced as at 'Jonathan' cv. (minimum value 0.339 at Jonathan and 0.202 at Idared cv.).

Leaves responses to the Frucol product treatments are very different comparing with fruit responses. For 'Jonathan' cv., the uniform decay in chlorophyll fluorescence over the entire surveyed time interval is real and statistically covered by Duncan test (Fig. 8 and 9). But this is also explained by the lowering rates in photosynthesis when fruit started the ripening stage. As little chlorophyll is available for degradation as low is the intensity of its degradation. Actually, the action of Frucol products did overlap the decay in chlorophyll synthesis only during the late ripening stages, starting on 17 August as happened in the case of fruit (Fig. 8 and 9). Hence, the little or non significant differences between changes in maximum quantum yield of PSII (Fv/Fm) recorded for all 6 variants (Fig. 7). Similar changes were observed in the case of 'Idared' cv. leaves and may be the causes are the same. But, the intensity of Frucol product effects was poorer than in the case on 'Jonathan' cv. (Fig. 10 and 11). But this particularity might be much more connected to the fact that 'Jonathan' cv. leaves senescence naturally comes upon earlier than leaves senescence in the 'Idared' cv. (Fig. 9 and 12).

4. Conclusions

Chlorophyll fluorescence parameters have been used to acknowledge the response of plant to foliar treatments with Frucol products designed for improvement of color intensity and extent on apple peel surface. The experimental set up was developed in linear blocks with three repetitions considering three main factors for an accurate assignment of the eventual effect of treatments: Factor A - apple cultivar (A-1 'Jonathan', A-2 'Idared'); Factor B – foliar treatments (frequency, dosage and Frucol product composition, V1-V6 variants); and Factor C – the periods and days the measurements (four periods during maturation and fruit ripening). According to the factor B variation, namely variants V4, V5 and V6 caring Frucol 1 and Frucol 2 were exhibiting significant differences against control in the Fv/Fm ratio in epicarp fruit area of the 'Jonathan' cv. The effects recorded on 'Idared' cv. epicarp fruit area were poorer than in the case of the 'Jonathan' cv., but significant for variant V4. For both cultivars the Fv/Fm ratio in foliage was poorly affected by all the applied treatments. But, the loss in chlorophyll synthesis rate due to foliage senescence over the August-September interval was as usually higher for 'Jonathan' cv. and much more intensive due to the applied treatments. Les effects were observed when treatments were applied to the 'Idared' cv. leaves.

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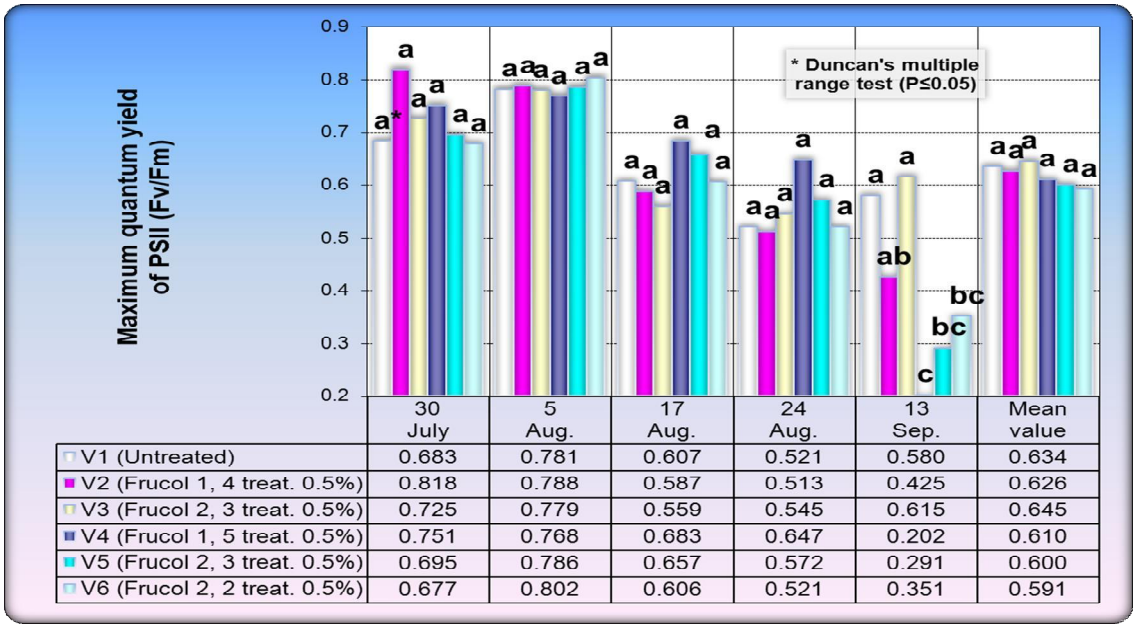
Tables and Figures

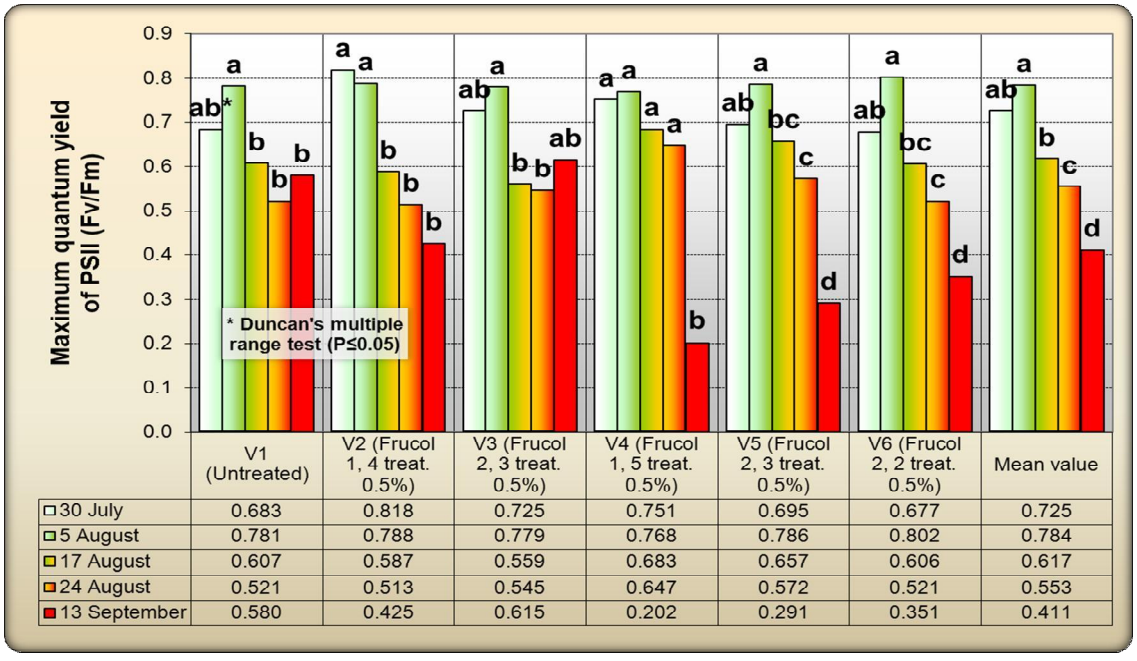
Table 1. Frucol product composition

Nr. crt.	Components	Concentration, g/l	
		Frucol 1	Frucol 2
1	Sulphur	50	30
2	Ethanol	-	50
3	Monoethanol amine/Triethanol amine molar ratio 2/1	-	10
4	Surfactants	-	8
5	Potassium naphthenate superbazic 4/1 eith concentration 1 mol potassium/l	990	944



	30 July	5 Aug.	17 Aug.	24 Aug.	13 Sep.	Mean value
V1 (Untreated)	0.683	0.781	0.607	0.521	0.580	0.634
V2 (Frucol 1, 4 treat. 0.5%)	0.818	0.788	0.587	0.513	0.425	0.626
V3 (Frucol 2, 3 treat. 0.5%)	0.725	0.779	0.559	0.545	0.615	0.645
V4 (Frucol 1, 5 treat. 0.5%)	0.751	0.768	0.683	0.647	0.202	0.610
V5 (Frucol 2, 3 treat. 0.5%)	0.695	0.786	0.657	0.572	0.291	0.600
V6 (Frucol 2, 2 treat. 0.5%)	0.677	0.802	0.606	0.521	0.351	0.591

Fig. 1. Maximum quantum yield of PSII (Fv/Fm) variation on the 'Jonathan' cv. fruit epicarp, depending on the variants of Frucol product application (factor B), at constant level of the factor C



	V1 (Untreated)	V2 (Frucol 1, 4 treat. 0.5%)	V3 (Frucol 2, 3 treat. 0.5%)	V4 (Frucol 1, 5 treat. 0.5%)	V5 (Frucol 2, 3 treat. 0.5%)	V6 (Frucol 2, 2 treat. 0.5%)	Mean value
30 July	0.683	0.818	0.725	0.751	0.695	0.677	0.725
5 August	0.781	0.788	0.779	0.768	0.786	0.802	0.784
17 August	0.607	0.587	0.559	0.683	0.657	0.606	0.617
24 August	0.521	0.513	0.545	0.647	0.572	0.521	0.553
13 September	0.580	0.425	0.615	0.202	0.291	0.351	0.411

Fig. 2. Maximum quantum yield of PSII (Fv/Fm) dynamics on the Jonathan cv. fruit epicarp, at constant level of Frucol treatments

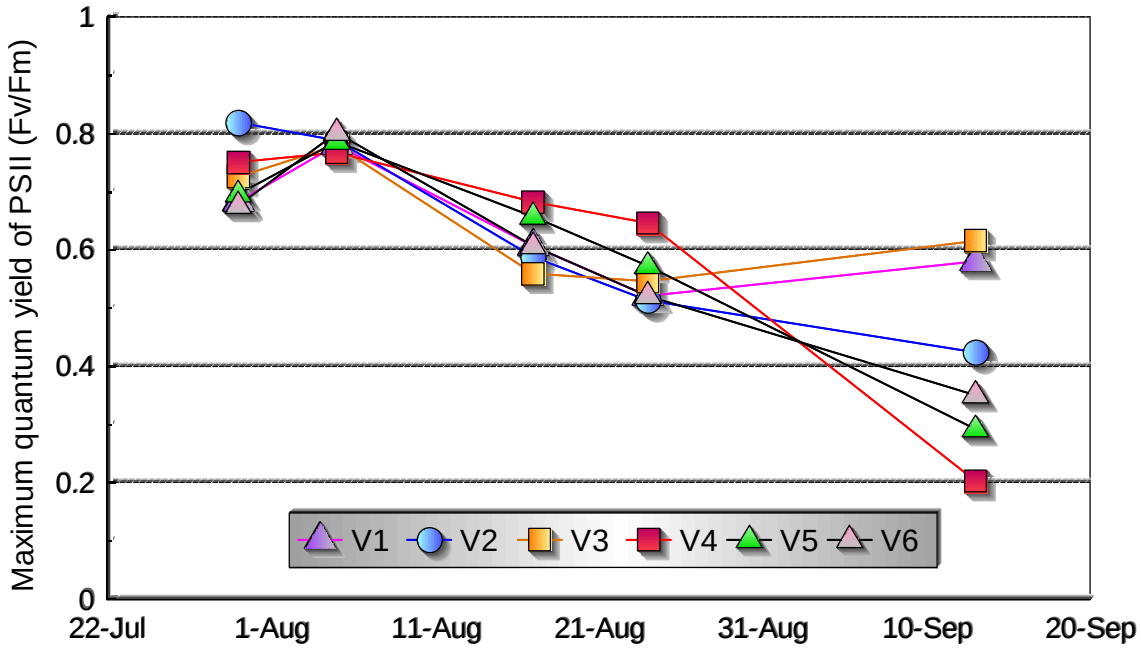
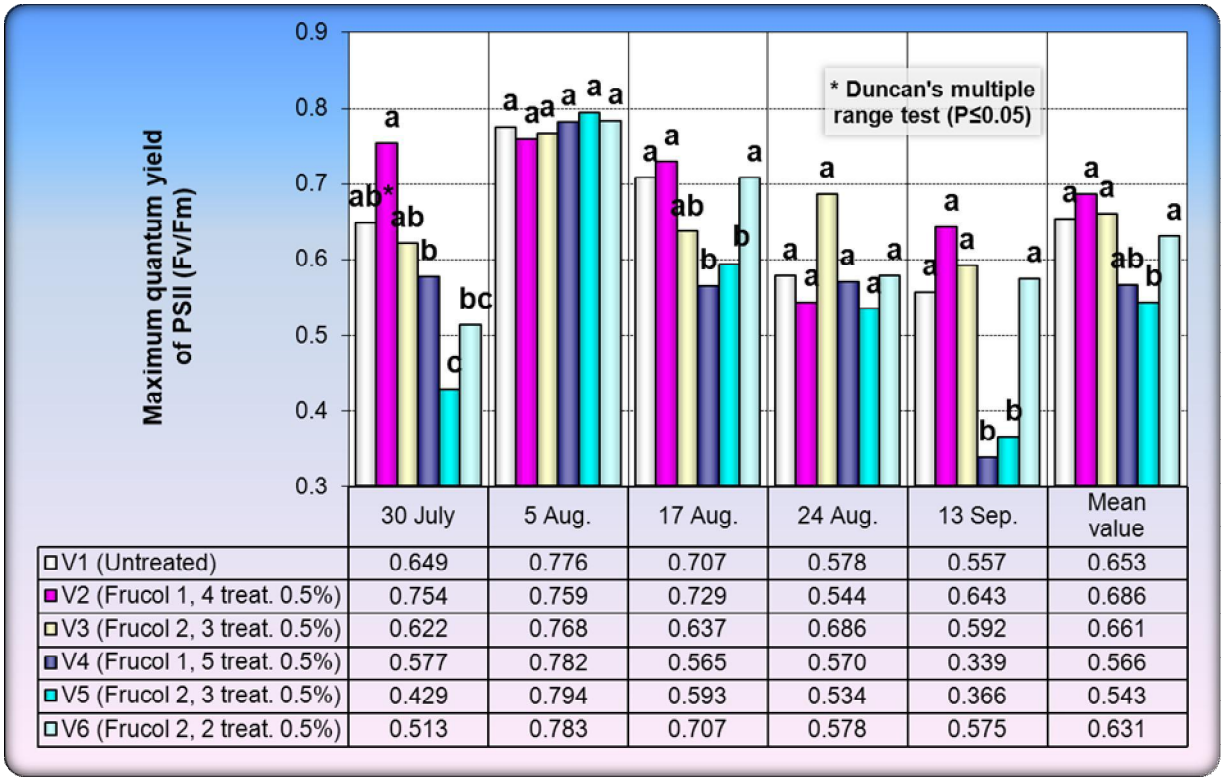
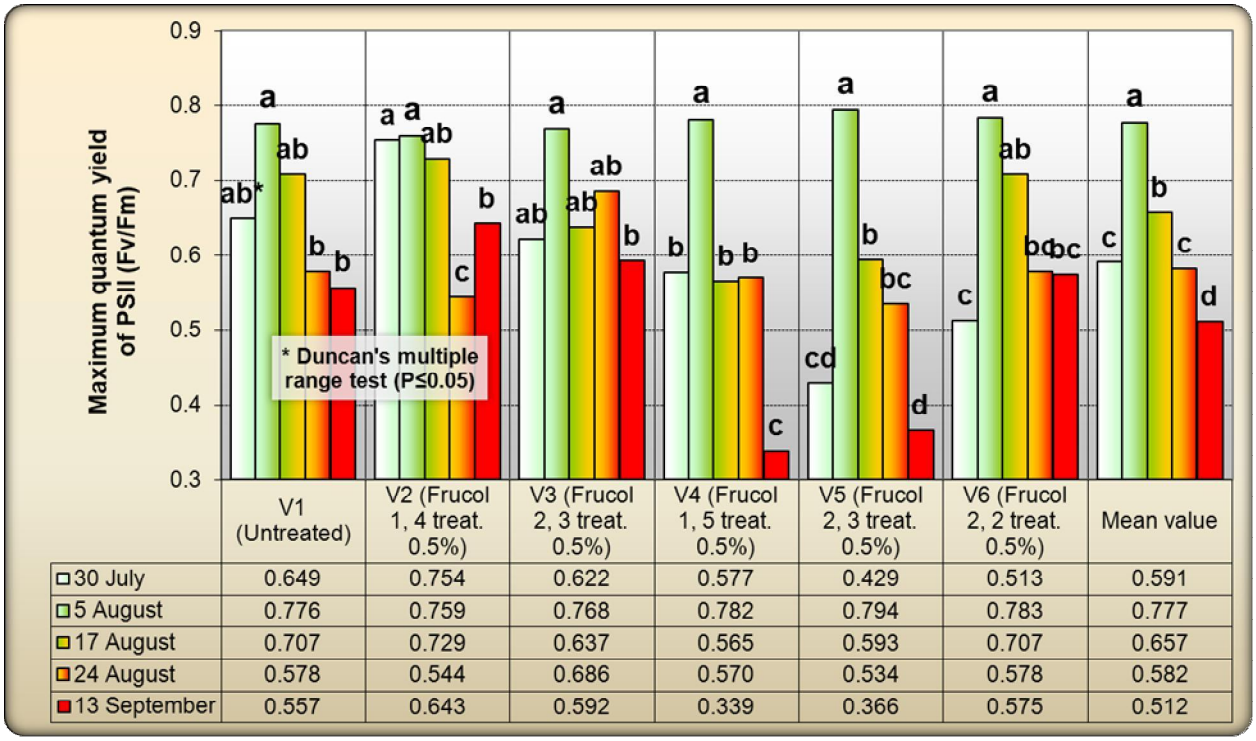


Fig. 3. Maximum quantum yield of PSII (Fv/Fm) dynamics on the 'Jonathan' cv. fruit epicarp depending on measurement timing



	30 July	5 Aug.	17 Aug.	24 Aug.	13 Sep.	Mean value
V1 (Untreated)	0.649	0.776	0.707	0.578	0.557	0.653
V2 (Frucol 1, 4 treat. 0.5%)	0.754	0.759	0.729	0.544	0.643	0.686
V3 (Frucol 2, 3 treat. 0.5%)	0.622	0.768	0.637	0.686	0.592	0.661
V4 (Frucol 1, 5 treat. 0.5%)	0.577	0.782	0.565	0.570	0.339	0.566
V5 (Frucol 2, 3 treat. 0.5%)	0.429	0.794	0.593	0.534	0.366	0.543
V6 (Frucol 2, 2 treat. 0.5%)	0.513	0.783	0.707	0.578	0.575	0.631

Fig. 4. Maximum quantum yield of PSII (Fv/Fm) variation on the 'Idared' cv. fruit epicarp depending on the variants of Frucol product application (factor B), at a constant level of measurement data



	V1 (Untreated)	V2 (Frucol 1, 4 treat. 0.5%)	V3 (Frucol 2, 3 treat. 0.5%)	V4 (Frucol 1, 5 treat. 0.5%)	V5 (Frucol 2, 3 treat. 0.5%)	V6 (Frucol 2, 2 treat. 0.5%)	Mean value
30 July	0.649	0.754	0.622	0.577	0.429	0.513	0.591
5 August	0.776	0.759	0.768	0.782	0.794	0.783	0.777
17 August	0.707	0.729	0.637	0.565	0.593	0.707	0.657
24 August	0.578	0.544	0.686	0.570	0.534	0.578	0.582
13 September	0.557	0.643	0.592	0.339	0.366	0.575	0.512

Fig. 5. Maximum quantum yield of PSII (Fv/Fm) dynamics on the Idared cv. fruit epicarp (factor C), at constant level of Frucol treatments

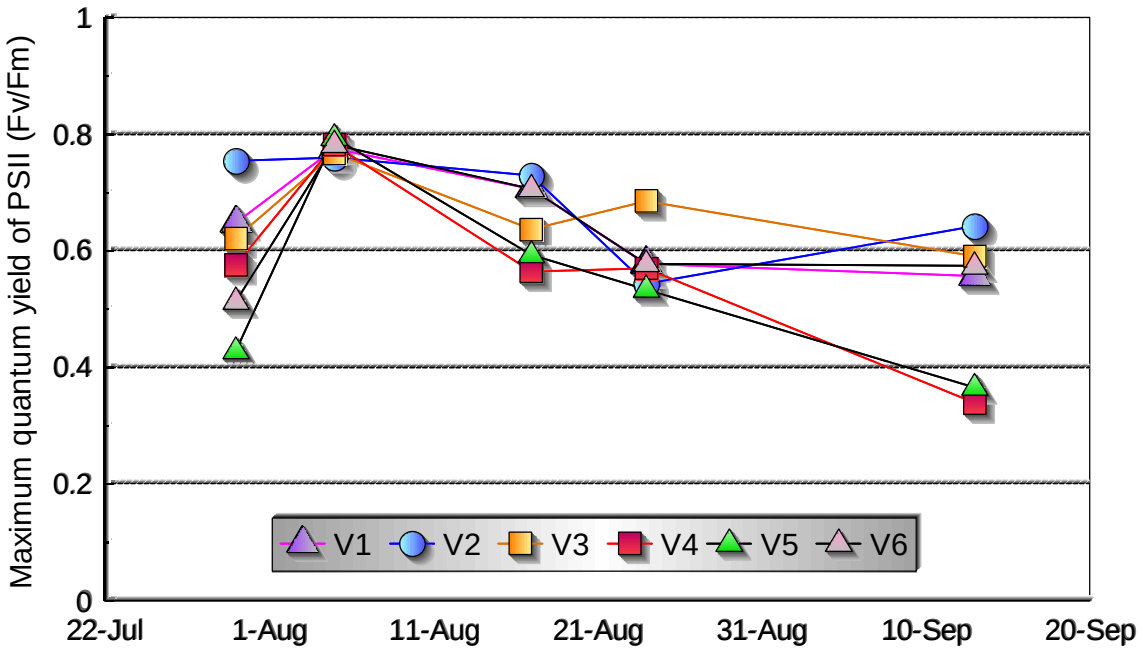
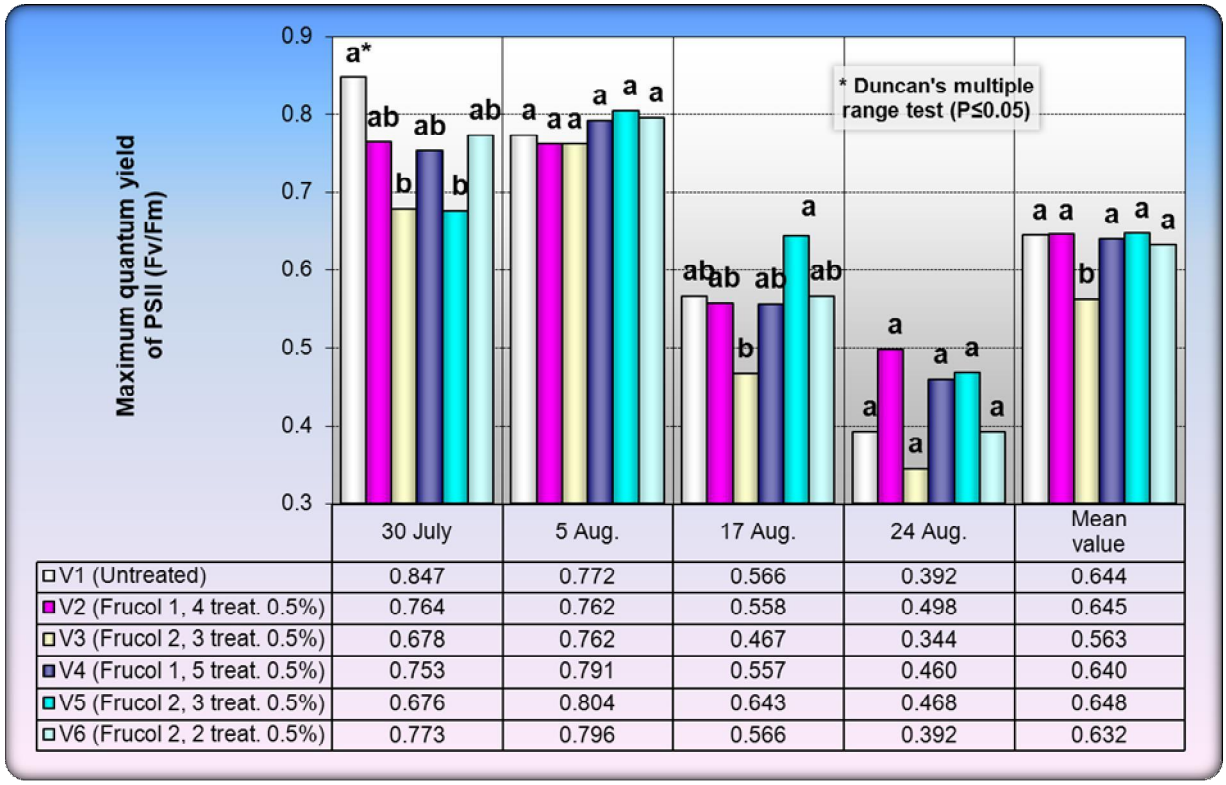
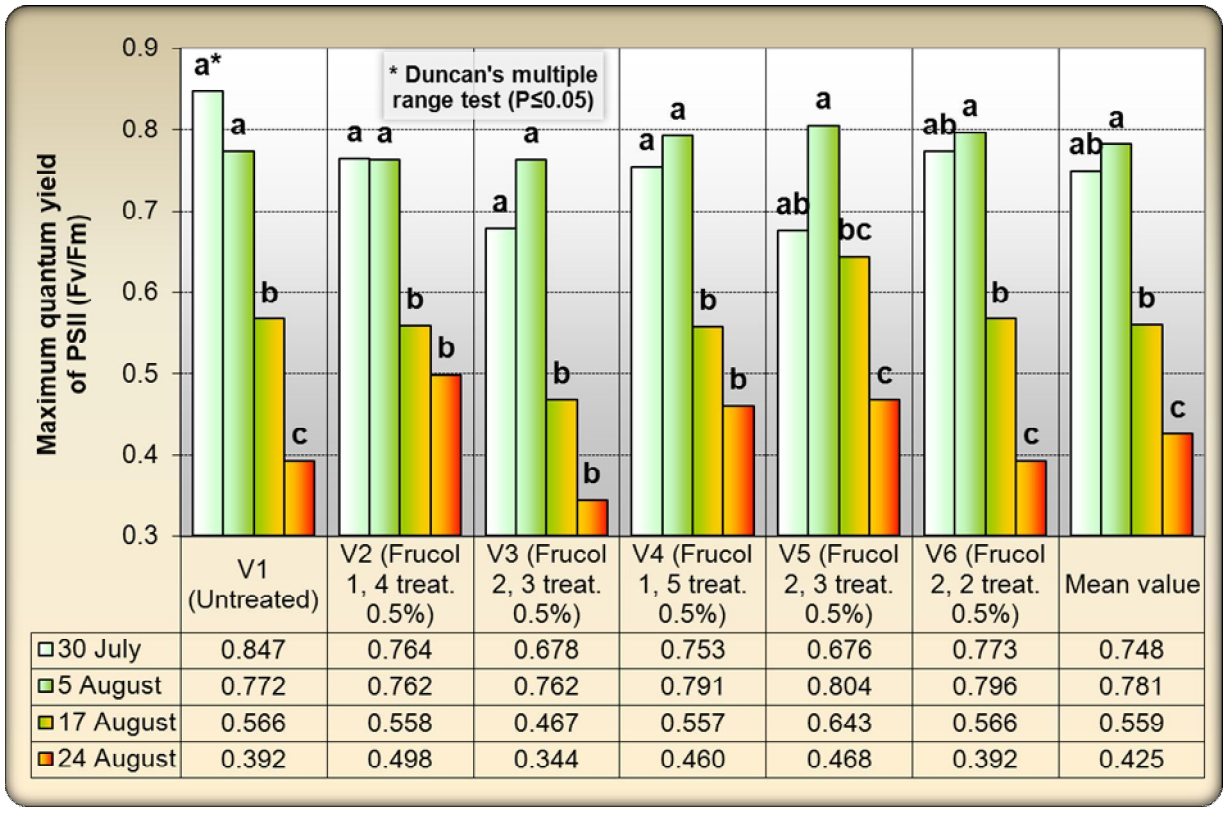


Fig. 6. Maximum quantum yield of PSII (Fv/Fm) dynamics on the 'Idared' cv. fruit epicarp depending on application timing



	30 July	5 Aug.	17 Aug.	24 Aug.	Mean value
V1 (Untreated)	0.847	0.772	0.566	0.392	0.644
V2 (Frucol 1, 4 treat. 0.5%)	0.764	0.762	0.558	0.498	0.645
V3 (Frucol 2, 3 treat. 0.5%)	0.678	0.762	0.467	0.344	0.563
V4 (Frucol 1, 5 treat. 0.5%)	0.753	0.791	0.557	0.460	0.640
V5 (Frucol 2, 3 treat. 0.5%)	0.676	0.804	0.643	0.468	0.648
V6 (Frucol 2, 2 treat. 0.5%)	0.773	0.796	0.566	0.392	0.632

Fig. 7. Maximum quantum yield of PSII (Fv/Fm) variation on the 'Jonathan' cv. leaves depending on the variants of Frucol product application (factor B) at a constant level of measurement data



	V1 (Untreated)	V2 (Frucol 1, 4 treat. 0.5%)	V3 (Frucol 2, 3 treat. 0.5%)	V4 (Frucol 1, 5 treat. 0.5%)	V5 (Frucol 2, 3 treat. 0.5%)	V6 (Frucol 2, 2 treat. 0.5%)	Mean value
30 July	0.847	0.764	0.678	0.753	0.676	0.773	0.748
5 August	0.772	0.762	0.762	0.791	0.804	0.796	0.781
17 August	0.566	0.558	0.467	0.557	0.643	0.566	0.559
24 August	0.392	0.498	0.344	0.460	0.468	0.392	0.425

Fig. 8. Maximum quantum yield of PSII (Fv/Fm) dynamics on the 'Jonathan' cv. leaves, at a constant level of the Frucol treatments

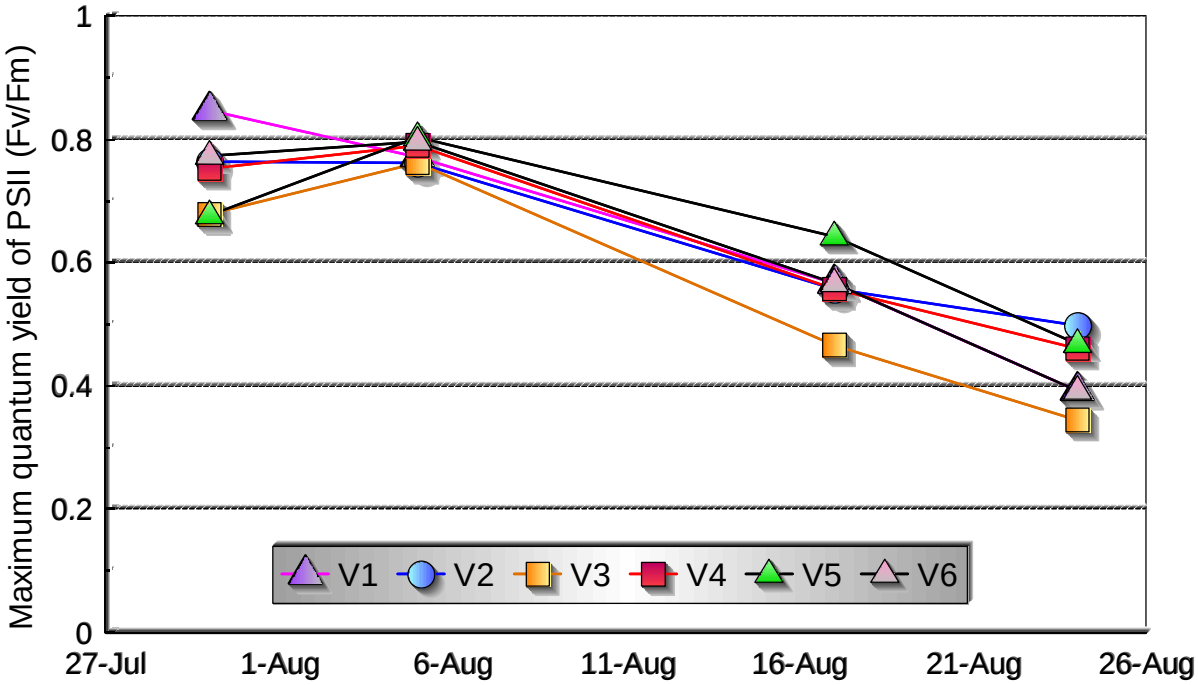


Fig. 9. Maximum quantum yield of PSII (Fv/Fm) dynamics on the Jonathan cv. leaves against application timing

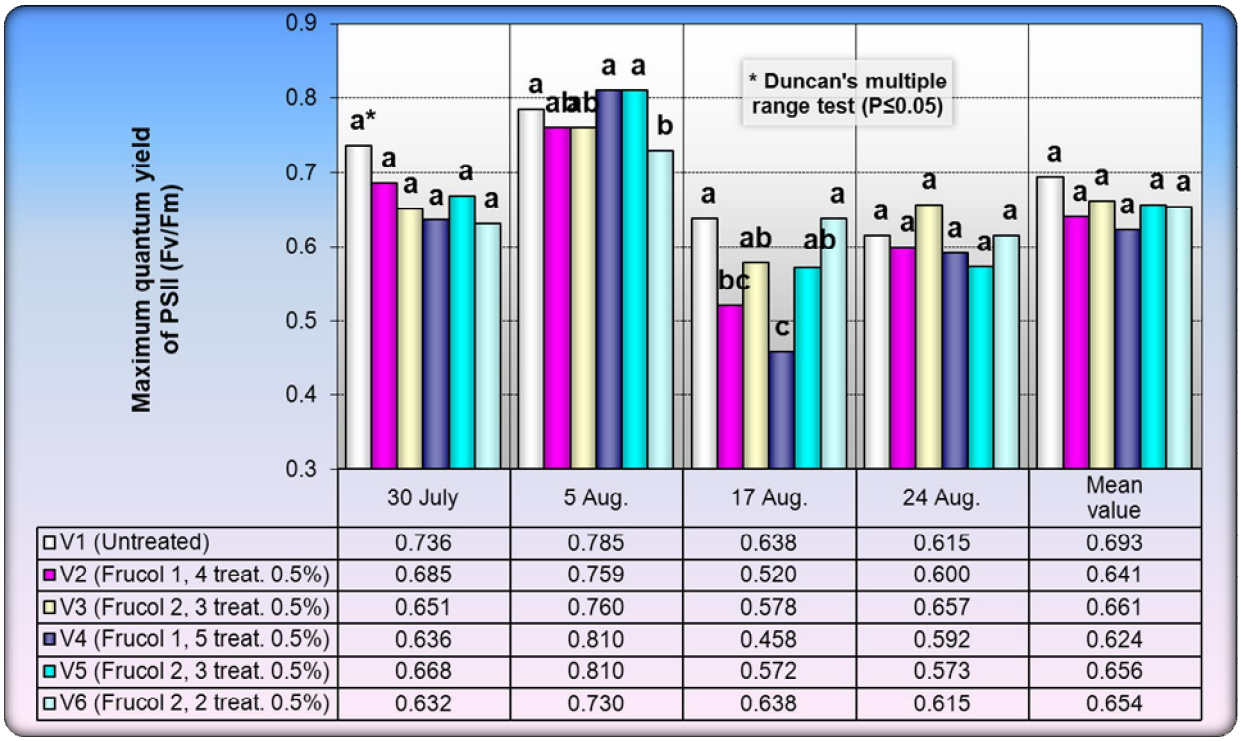
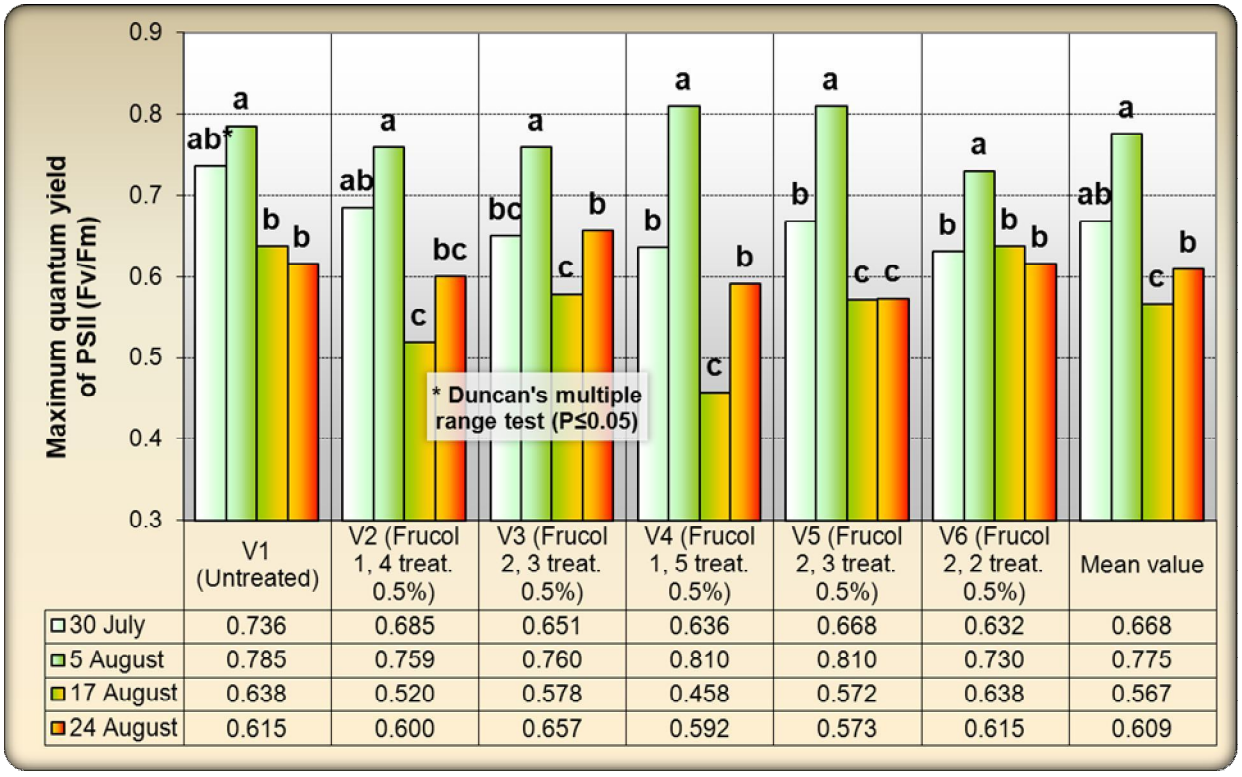


Fig. 10. Maximum quantum yield of PSII (Fv/Fm) variation on the 'Idared' cv. leaves depending on the variants of Frucol product application (factor B),at a constant level of measurement data



	V1 (Untreated)	V2 (Frucol 1, 4 treat. 0.5%)	V3 (Frucol 2, 3 treat. 0.5%)	V4 (Frucol 1, 5 treat. 0.5%)	V5 (Frucol 2, 3 treat. 0.5%)	V6 (Frucol 2, 2 treat. 0.5%)	Mean value
30 July	0.736	0.685	0.651	0.636	0.668	0.632	0.668
5 August	0.785	0.759	0.760	0.810	0.810	0.730	0.775
17 August	0.638	0.520	0.578	0.458	0.572	0.638	0.567
24 August	0.615	0.600	0.657	0.592	0.573	0.615	0.609

Fig. 11. Maximum quantum yield of PSII (Fv/Fm) dynamics on the 'Idared' cv. leaves, at a constant level of the Frucol treatments

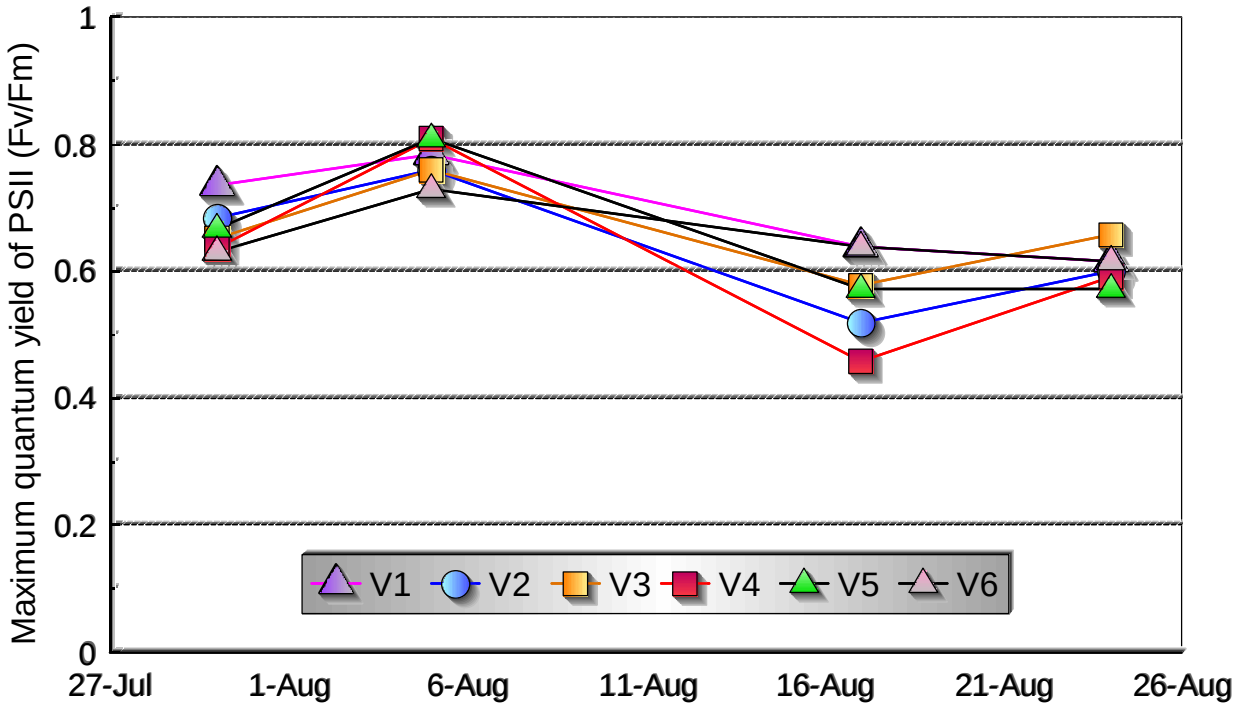


Fig. 12. Maximum quantum yield of PSII (Fv/Fm) dynamics on the Idared cv. leaves against application timing