Bearing effect on the quantum yield of satsuma mandarin leaves

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ABSTRACT

As a part of research on the effect of bearing on photosynthesis of satsuma mandarin a comparison of quantum yield (Fv/Fm) between bearing and non-bearing trees was made for two cultivars ('Aoshima' and 'Miyagawa'). Fv/Fm has been stable at about 0.8 up to October, regardless of shoots type or cultivars. Thereafter it decreased gradually, especially in vegetative shoots. The Fv/Fm for vegetative shoots of 'Aoshima' showed higher in bearing trees than in non-bearing trees, excluding October. Such difference was not observed in the vegetative shoots of 'Miyagawa' and mixed shoots of both cultivars. Harvest resulted in marked decrease in Fv/Fm of mixed shoots, regardless of cultivars. Whereas it was not observed in vegetative shoots. These results suggested that fruit load generally do not influence on Fv/Fm of the mixed and vegetative shoots but harvest induced any damage in PSII system in the leaves of the mixed shoots.

It is well known that photosynthesis is affected by bearing (apple, Wibbe and Blanke, 1995; grapevine, Loveys and Kriedeman, 1974; pecan, Wood, 1988). Also in citrus (Lenz and Daunicht, 1971) higher photosynthesis has been reported when the trees bear more than when they bear less. However, reports about how and where bearing affects the photosynthetic process is not sufficient. Photosynthesis, which fixes carbon dioxide, is composed of two processes; the Calvin-Benson cycle: enzymes chain relating CO_2 fixation and the electron transport system: producer of the cycle motive force (Foyer et.al.,1990). Reports have indicated that bearing may regulate photosynthesis via stomatal behavior (Loveys and Kriedeman, 1974; Okuda et al., 1996), but none have shown whether it affects the electron transport system that drives the Calvin-Benson cycle. In many plants, physiological stresses such as heat (Havaux,1992) and low temperature (Bjorkman, 1987), as well as water stress (Havaux,1992) are known to damage the chlorophyll-PSII complex thereby reducing CO_2 uptake. Bearing may function as a type of stress for the tree, visually excessive bearing being seen to damage trees. On the other hand, bearing is considered to act as a promoter that enhances

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photosynthesis (Lenz and Daunicht, 1971; Wibbe and Blanke, 1995; Wood, 1988). To investigate the effect of bearing on energy transfer in PSII system of satsuma mandarin leaves we made a comparison in Fv/Fm which represented quantum yield in PSII system (Demmig and Bjorkman 1987) between bearing and non-bearing trees. Two satsuma mandarin cultivars that greatly differ in sink (fruit) volume and activity were used for this experiment.

MATERIALS AND METHODS

Plant material

The two cultivars of satsuma mandarin used were 28-year-old 'Aoshima' and approximately 40-year-old 'Miyagawa' satsuma mandarin (*C. unshiu* Marc.) trees grown in an experimental open field in the mid-district (Lat. 35° 03′ N., Long. 138° 31′ E.) of Japan. The 'Aoshima' is late maturing (harvest: early-December) and bears relatively large fruit (average weight 115g). 'Miyagawa' is an early maturing cultivar (harvest: early-November) that bears relatively small fruit (average weight 102g).

Measurement of fluorescence

A PAM 2000 portable fluorometer (Waltz, Germany) with attachments was used for chlorophyll fluorescence measurements. In the Fo and Fm determinations, after dark adaptation for fifteen minutes produced by a dark leaf clip, Fo, minimum fluorescence, was measured under low intensity light, 650 nm (peak wavelength) measuring light at 600Hz modulation. The emission induced by a saturating pulse (0.1sec) repeated eight times was recorded as Fm, maximum fluorescence. The variable fluorescence, Fv, was calculated by subtracting Fo from Fm (Calatayud et al., 1996). The quantum yield (Fv/Fm), representative of maximal photochemical energy dissipation, was obtained from them. The trees were completely defruited in August, no fruit being removed from the rest of the trees. Fluorescence parameters were compared from August (before fruit thinning) to December in order to investigate the effects of bearing on Fv/Fm. The number of leaves per fruit was about 15 for 'Aoshima' and 12 for 'Miyagawa', relatively lower than the usual values of 25-30 for 'Aoshima' and 20-25 for 'Miyagawa' after fruit thinning. Measurements were made monthly on five leaves from each of five trees ('Aoshima') or of three trees ('Miyagawa'). The average for the five leaves is regarded as representing the type of shoot on the tree. The experiments were performed on intact attached new leaves from mixed and vegetative shoots. The terminal leaves of each type of shoot were measured because they showed a high rate of photosynthesis (Okuda et al.,1990).

RESULTS AND DISCUSSION

Change in fluorescence emitted from dark-adapted leaves of mixed and vegetative shoots of two satsuma mandarins

1. Mixed shoots

The Fv/Fm values for the bearing and non-bearing trees of 'Aoshima' and 'Miyagawa' were almost stable at about a little less than 0.8 up to October thereafter they decreased gradually (Figure 1-a, -c). Especially the bearing trees showed an abrupt decrease after harvest in early November for 'Miyagawa' or in early 'December' for 'Aoshima'. However, as for 'Miyagawa' the conspicuous drop was temporary and the Fv/Fm value rised again.

There were no differences in Fv/Fm of mixed shoots between bearing and non-bearing trees, regardless of great difference in sink size and activity of fruit and maturing time, except for data obtained just after harvest (Figure 1-a, -c). This means that bearing does not affect quantum yield of mixed shoots which are considered to be strongly effected by bearing. It is considered that Fv/Fm well reflect on the status of PSⅡcenter and the decrease imply the damage such as photoinhibition (Bjorkman, 1987). Therefore a remarkable drop in Fv/Fm after harvest (Figure .1-a, -c) suggested that fruit removal by harvest caused any temporary damage in PSⅡsystem then photochemical energy dissipation could decrease. But this damage possibly be somehow recoverable as shown in 'Miyagawa' (Figure 1-c).

2. Vegetative shoots

The Fv/Fm values for the bearing and non-bearing trees of 'Aoshima' and 'Miyagawa' were relatively stable from August to October at about 0.8 or a little less than it, then decreased markedly. The decrease was almost same for bearing and non-bearing trees of 'Miyagawa' whereas as for 'Aoshima' the Fv/Fm of the non-bearing trees decreased more markedly.

There were no differences in Fv/Fm between bearing and non-bearing tress. This indicated

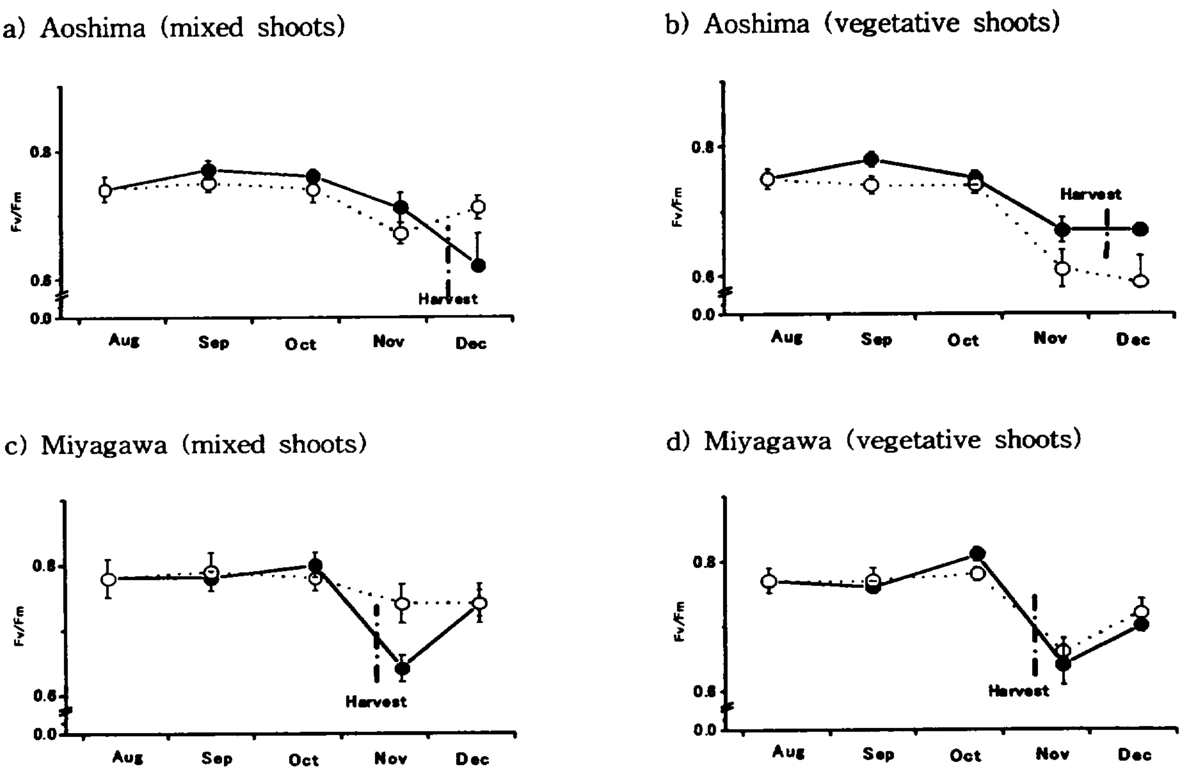

Fig. 1. Seasonal changes in Fv/Fm of bearing (●) and non-bearing trees (○) of 'Aoshima' (mixed shoots, a ; vegetative shoots, b) and 'Miyagawa' (mixed shoots, c ; vegetative shoots, d) unshiu.

In non-bearing trees fruit was thinned in August. No fruit was taken from bearing trees. Fv/Fm (●,○) for mixed and vegetative shoots from each treatment were measured until December. Vertical bars represent standard error (n=5 for Aoshima, n=3 for Miyagawa).

that bearing did not affect quantum yield in also vegetative shoots of 'Aoshima' and 'Miyagawa'(Figure 1-b, -d). Considered that bearing trees showed similar decreasing pattern in Fv/Fm as non-bearing trees before and after harvest, harvest appeared to affect nothing on quantum yield in the vegetative shoots. The bearing trees of 'Aoshima' showed more Fv/Fm value than non-bearing tees, excluding October. Similar result could not be found in the mixed shoots being influenced more by bearing. Although the cause is obscure, there could be the case that fruit load enhance PSII activity. This is also supported by that the effect appeared only in 'Aoshima', stronger cultivar in sink volume and activity, than 'Miyagawa'.

The decreases in Fv/Fm after November were conspicuous in non-bearing trees for both cultivars. This decrease could be because that low temperature (Farage and Long, 1987) and drought stress (Bjorkman and Powell, 1984) from late fall to early winter increase the sensitivity of photoinhibition and thereby the PSII system in the leaves may be easily damaged. Moreover, it is interesting that there was difference in the seasonal change in quantum yield depending on shoots type. This suggest that the original difference may be kept in relation to PSII status even if all fruit was removed.

The above results, using two satsuma mandarin cultivars that differ in sink volume and activity for nutrients and water, the effect of fruit load on quantum yield of mixed and vegetative shoots are considered to be small. However, it is appeared that harvest induced a temporary decrease in quantum yield of mixed shoots.

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