Effects of shading orientation on soybean isoflavone concentration to predict the influence of trees in agroforestry systems

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Abstract

Introduction Soybean cultivation in Italy has developed since the 80s mainly for animal feeding, thanks to its high protein content, and for human uses mainly for oil production.

Agroforestry practices are becoming increasingly important as a means to improve carbon sequestration and mitigate climate change. Soybean is a crop that could fit well with this new agricultural approach, especially because it is a nitrogen fixing species. Soybean is also increasingly used for nutraceutical production. Isoflavones are the most important nutraceutical compounds, and are used for their antioxidant activity and anticholesterolemic effect.

Materials and methods The experimental trials were carried out in 2019 at the experimental farm of the University of Padova (Legnaro, Padova, I). Total seed isoflavone concentration (TIC) and the isoflavone profile was evaluated in the variety "Sarema" (Semfor, Casaleone – Verona, I), which is largely cultivated in NE Italy. The aim of the work was to study the effects of differently-orientated artificial shading on TIC in soybean in order to predict the effects of shading due to tree lines within an agroforestry system.

Soybean plants were cultivated under four 4-m^2 shaded areas within cube structures (isolators), two of which had only one open side (with light entering) facing to East, and two facing to West. The shading level of the net covering the isolators was 50% of photosynthetic active radiation (PAR). An external control under full sun conditions was evaluated near the shaded plants. Three independent sampling areas were considered in each isolator and in the control area (n = 6). Sowing density was 30 plants m^{-2}. At harvest the TIC was measured by HPLC (Hubert et al., 2005).

The East-West shading orientation was chosen based on the documented greater morphological modifications induced on soybean plants compared to North-South directions (Kasperbauer et al., 1987).

Results TIC of East-lit plants (i.e., lighting from East) was 25% higher than in the unshaded controls (NSC), and 27% higher than West-lit plants (i.e., lighting from West)($P<0.05$)(Figure 1). This effect may be related to the different light quality of East- or West-lighted soybean plants. In fact, light with the main direction East, from 07.00-12.00 a.m., is expected to be more depleted in its far red (FR) component, This being preferentially filtered by the abundance of both morning mist and low cloud cover (+ 30% low cloud cover in the time 7.00-12.00 a.m. vs. 14.00-19.00 p.m.) (from Meteo Blue, CH).

It is known that light with a relatively high R (red) / FR (far red) ratio (i.e., light from the East, at morning) stimulates the transition from inactive phytochrome "pr" to the active form "pfr" by isomerization of the phytochromobilin. This isomerization causes a morphological modification of the phytochrome Holo-proteins, thus exposing their nuclear localization sequences (NLSs) by which they can be transported to

the cell nucleus and be activated by dephosphorylation (Lorrain et al., 2008). Phytochrome "pfr" prevents the expression of genes for cell expansion by marking the PIF proteins with ubiquitin (Xu et al., 2017).

This effect could lead the plants exposed to light from the East to produce less biomass, as was observed (-22% vs. West-exposed, P<0.05) and lower yield. It is also known that the activity of the PAL enzyme (Phenylalanine ammonium-lyase), one of the main enzymes of the metabolic pathway of flavonoids and isoflavones, is proportional to the concentration of the "pfr" form of phytochrome and this would explain the greater isoflavone concentrations observed in East-lighted plants (Brodenfeldt 1988).

Conclusions The East or West orientation of shading affects the metabolic activity of soybean plants. A principal exposure to light from the East (e.g., soybean at the East side of a possible tree row) can stimulate greater activity of the isoflavone pathway at the expense of growth and yield. The choice of the shading orientation in agroforestry systems could be relevant to maximise yield or nutraceutical compounds.

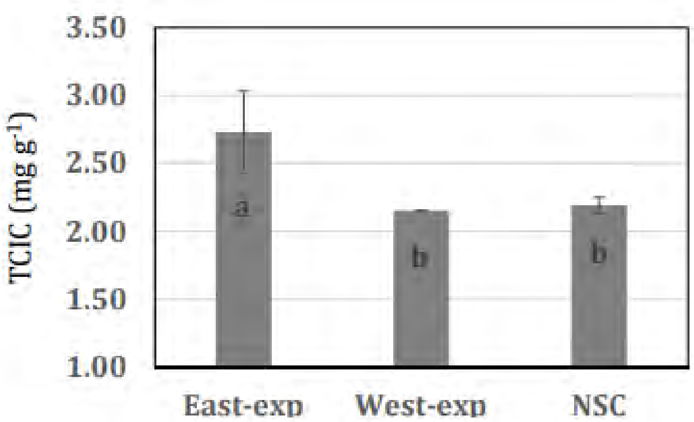

Figure 1. Total Isoflavone Concentration (TIC) in soybean variety Sarema cultivated under prevalently light exposure to East (East-exp) and West (West-exp), compared to not shading controls (NSC, full sun) (Tukey-Kramer test, P<0.05).

References

Kasperbauer MJ, (1987) Far-red light reflection from green leaves and effects on phytochrome-mediated assimilate partitioning under field conditions. Plant physiology, 85(2): 350-354.
Lorrain S, Allen T, Duek PD, Whitelam GC, Fankhauser C, (2008) Phytochrome˜ mediated inhibition of shade avoidance involves degradation of growth˜ promoting bHLH transcription factors. The Plant Journal, 53(2): 312-323.
Xu X, Kathare PK, Pham VN, Bu Q, Nguyen A, Huq E, (2017) Reciprocal proteasome-mediated degradation of PIFs and HFR1 underlies photomorphogenic development in Arabidopsis. Development, 144(10):1831-1840.
Brödenfeldt R, Mohr H, (1988) Time courses for phytochrome-induced enzyme levels in phenylpropanoid metabolism (phenylalanine ammonia-lyase, naringenin-chalcone synthase) compared with time courses for phytochrome-mediated end-product accumulation (anthocyanin, quercetin). Planta, 176(3): 383-390.
Hubert J, Berger M, Daydé J (2005) Use of a simplified HPLC−UV analysis for soyasaponin B determination: study of saponin and isoflavone variability in soybean cultivars and soy-based health food products. J Agric Food Chem 53 (10): 3923–3930.