Yield gaps estimation for greenhouse tomato crops in Uruguay

Berrueta, C.[a], Heuvelink, E.[b], Giménez, G.[a], Dogliotti, S.[c]

a Programa de Horticultura, Instituto Nacional de Investigación Agropecuaria Las Brujas, Ruta 48 Km 10 (90200), Rincón del Colorado, Uruguay.
b Horticulture and Product Physiology, Wageningen UR, Droevendaalsesteeg 1 6708 PB, Wageningen, The Netherlands.
c Departamento de Producción Vegetal, Facultad de Agronomía, Universidad de la República, Garzón 809 (12900), Montevideo, Uruguay.
E-mail: cberrueta@inia.org.uy

6th International Symposium for Farming Systems Design

Introduction

Understanding and ranking the main causes of yield gaps is essential to provide feedback to farmers and extension agents to contribute to reduce both yield gap and yield variability between farms.

Objective: quantify yield gaps in greenhouse tomato crops in the south region of Uruguay and assess opportunities for increasing tomato production by modifying those factors defining potential yield (Van Ittersum and Rabbinge, 1997).

Methods

We assessed yields and yield components across seasons, in 110 greenhouse tomato crops (indeterminate beef tomato varieties) during 2014/15 and 2015/16 in south Uruguay, and compared them with potential and attainable yield. We distinguished 5 types of tomato crop cycles (Table 1).

Table 1. Description of crop cycle types and number of crops.

Crop cycle type	Crop period length (days)	Transplanting date	Crops
Short spring	< = 200	1st July until 30th September	33
Short autumn	< = 200	1st January until 31th March	30
Short summer	< = 200	1st October until 31th December	11
Long winter	> 200	1st February until 31th March	5
Long summer	> 200	1st August until 31th December	31

Potential yield was calculated with a simulation model based on photosynthetic active radiation (PAR) and light use efficiency, and TOMSIM to estimate assimilate partition and fruit yield. Since yield was primarily determined by cumulated PAR intercepted, a boundary function was fitted to estimate **Attainable yield** as a function of cumulated PAR intercepted.

Conclusions

Large yield gaps were detected in tomato greenhouse crops in Uruguay and closing these gaps is a challenge.

For **long summer and short spring/summer** crops the greatest impact in yield could be obtained by increasing LAI by reducing plant lowering operations and leaf pruning intensity, and by increasing plant density.

For **autumn crops**, yield could be improved by earlier planting, reducing leaf pruning intensity after harvest beginning, and increasing greenhouse transmissivity by more frequent plastic cover renewal and removing roof shading screens and whitening.

Reference
Van Ittersum, M.K., Rabbinge, R., 1997. Concept of production ecology for analysis and quantification of agricultural imput-output combination. F. Crop. Res. 52, 197–208.

Results and discussion

The gap between actual and potential yield considering a greenhouse transmissivity of 70% (PY70) was on average 10.7 kg m^{-2} (44% of PY70). Average gap was higher for short summer and spring crops (57%), than for long summer crops (46%) and short autumn crops (24%). Overall gap was divided into three components (Fig. 2).

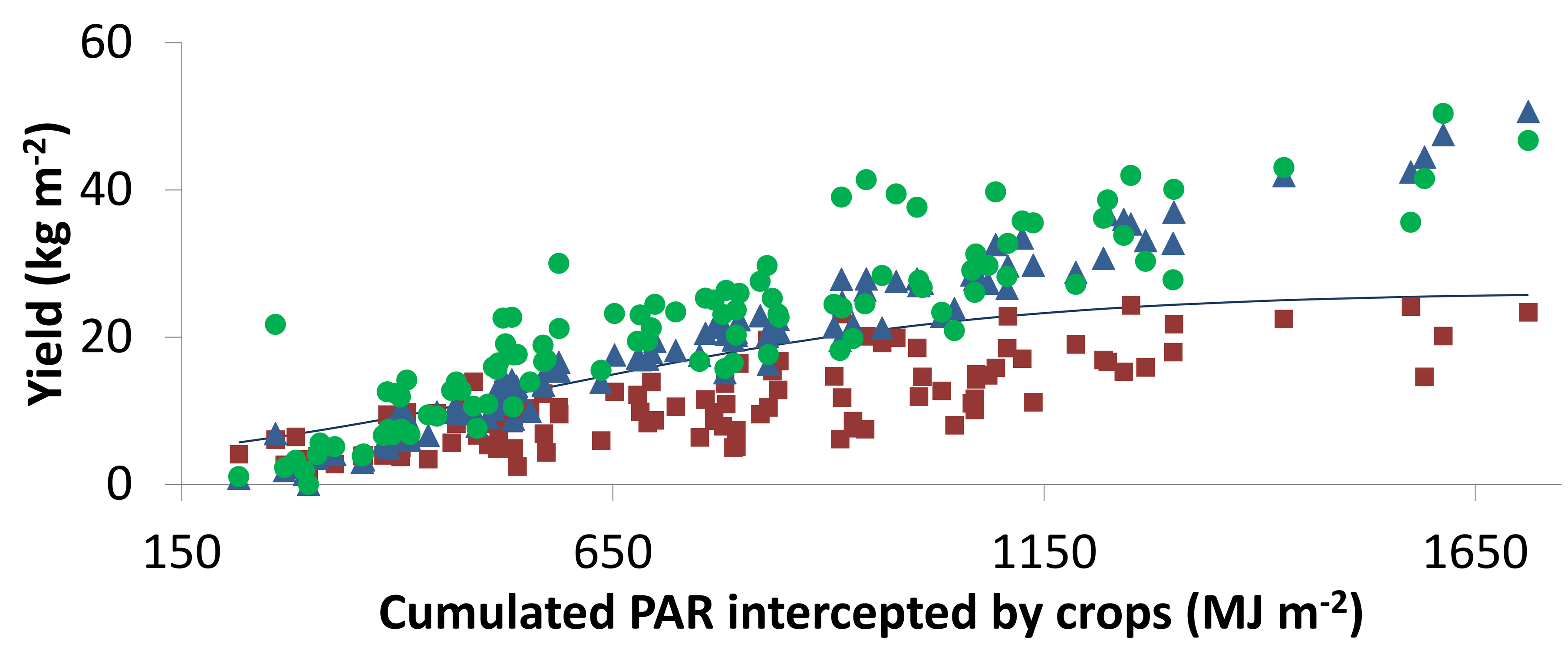

Fig. 1. Actual (■), simulated potential considering a greenhouse transmissivity of 70% (●), simulated potential with real greenhouse transmissivities (▲) and attainable yield (fitted boundary line for actual yields, $y_i = 26.16 / (1 + (7.81\, e^{-0.0036\, x_i}))$, as a function of cumulated PAR intercepted by the crops, R^2 adj: 0.95, N = 109.

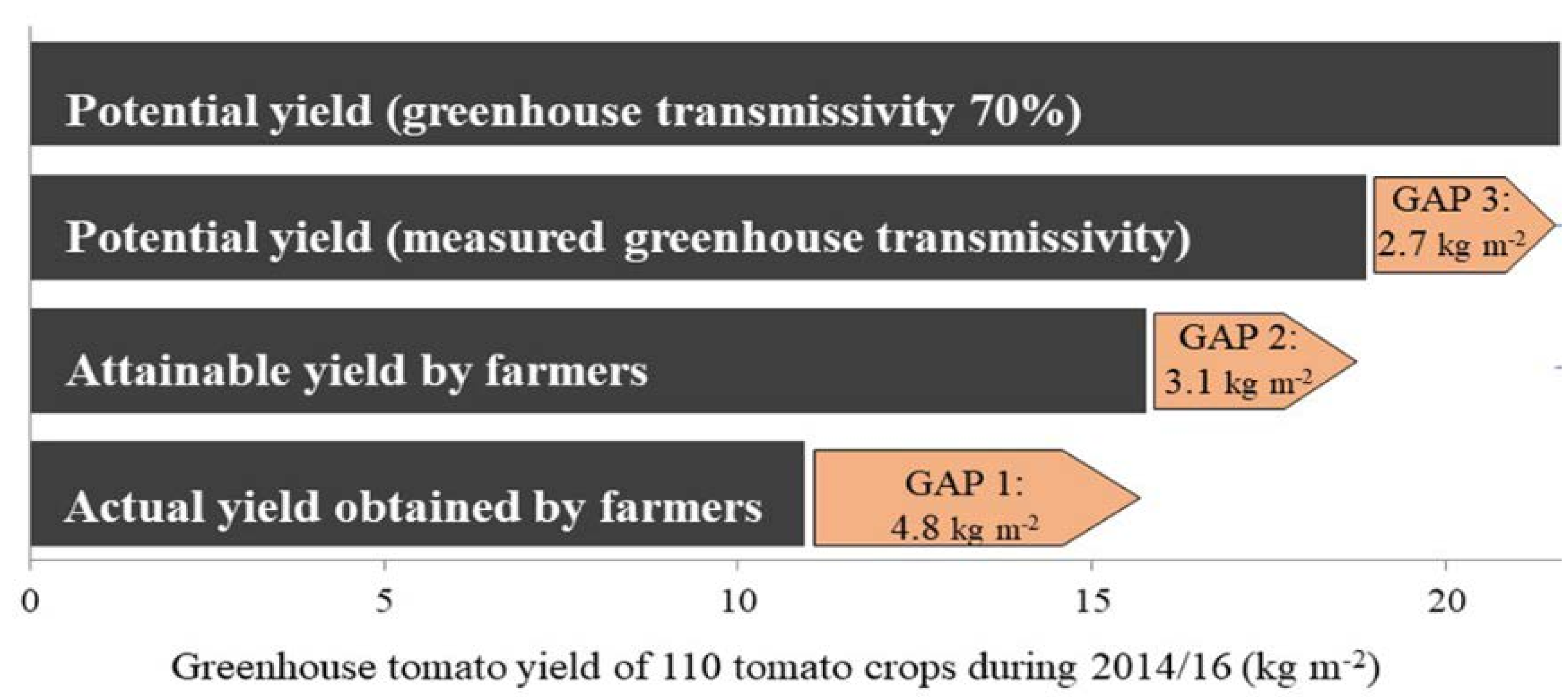

Fig. 2. Production levels and yield gaps (1, 2 and 3).

Cumulated PAR intercepted was the variable most highly correlated with yield (rs:0.8, p:<0.0001). PAR intercepted depends on daily incident radiation, crop period length and leaf area index (LAI). Daily incident radiation is affected by seasonal differences due to transplanting date, crop duration and greenhouse transmissivity. Average observed fraction PAR intercepted was 70%, 22% lower than target. Differences were observed among crop cycle types (Fig. 3). Fraction PAR intercepted at middle of harvest was correlated with leaf removal intensity (rs:-0.37, p-value:0.0059).

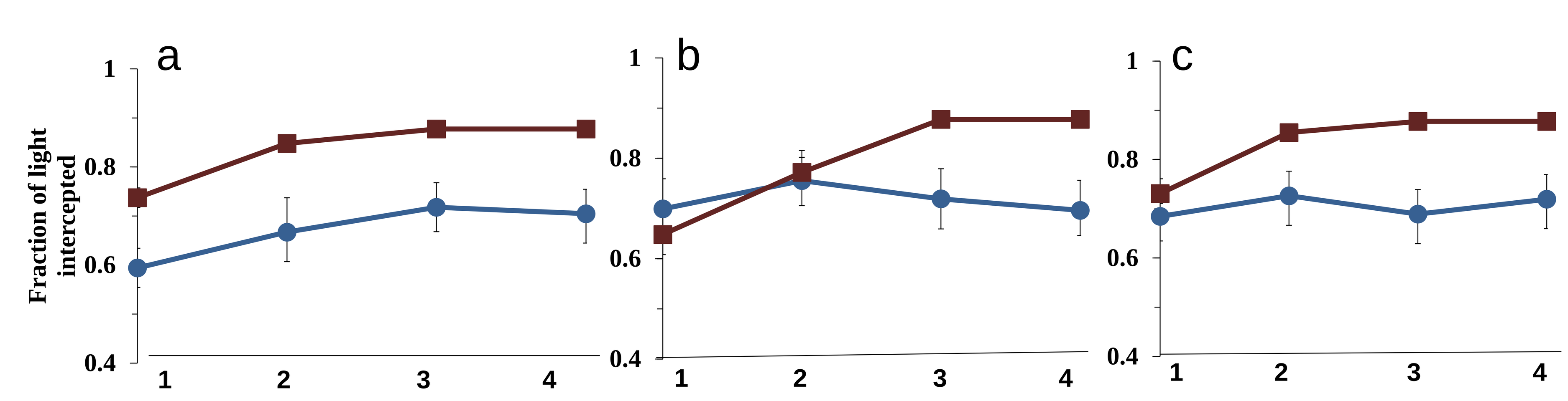

Fig. 3. Observed (●) and simulated (■) fraction PAR intercepted at first truss flowering (1), third truss initial fruit development (2), first ripe fruits (3) and middle of harvest (4), for short spring/summer (a), short autumn (b) and long summer crops (c). Vertical bars: 95% confidence interval for the mean. N = 44, 30 and 31, respectively.