

International Autonomous Greenhouse Challenge (2nd edition)

Economics

This document reports the prices necessary for the calculation of net profit in the Autonomous Greenhouse Challenge 2020.

Data on resource consumptions, tomato production and quality are reported in the dataset “Autonomous Greenhouse Challenge, Second Edition (2019)”.

NET PROFIT CALCULATION

The net profit reached in the growing challenge accounts for 50% of the final score.

Of course, the costs of running an experiment in a small research compartment are not similar to those of a commercial enterprise, and therefore, the profit-calculation provides a quantified judgement on the performance, rather than actual profit as it would be under commercial circumstances. Labour costs are difficult to quantify and capital costs are hardly accounted for. Also, packaging, transport, sales costs, costs for general management, interest etc. are not included.

Still, as the research greenhouses are realistic in terms of resource usage, a net-profit calculation can be made to create a quantified ranking of performance.

For all compartments the net profit calculation is made according to:

$$\text{Net Profit} = \text{Income} - \text{Fixed costs} - \text{Variable costs}$$

Fixed costs

The fixed costs represent the costs for plants, the CO₂ connection, lamps and screens. The plant costs were set to 2.00 euro for 1-stem plants and 2.20 euro for 2-stem plants. All teams started with 2-stem plants so the plant costs are the multiplication of this price with the number of plants per m².

All teams have the same configuration for lamps and screens, so depreciation and maintenance costs are not part of the net profit computation. The same applies to CO₂ dosing capacity.

Variable costs

The variable costs represent the electricity costs of the lamps, the energy costs for heating, the costs for CO₂, and the costs for crop maintenance. Costs of drain treatment are excluded.

| Variable costs | Value |
|--|--|
| Labour for crop maintenance ¹ | 0.0085 € per stem/m ² per day |
| Electricity | 0.08 €/kWh during peak-hours (07:00-23:00) |

| | |
|-----------------|--|
| | 0.04 €/kWh during off-peak hours |
| Heat | 0.0083 €/MJ. |
| CO ₂ | 0.08 €/kg for the first 12 kg/m ² 0.2 €/kg for the following kg's. |

¹Costs for crop maintenance

Growing a crop involves labour. In the challenge the labour costs cannot be reasonably determined because the small compartments and the many monitoring tasks by the staff result in a very large overhead.

However, a relation between crop management on the basis of number of stems per m² and labour can be made. Stem density is dependent on the management strategy and may therefore differ per team. The costs for crop management are set to € 0.0085 per stem per m² per day.

Income

The gains derive from the 'sale' of the harvested tomatoes.

The harvest was performed per truss, three times per two weeks (Monday, Friday, Wednesday). This is more challenging than harvest per fruit, as all fruits on one truss have to be of good weight and quality at the same time. Teams had the possibility to instruct the staff on the number of fruits to be maintained per truss in the top of the canopy (on a weekly basis).

There were two main harvest categories:

- **Class A:** tomatoes that can be commercially traded and were valued with full price.
- **Class B:** tomatoes that cannot be commercially traded and were valued with half the price. Class B tomatoes for instance have blossom end rot or another deformation.

[Figure 2](#) at the end of the document gives an overview of the harvest protocol followed during challenge and at the final harvest.

Every 2 weeks, samples from both harvest categories were sent to the taste-laboratory for the quality tests. The overall quality measurements are listed below:

- Flavour level on a scale of 0 (dislike) - 100 (like), calculated with Flavour Model Tomato version 2.1 (2011)
- Total soluble solids (TSS, °Brix)
- Titrable acid (Acid, mmol H₃O⁺/100 gr)
- % juice pressed from the fruit wall (pericarp) of the tomato (%Juice, %)
- breaking force of the fruit wall (pericarp), as an indicator of the perceived firmness during chewing (Bite, N)
- average fresh fruit weight (Weight, g)

In addition, fruit dry matter content was determined.

Tomato prices

In the challenge, tomato prices depended on Total Soluble Solids content (Brix) determined by our taste-laboratory. Figure 1 and Table 1 show the price trend over time and according to Brix value.

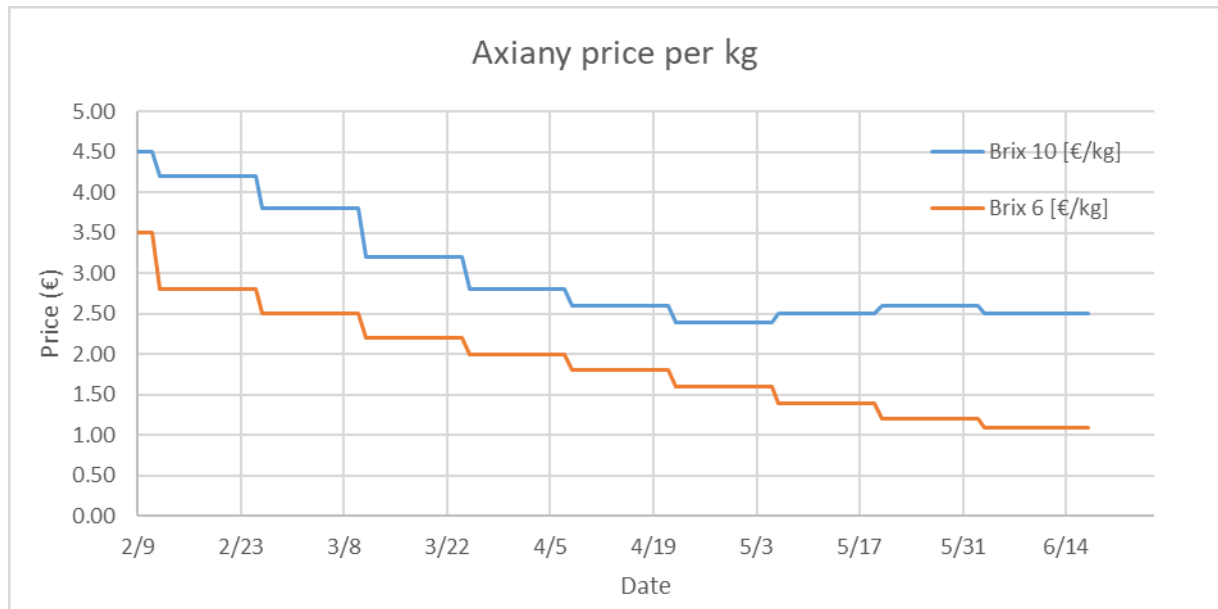




Figure 1

| Datetime | Brix 10 [€/kg] | Brix 6 [€/kg] |
|-----------|----------------|---------------|
| 1/1/2020 | 5.00 | 3.00 |
| 1/14/2020 | 5.00 | 3.00 |
| 1/15/2020 | 5.20 | 3.50 |
| 1/28/2020 | 5.20 | 3.50 |
| 1/29/2020 | 4.50 | 3.50 |
| 2/11/2020 | 4.50 | 3.50 |
| 2/12/2020 | 4.20 | 2.80 |
| 2/25/2020 | 4.20 | 2.80 |
| 2/26/2020 | 3.80 | 2.50 |
| 3/10/2020 | 3.80 | 2.50 |
| 3/11/2020 | 3.20 | 2.20 |
| 3/24/2020 | 3.20 | 2.20 |
| 3/25/2020 | 2.80 | 2.00 |
| 4/7/2020 | 2.80 | 2.00 |
| 4/8/2020 | 2.60 | 1.80 |
| 4/21/2020 | 2.60 | 1.80 |
| 4/22/2020 | 2.40 | 1.60 |
| 5/5/2020 | 2.40 | 1.60 |
| 5/6/2020 | 2.50 | 1.40 |

| | | |
|-----------|------|------|
| 5/19/2020 | 2.50 | 1.40 |
| 5/20/2020 | 2.60 | 1.20 |
| 6/2/2020 | 2.60 | 1.20 |
| 6/3/2020 | 2.50 | 1.10 |
| 6/16/2020 | 2.50 | 1.10 |
| 6/17/2020 | 2.50 | 1.10 |

Table 1. Price evolution tomato (cv Axiandy)

| Example truss | Classification |
|---|--|
|  | <p>During the continuous harvesting period, the greenhouse staff picks clusters in a ripening stage as shown here to the left. The vast majority of the fruits is fully red and the few green fruits at the far end will become red during the first shelf life days.</p> <p>Clusters like this are classified as class A.</p> <p>Any cluster with less red fruits will be left on the plant and will be harvested in one of the following harvest instances.</p> |
|  | <p>Clusters that are half-damaged or half-grown, or at the final harvest day are not predominantly red (like the one shown here to the left) are classified as class B and valued with half the price.</p> <p>So, in terms of weight, the full cluster will be weighed, but as half of the cluster will be removed during the sorting procedure, it only counts for half the price.</p> |


| | |
|---|---|
|  | <p>On the last harvest day, there will also be clusters which are predominantly green, like the one shown here.</p> <p>In case such clusters are found on this last harvest day, they will be left at the crop and end up in the shredder when the greenhouse is cleaned up.</p> <p>Such green clusters are therefore classified unsellable.</p> |
|---|---|

Figure 2