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OS5.5

Phenology modelling of fava bean (*Vicia faba L.*) cv. Reina Mora inside a Mediterranean naturally ventilated solar greenhouse.

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1. Introduction

Contribution to the Sustainable Development Goal

https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Target 2.2 - **End all forms of malnutrition.**

Recover a traditional product with a high fiber and protein content.

Target 13.1 - **Strengthen resilience and adaptive capacity to climate-change**

Protect the crop from winter frosts and strong winds.

Target 15.5 - **Reduce the degradation of natural habitats, halt the loss of biodiversity.**

Produce without using any phytosanitary product.

Target 2.2 - **End all forms of malnutrition.**

Today, **fiber intake in High-Income Countries** (HICs) is around **15 g/day**, well **below** Burkitt's **recommended** amount of fiber of more than **50 g/day** (O'Keefe, 2019).

Currently, there is also a **deficit** in the **consumption of vegetable protein** in the diet of Europeans (Short *et al*., 2022) that can be compensated by including **legumes in prepared fast food** (EC, 2018).

Fava beans have a **high protein content** (26-33% over dry weight) and **dietary fiber** (insoluble fraction range: 10-16%), in addition to **minerals** such as iron or zinc (Mayer Labba *et al*., 2021).

Target 13.1 - **Strengthen resilience and adaptive capacity to climate-change.**

Biological nitrogen fixation is attracting increasing attention due to the depletion of fossil fuels and environmental degradation globally, as it is **renewable**, **clean and environmentally friendly** compared to the industrial production of nitrogen fertilizers (Jensen and Hauggaard-Nielsen, 2003).

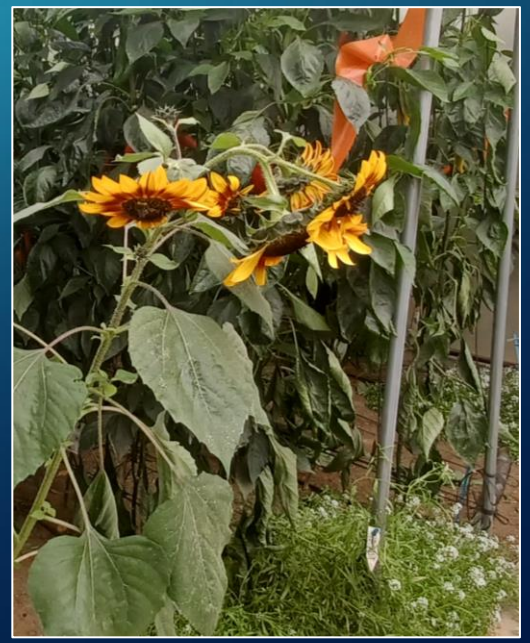
Faba beans have been shown to be **effective in fixing nitrogen from the air in the soil** (Fan *et al*., 2006).

1. Introduction

Target 15.5 - **Reduce the degradation of natural habitats, halt the loss of biodiversity.**

In recent years, **pest control** in greenhouses in Almeria is moving towards greater use of **biotechnology** and **less application of chemicals** (Acebedo *et al*., 2022).

Currently, the use of **island shelter plants** for **auxiliary insects** introduced into greenhouses and for **native fauna** that can enter spontaneously is proliferating.



1. Introduction

Fava beans (*Vicia faba* L.) are one of the **oldest crops** in the world and one of the most important **grain legumes** used for human and animal food.

1. Introduction

In Spain its **commercialization** is carried out in the form of **fresh pod**s, for the consumption of grains, as **frozen grains** and in the form of **dry** and **fried** or **toasted grains**.

Fresh pods of faba bean

2-5 €/kg

Frozen faba grains

4-10 €/kg

Fried grains

5-10 €/kg

Toasted grains

5-10 €/kg

Figure 1. Different form of commercialisation of faba beans in the supermarkets.

1. Introduction

In some villages of Almeria, it was traditional the consumption of **tender faba pods flour coated fried** in olive oil, so-called "***jaruguillas***".

Given the current **lack of fiber** and **vegetable proteins** in the **diet of Europeans**, and the **need to diversify crops** in the greenhouses of Almeria (Spain), we have analysed the possibility of growing **faba beans in greenhouses** for the production of **tender fresh pods.**

2. Objetive

The objective of this work is to **analyze the phenology** and **production** of **fava bean** cultivated in a **semi-opened greenhouse** and compare the **development** of the observed crop with the potential development in **open field** and in **naturally ventilated solar greenhouses**.

3. Materials and methods

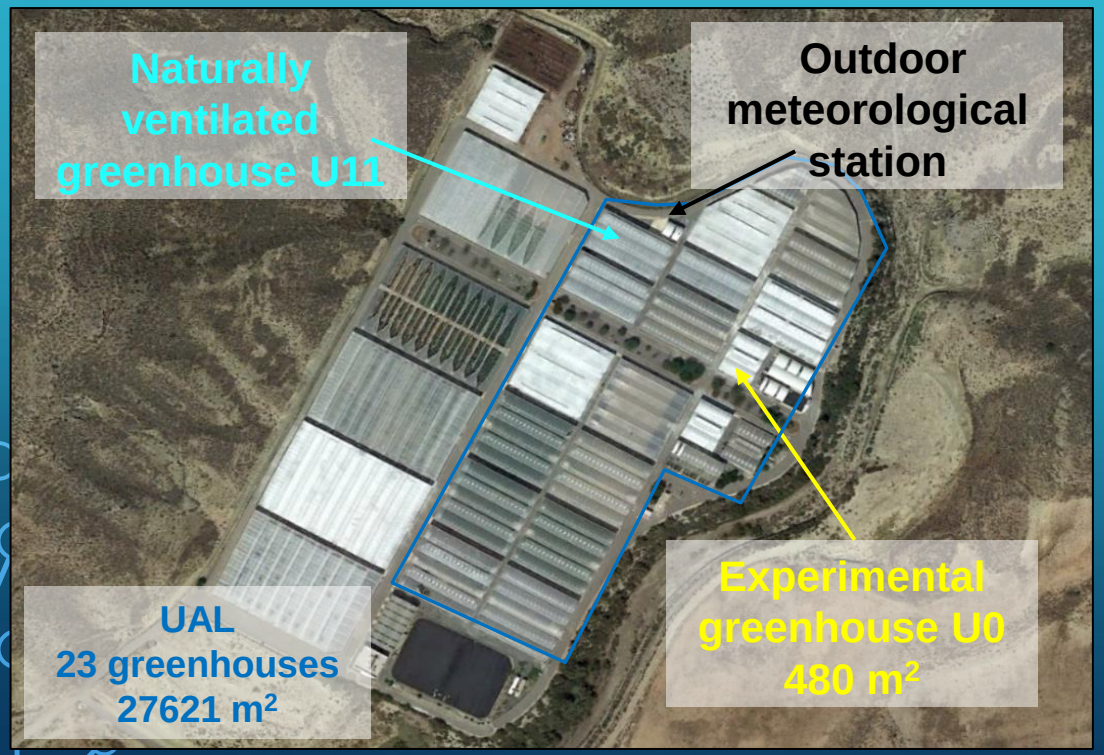
3.1. Experimental set-up

On **October 4, 2022**, the variety '***Reina Mora***' of faba beans (Semillas Fitó, Barcelona, Spain) was sowed in an "*arenado*" **sand mulching soil** inside a solar three-span greenhouse, using thermal blanket to cover the soil for three weeks (until the October 25).

Figure 2. Faba beans sowed in "*arenado*" soil in a greenhouse under thermal blankets.

3. Materials and methods

The greenhouse was located in the **Experimental Station UAL-ANECOOP** "*Catedrático Eduardo Fernandez*" in **Almería, Spain** (Longitude: 2°170 W, Latitude: 36°510 N, altitude: 90 m above mean sea level and time zone GMT+2).



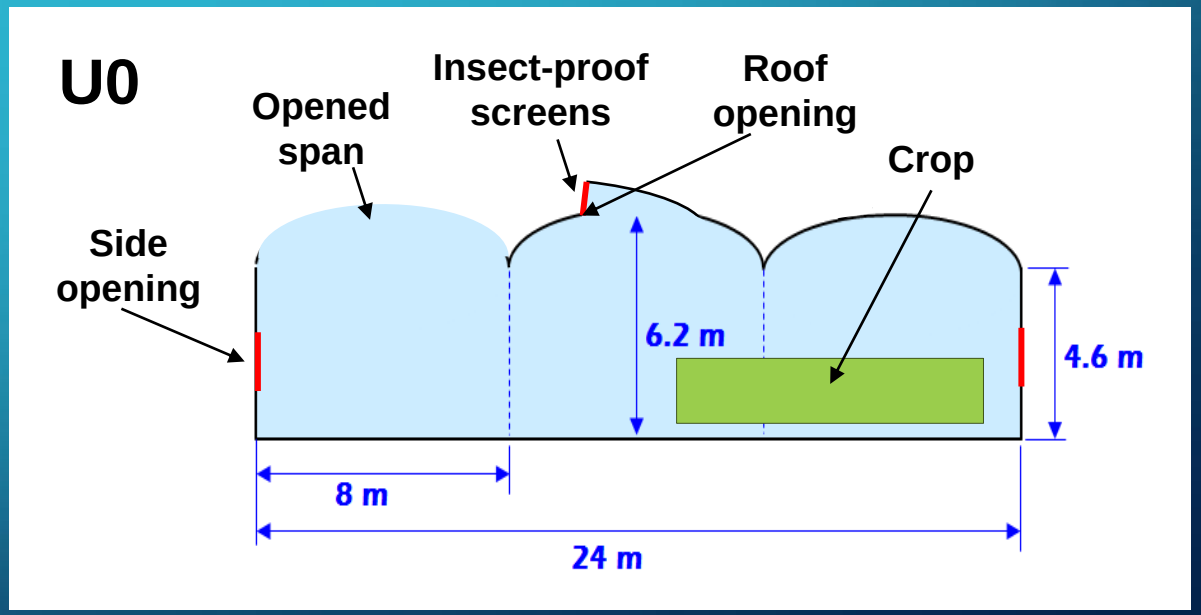
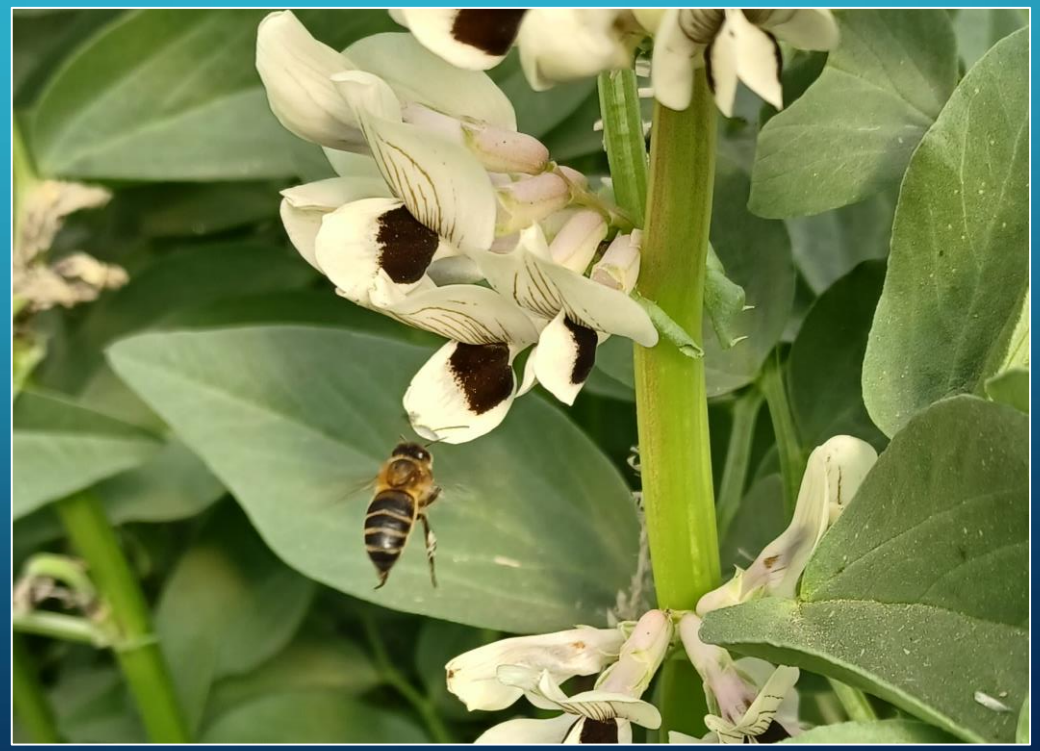


Figure 3. Experimental semi-opened greenhouse.

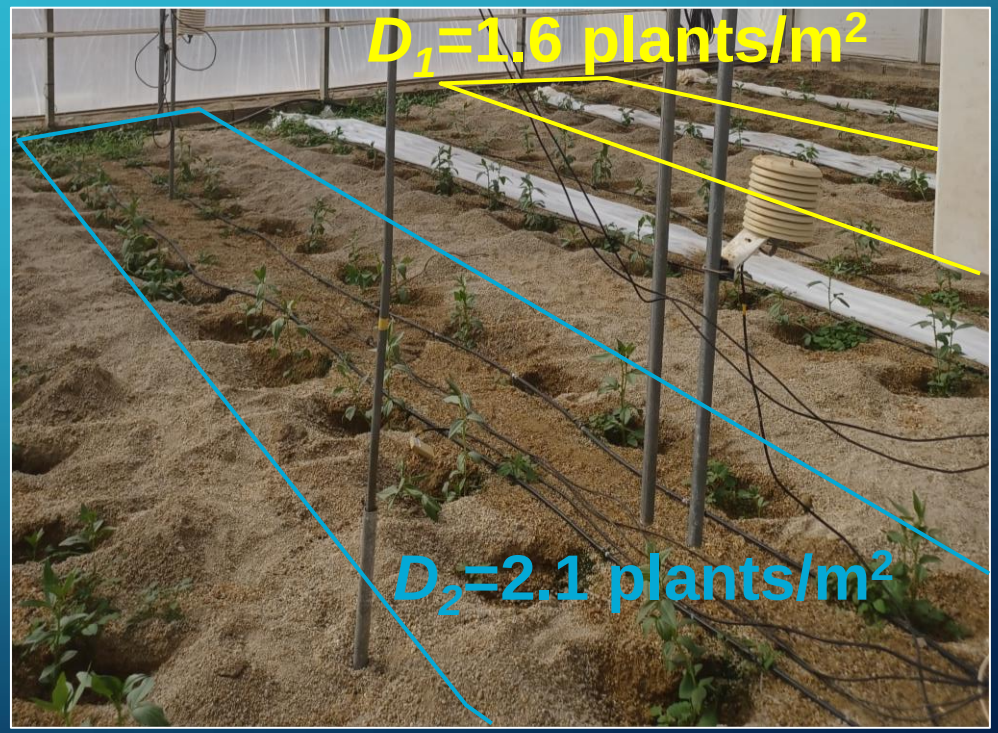
3.2. Crop management

During the development of the crop, **no phytosanitary treatment** was carried out, **nor beneficial insects** of integrated control or **pollinators** were **directly introduced,** and the **plastic cover** was **removed** in the roof of the **north span** to allow entry of **insect from outside**.



3. Materials and methods

Three planting densities were analysed D_1=1.6, D_2=2.1 y D_3=3.9 plants/m^2.



3.3. Phenological analysis

The **phenological stages** of the crop were determined when **more than half of the plants** of the **two rows** of each density analysed reached the corresponding stage.

The recorded phenological stages included the **days required** to reach **three** and **six leaves stage**, **flowering**, **first pod formation** and **pod development at the marketable s**ize (10-14 cm large and 7-9 g of weight).

three leaf stage

six leaf stage

flowering

pod formation

pod development

3. Materials and methods

The number of **Growing Degree Days (GDD)** accumulated for reaching each phenological stage was calculated using the following equation (Etemadi *et al*., 2018):

$$GDD=(T_{max}+T_{min})/2 - T_{base}$$

T_{base} is the **base temperature** equal to 4 °C.

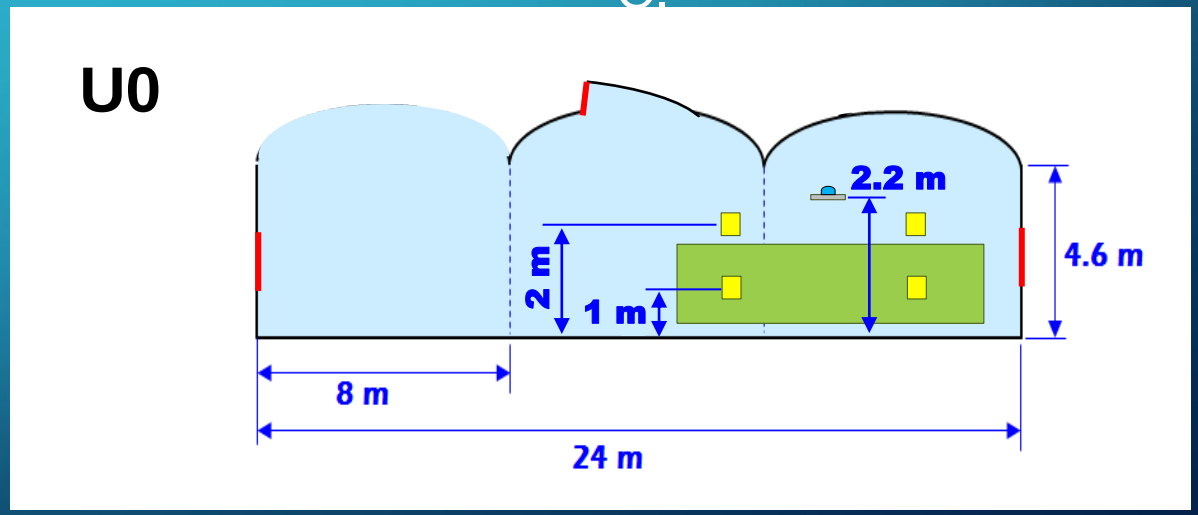


Figure 4. Sensors installed inside the greenhouse.

3.4. Plant development and production measurement

Throughout the growing period, the **height** of 6 plants and the **number of stems** were measured.

Plants were **staked between horizontal twine lines** to maintain rows about 30-40 cm wide.

The yield of **tender pods** were carried out once or twice a week (18 harvests), **weighing the production** of all plants and counting the **number of harvested pods**.

3. Materials and methods

For each density **20 pods** were randomly selected every harvest for which their **fresh weight** was determined with an SPO 63 Scaltec balance (accuracy 0.1 g), **the length of the pod**, the **width of the pod** with a digital gauge and the **number of grains** per pod.

4. Results and Discussion

4.1. Phenology

The **crop density did not show significant differences** in required **GDD** to reach their different **phenological stages** of growth.

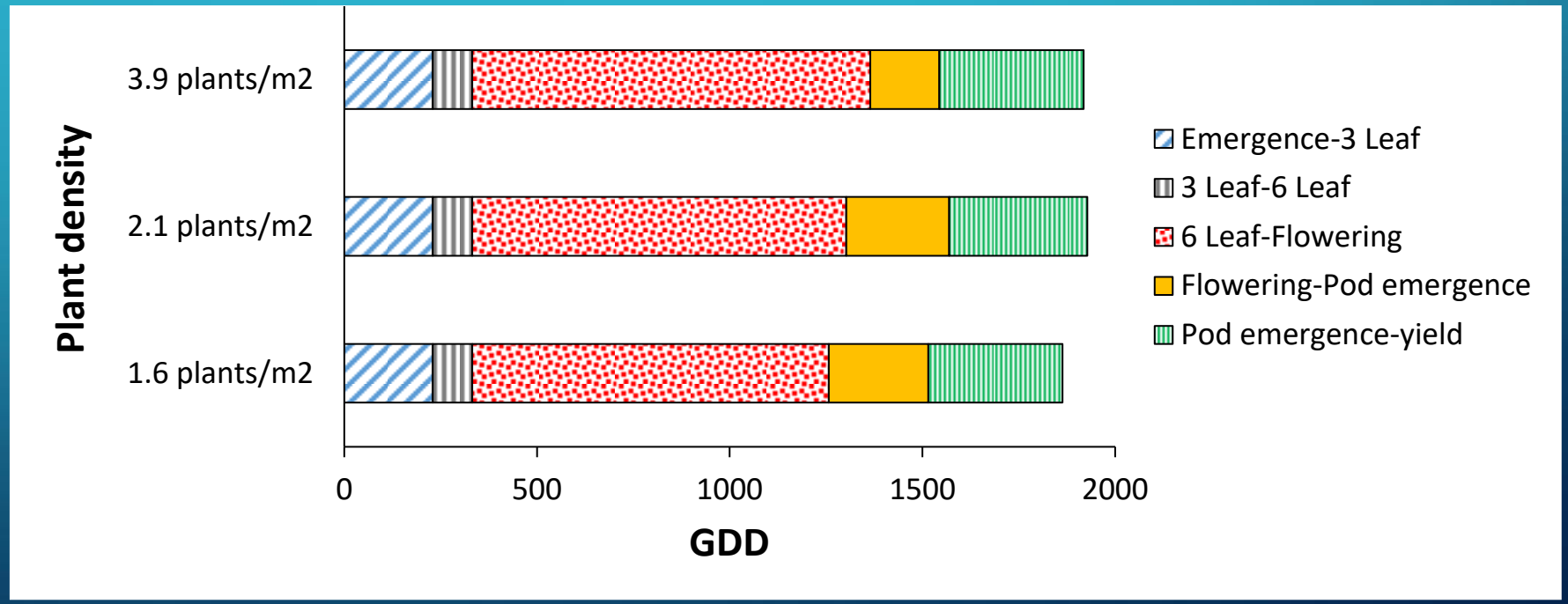


Figure 5. Growing Degree Days (GDD) required to reach various growth stages of three faba bean varieties analysed for plant inside a semi-open greenhouse.

4. Results and Discussion

Table 1. DAS and GDD during faba bean growing measured in the experimental greenhouse and values of DAS estimated with temperatures measured inside a naturally ventilated greenhouse and outside.

Phenological stage	Emergence-3 Leaf	3 Leaf-6 Leaf	6 Leaf-Flowering	Flowering-Pod emergence	Pod emergence-yield
Dates when the phenologycal stage was reached					
1.6 plants/m^2	14/10/2022	21/10/2022	15/12/2022	04/01/2023	02/02/2023
2.1 plants/m^2	14/10/2022	21/10/2022	19/12/2022	08/01/2023	08/02/2023
2.1 plants/m^2	14/10/2022	21/10/2022	07/12/2022	09/01/2023	08/02/2023
3.9 plants/m^2	14/10/2022	21/10/2022	24/12/2022	06/01/2023	07/02/2023
Days After Sowing (DAS) inside the experimental greenhouse					
1.6 plants/m^2	10	17	72	92	121
2.1 plants/m^2	10	17	76	96	127
2.1 plants/m^2	10	17	64	97	127
3.9 plants/m^2	10	17	81	94	126
Cumulated Growing Degree Days (GDD) inside the experimental greenhouse					
1.6 plants/m^2	229.7	331.7	1256.9	1515.6	1863.7
2.1 plants/m^2	229.7	331.7	1302.7	1569.4	1928.0
2.1 plants/m^2	229.7	331.7	1149.3	1586.0	1928.0
3.9 plants/m^2	229.7	331.7	1364.4	1543.6	1918.2
Mean	**229.7**	**331.7**	**1268.3**	**1553.6**	**1909.5**
Etimated Days After Sowing (DAS) inside the a naturaly ventilated greenhouse					
GDD inside U11	9	16	70	89	111
Etimated Days After Sowing (DAS) outside the greenhouse					
GDD outside	11	19	87	111	156

4. Results and Discussion

The **average temperature** inside the **semi-opened experimental greenhouse** was **+4ºC higher** than that **outside** and **–3.5ºC lower** than that of a **standard greenhouse**.

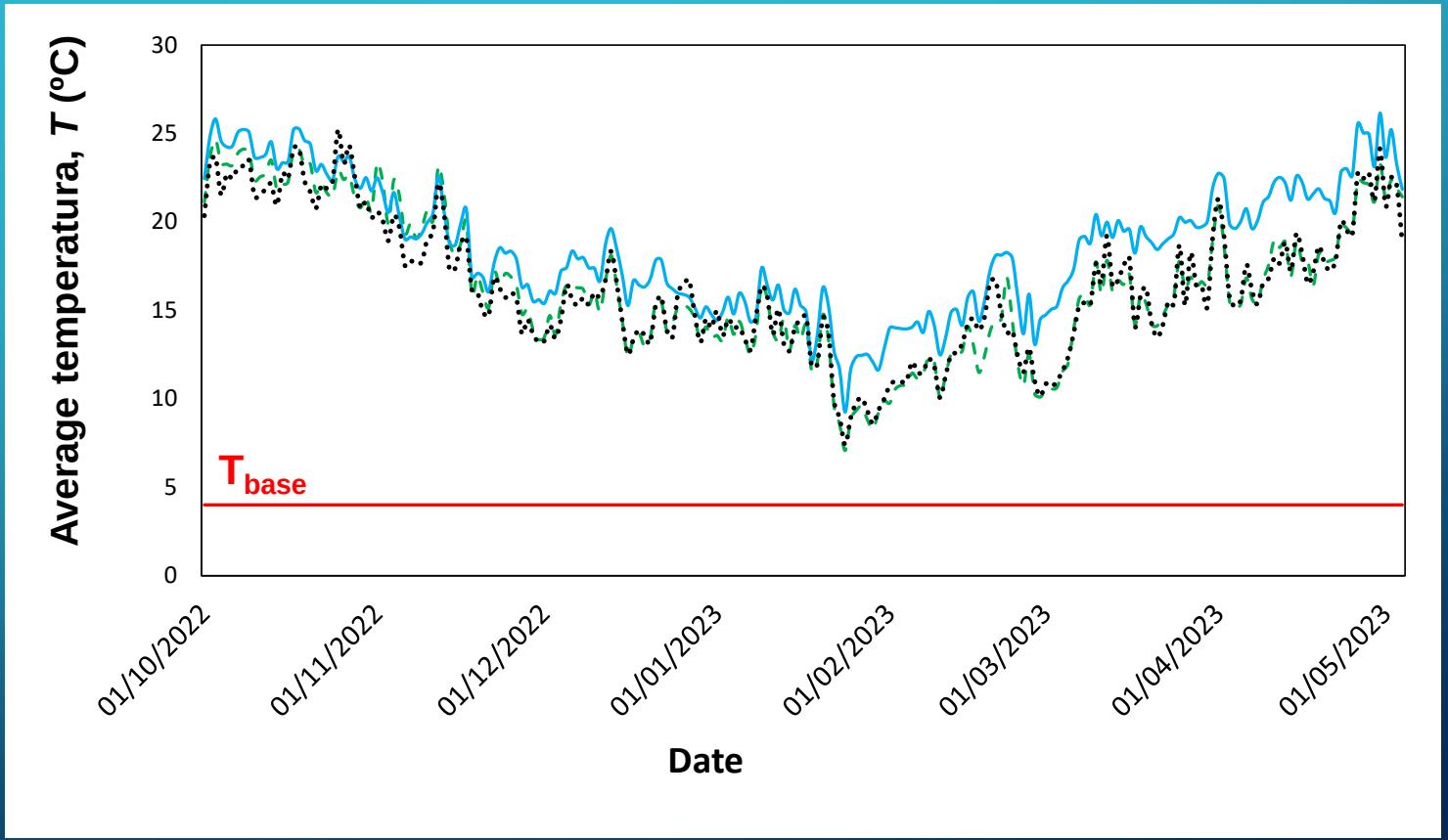


Figure 6. Evolution of average temperatures measured inside the experimental greenhouse (- - -), inside a ventilated greenhouse (---) and outside (····).

4. Results and Discussion

The development of the crop **inside the semi-opened greenhouse** allows to **advance by 30 days** the date of the **first harvest** of the **tender fava bean pods**.

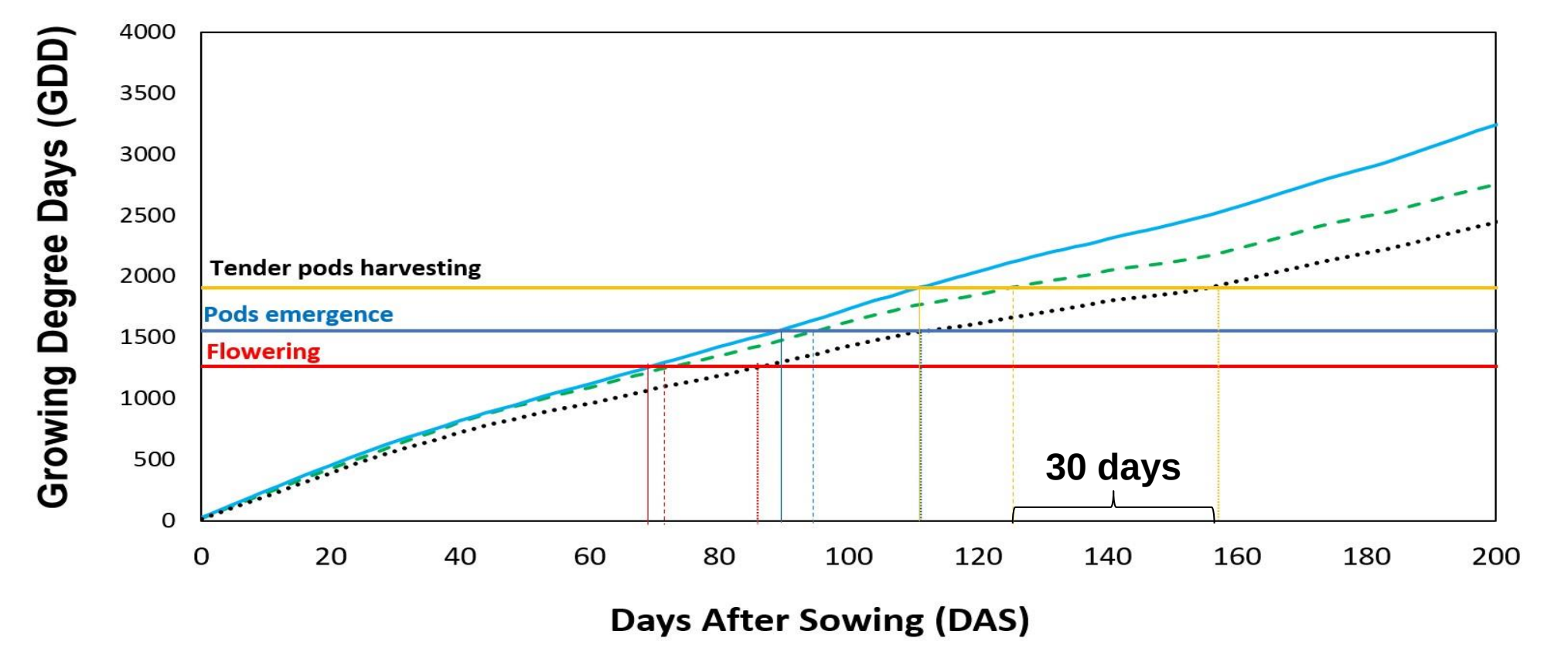


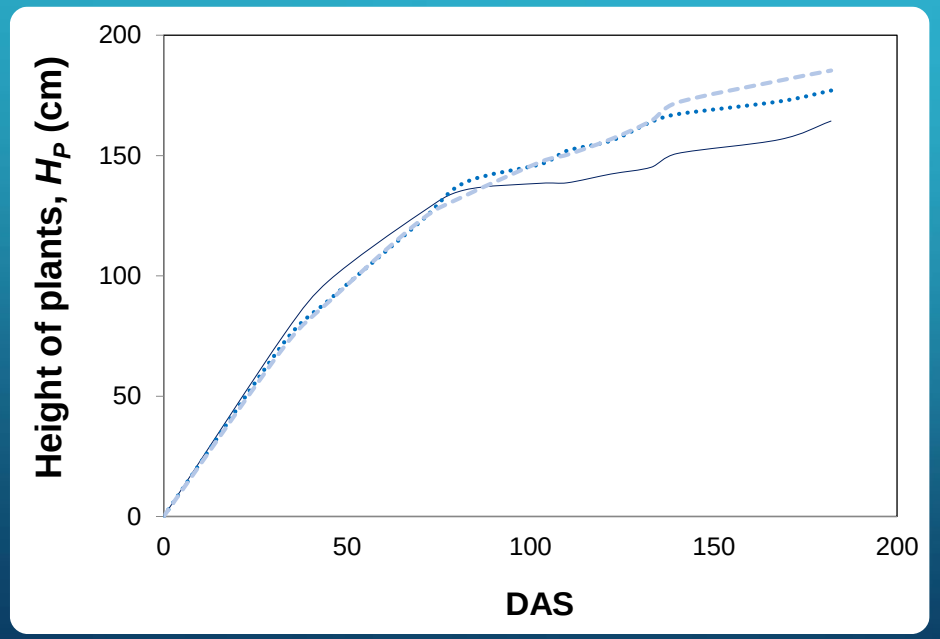
Figure 7. Evolution of GDD in function of DAS measured inside the experimental greenhouse (- - -), inside a ventilated greenhouse (---) and outside (····).

4.2. Plant growth

Some **plants reached** at the end of the crop, **182 days after sowing** (DAS), **heights above 2 m.**

The **increase in planting density** produced an **increase in the final height** of the plants due to **competition for available light**.

a)



b)

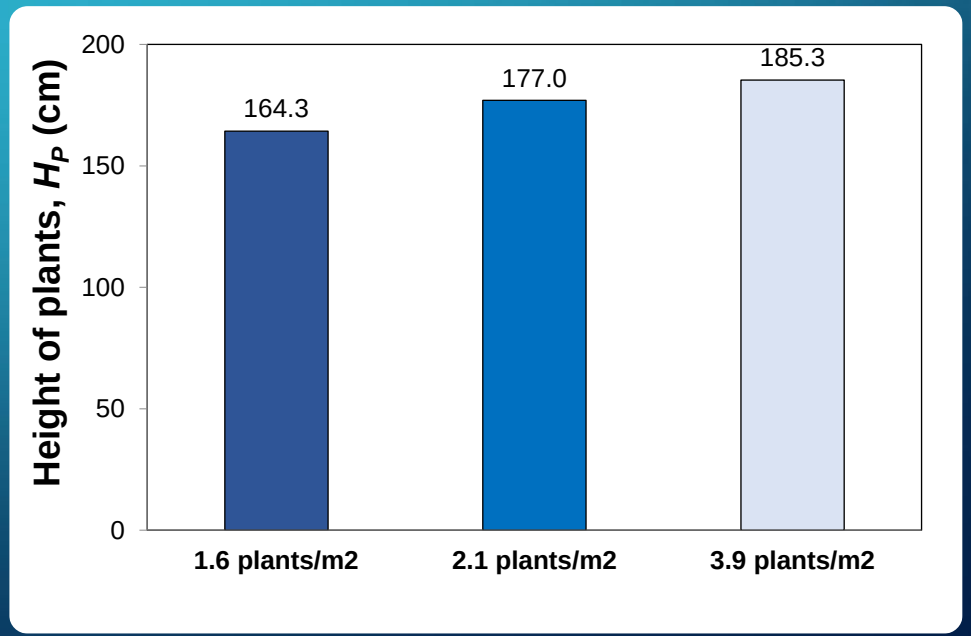
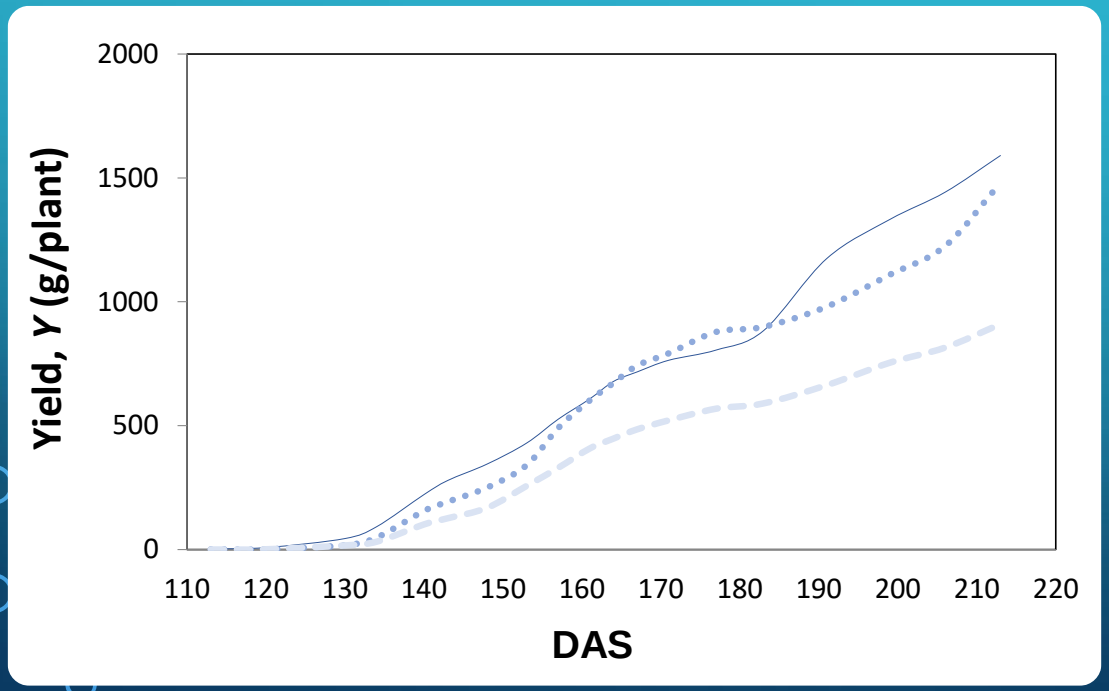


Figure 8. Evolution of the height of the faba bean plants (a) and final values reached for the three densities tested (b).

4.3. Crop production

Although the greater production per plant was obtained with the lower density, the **highest production** of tender fresh pods of **3.57 kg/m^2** was obtained for the **highest density of 3.9 plants/m^2.**

a)



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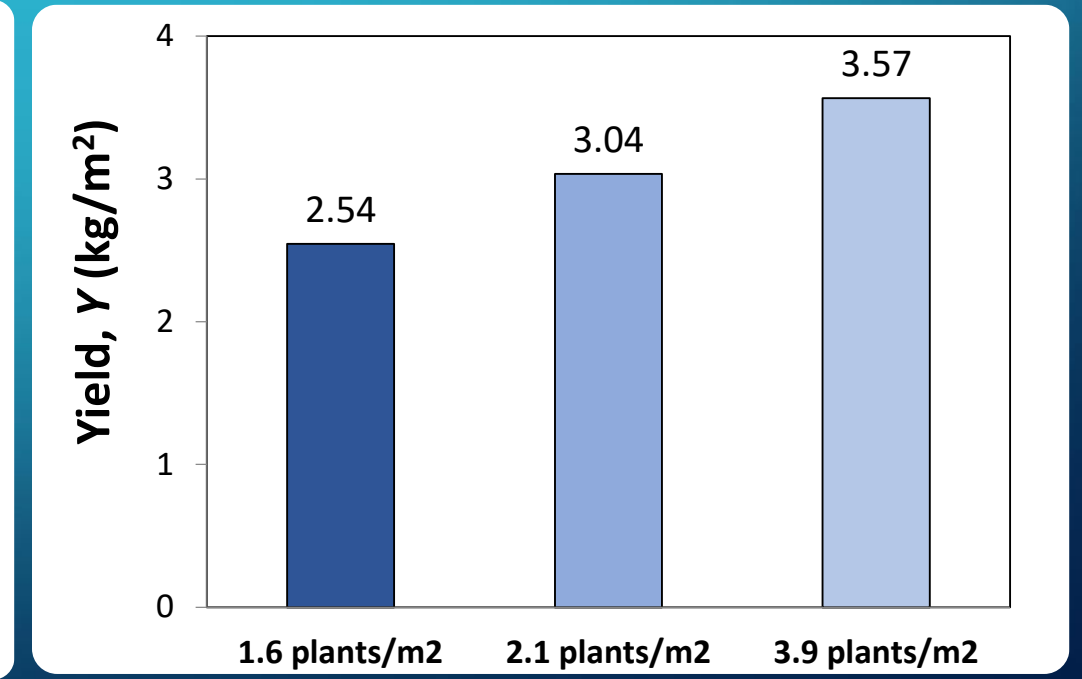
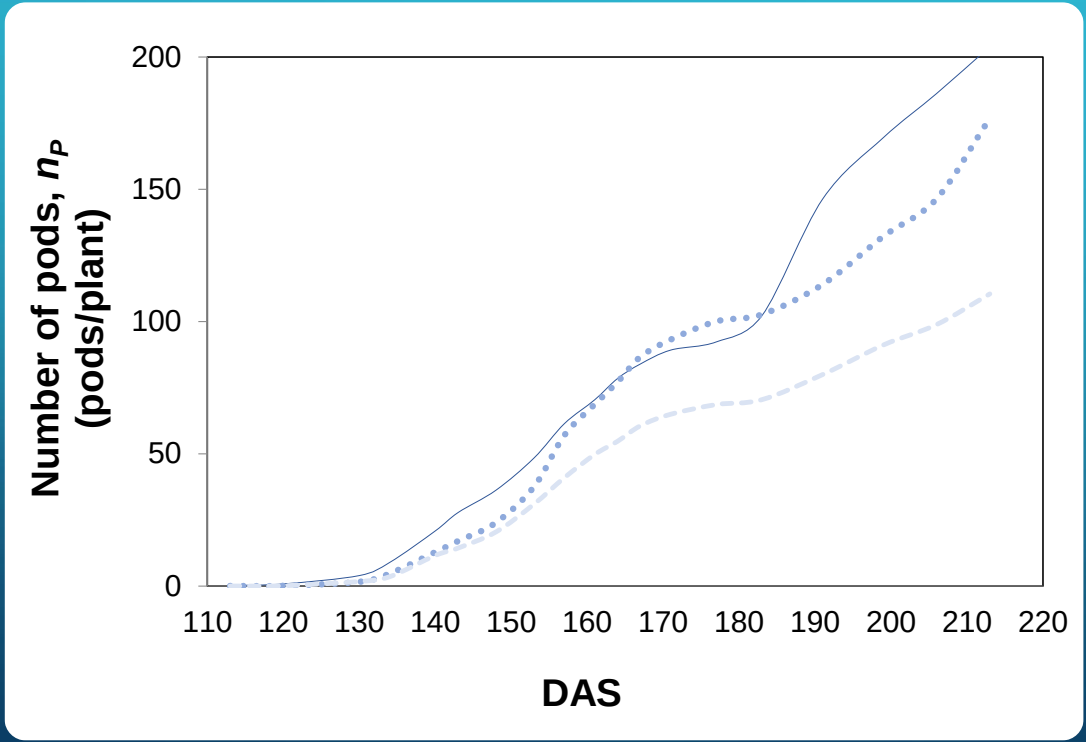


Figura 9. Evolution of yield throughout the harvest period (b) and total pod production (b).

4. Results and Discussion

The maximum number of pods per plant was obtained with the lowest density, but with the **highest density more pods per square meter** were obtained.

a)



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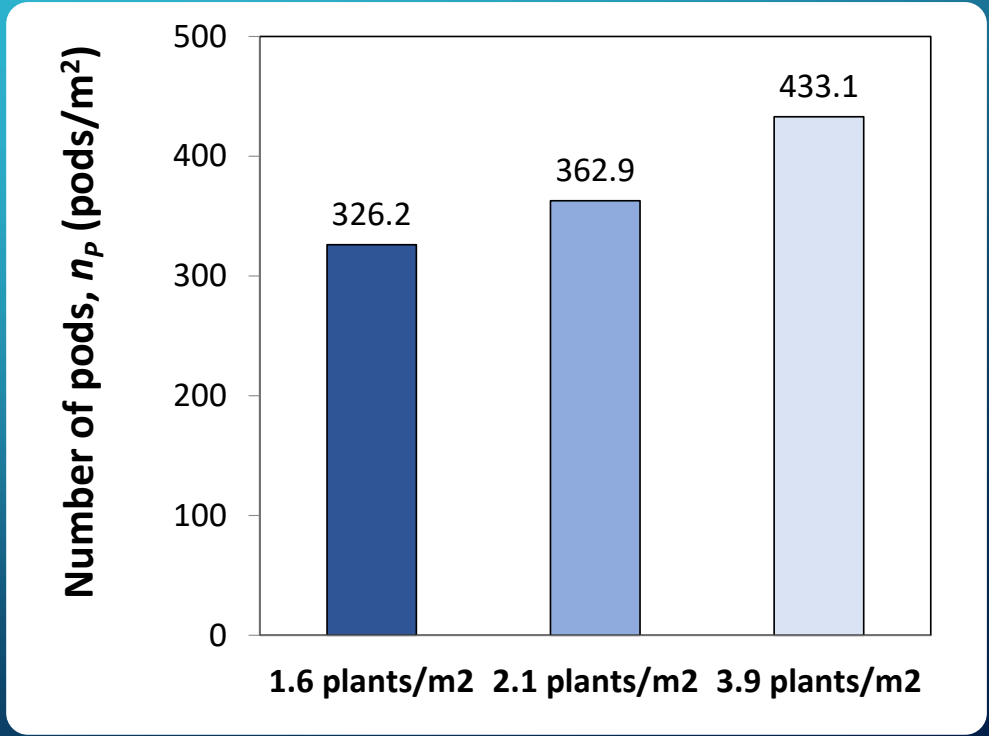
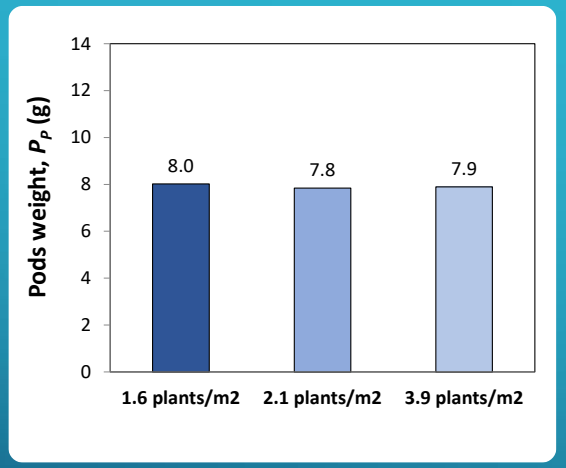


Figure 10. Evolution of pod number throughout the harvest period (a) and final production (b).

4. Results and Discussion

The **width of pods** was statistically **greater for the denser crop** (11.4±1.9 mm). No statistically significant differences were observed in length (13.0±3.7 cm), weight (8.4±5.6 g) and number of grains per pod (5.4±1.0).

a)



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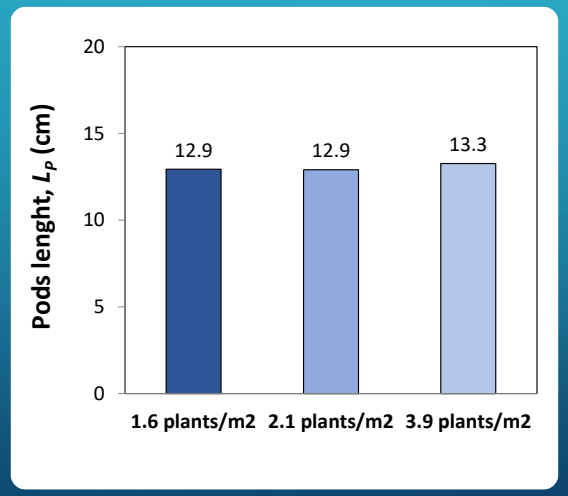
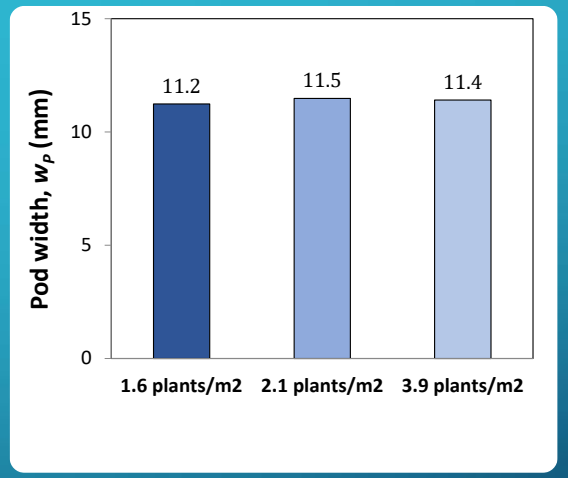


c)



d)

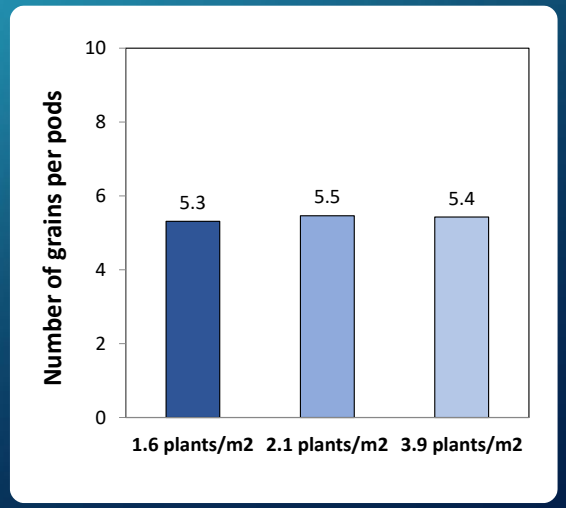


Figure 11. Average weight (a), length (b), width (c) and number de grains per pods (d).

4.4. Biodiversity development

As the greenhouse was semi-opened, there was the spontaneous entry of **both pest insects** and **predators** maintaining a balance **without negative effects** on the **crop development** and **production.**

Nest with eggs of european tarling (Sturnus vulgaris)

Coccinella septempunctata

Balaustium hernandezi

5. Conclusions and perspectives

- The cultivation of **faba beans** for consumption of **tender pods** "***jaruguillas***", has been shown possible in a **semi-opened solar greenhouse of Almeria**, reaching a productivity of more than **3.5 kg/m²** **without** the use of **phytosanitary products** and without the **release** of **auxiliary insects**.

- The development of the crop **inside the semi-open greenhouse could advance by 30 days** the date of the **first harvest** of the **tender fava bean pods** in comparison with outside.

THANK YOU FOR YOUR ATTENTION

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