Shortening the Breeding Cycle

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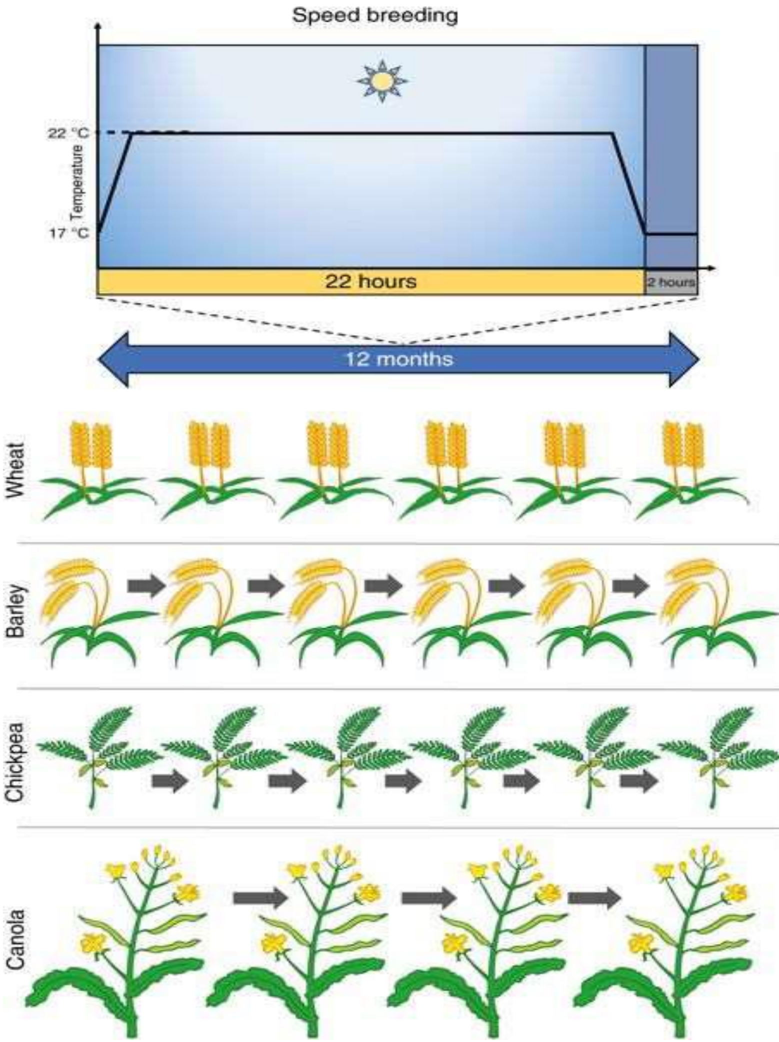
Speed breeding technology



Speed breeding time lapse

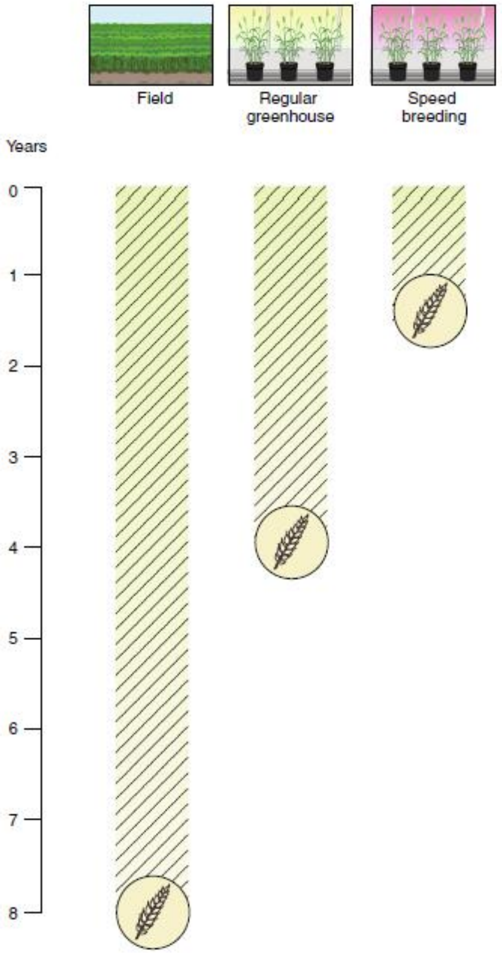
Speed Breeding | Regular Greenhouse

Grass pea speed breeding
16 h | 22h

Watson *et al.* 2018

Why speed breeding?

- Faster breeding process ⟶ faster response
- Development of mapping populations
- Step-wise selection (F2-F7) using markers/phenotype
- Supports faster non-GMO crop improvement

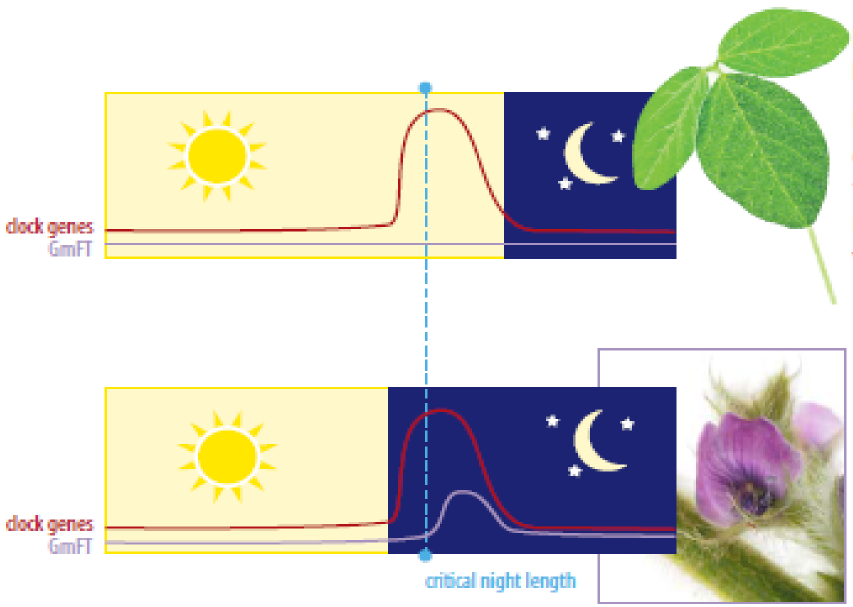


Hickey *et al.* 2019

Speed breeding long-day crops

- Speed breeding introduced for long-day crops (Watson *et al.* 2018)
- ~22h light (regular bulbs = Na-vapor)
- Light quality not considered
- Very fast for non-winter crops
- No issue with moderate light quantity (~450 PPFD)
- Harvesting immature seeds
- However this approach is limited to long day crops and can not be applied to photoperiod sensitive crops

What about short-day crops?



Major short-day crops: rice, soybean, sorghum, millets, amaranth **<12h light**

- **Challenges:**
  - Short light treatment
  - Limited photosynthesis rate

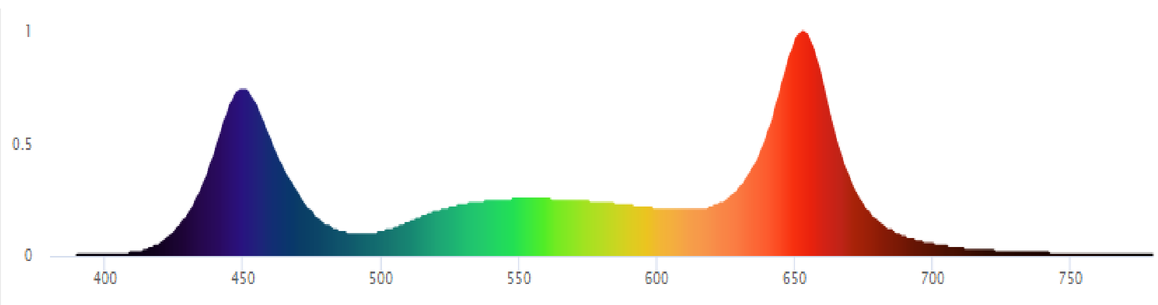
To date no protocol established to generate more than 5 generations of soybean per year (Jähne et al 2020)

AIM:
- to generate ~6-7 generations of soybean per year by using long-day photoperiods
- the impact of intracanopy lighting on photosynthetic capacity of plants

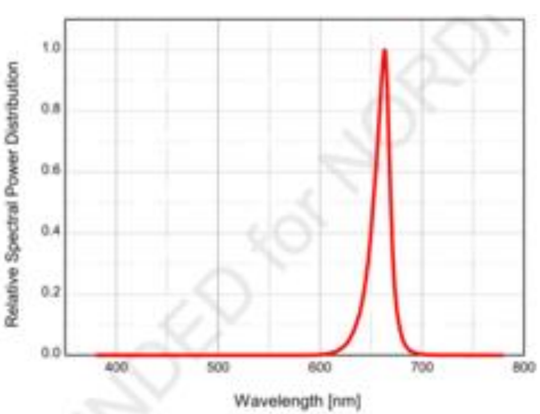
Modifying soybean to long-day crop

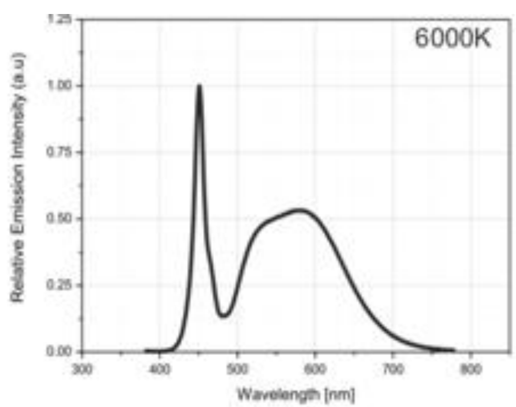
Accelerated soybean generation in response to 16h – 22h photoperiod after full flowering (R1-R3)

LED light spectra (Red/Blue 2:1)

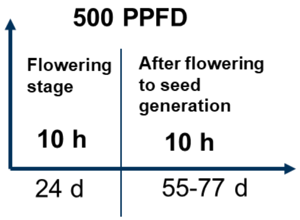


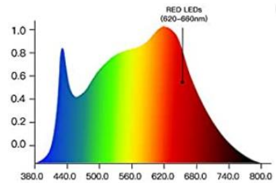
Non-custom LED light spectra

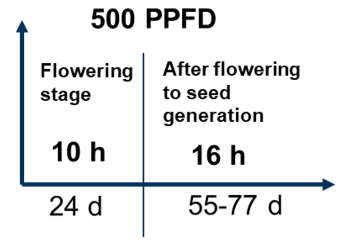


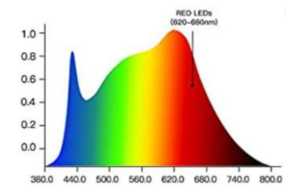


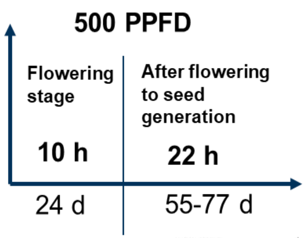
Soybean response to 16h – 22h photoperiod after full flowering (45 DAS)

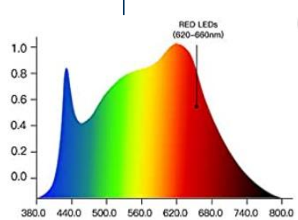


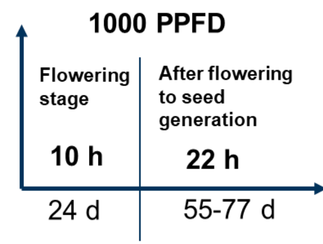


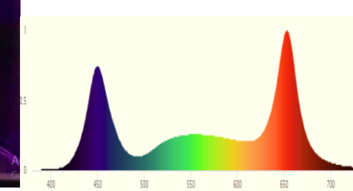




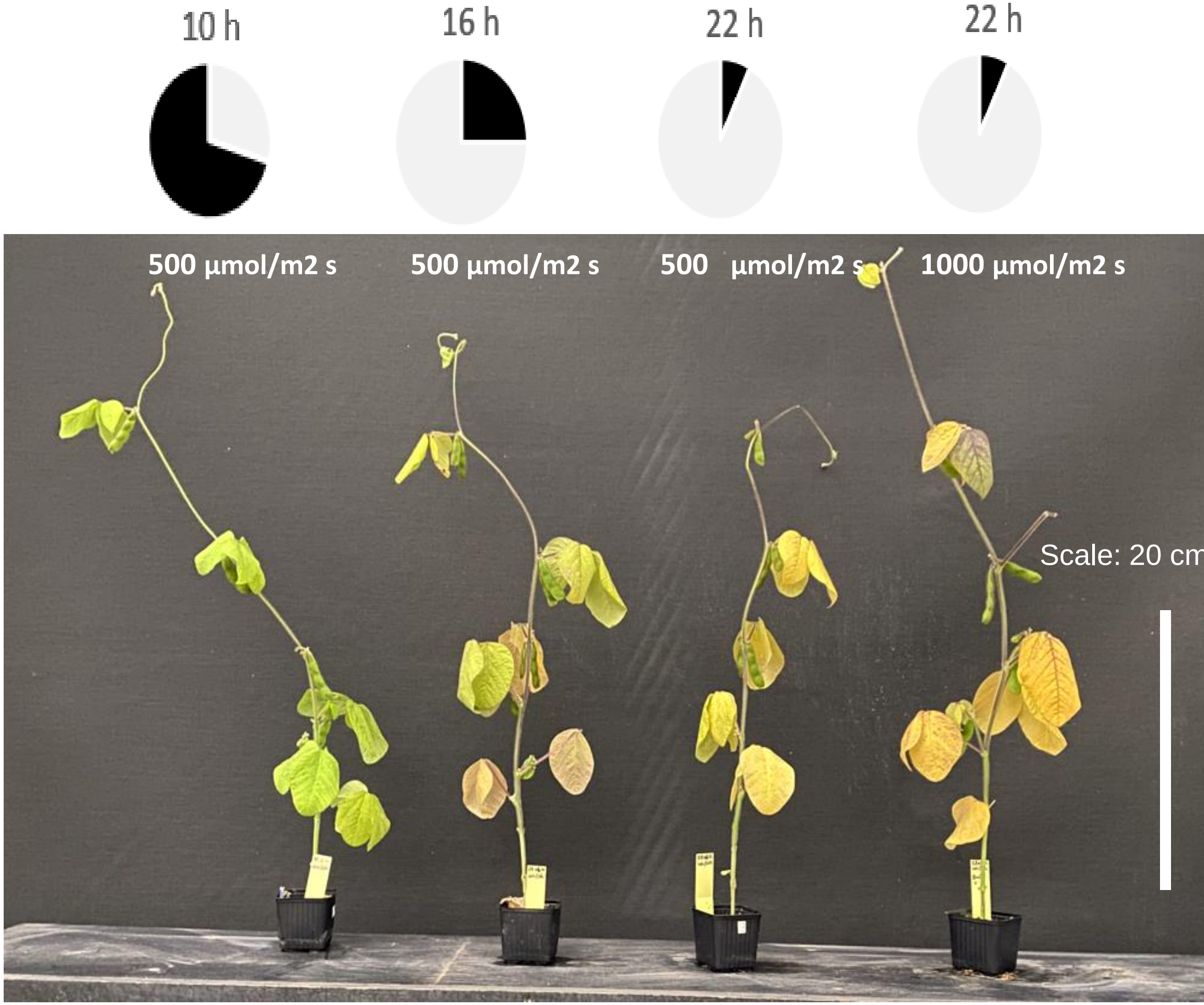


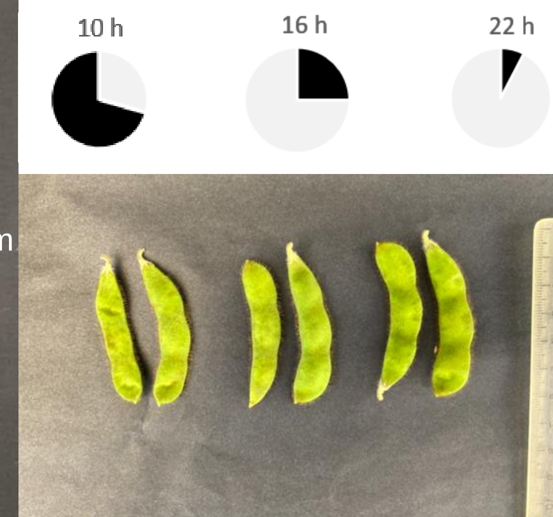






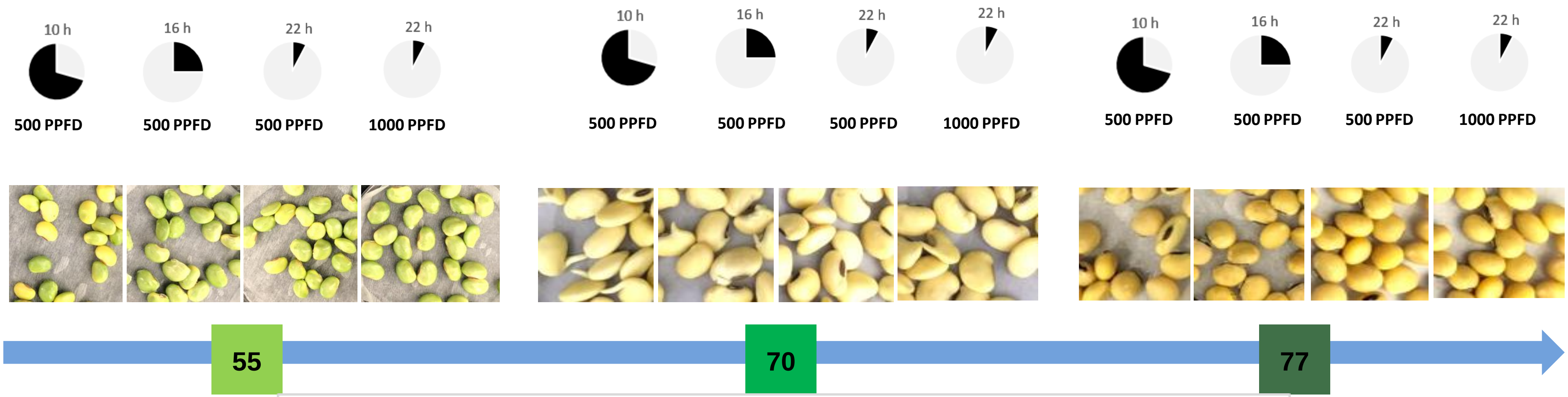
Soybean growth and pod development
30 DAS

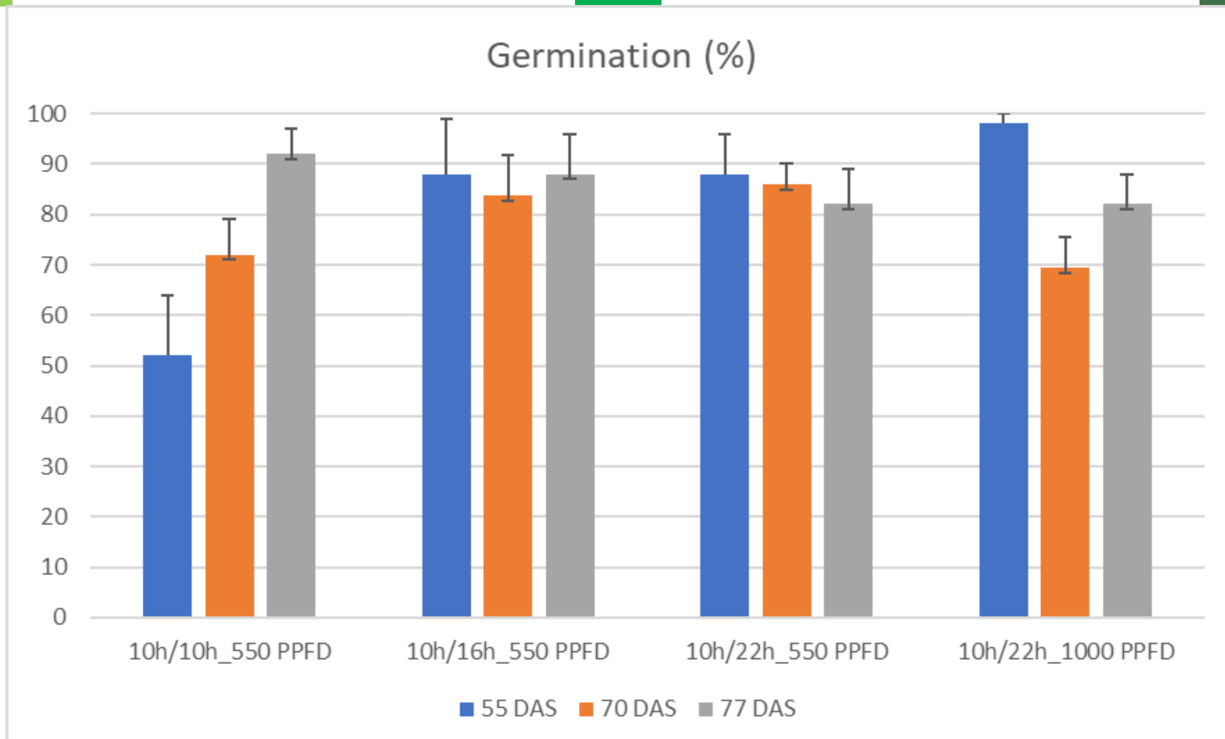




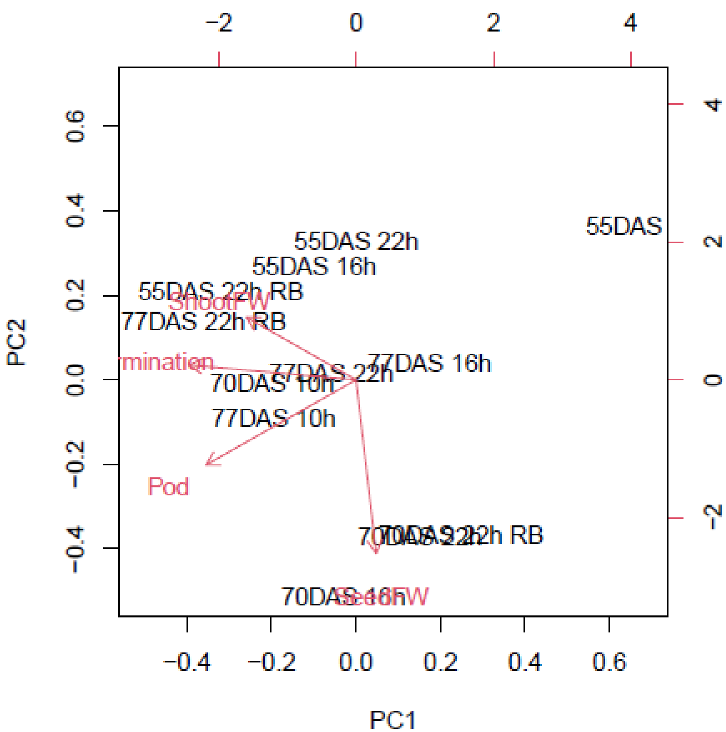
Soybean growth 55 DAS and seed development

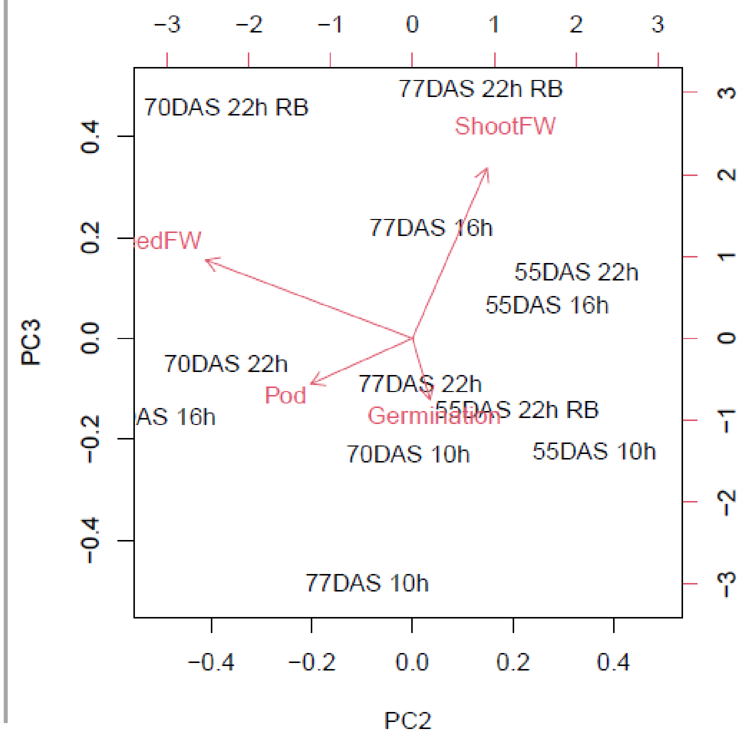
Fresh seed harvest





PCA based on biomass and germination





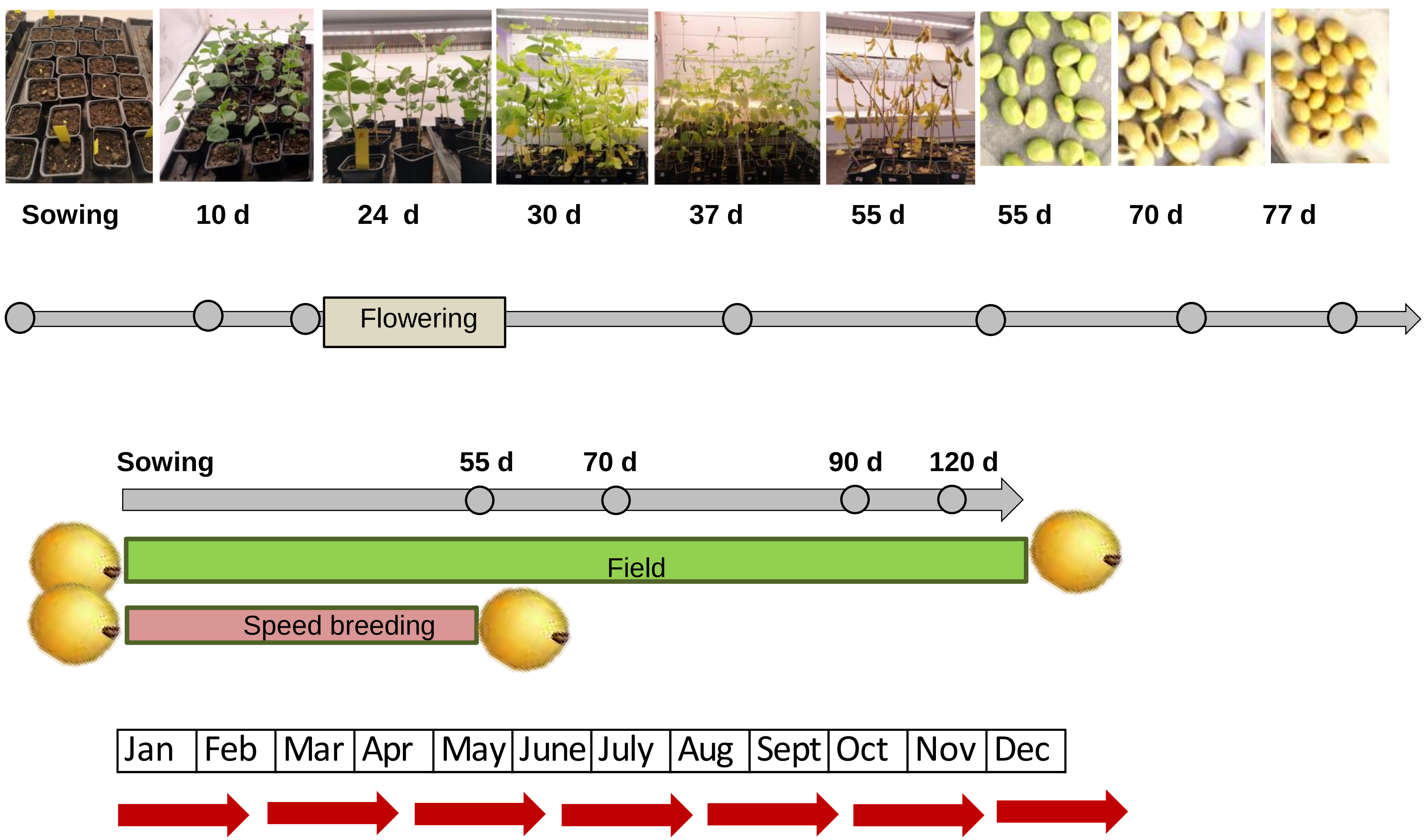
- Seed FW was the highest in the 70DAS 16h and 22h photoperiod.
- Germination rate was the highest in the 77DAS 22h and 55DAS 22h.
- 55DAS 10h treatment gave the most distinct results and lowest biomass and germination.

Importance of components:

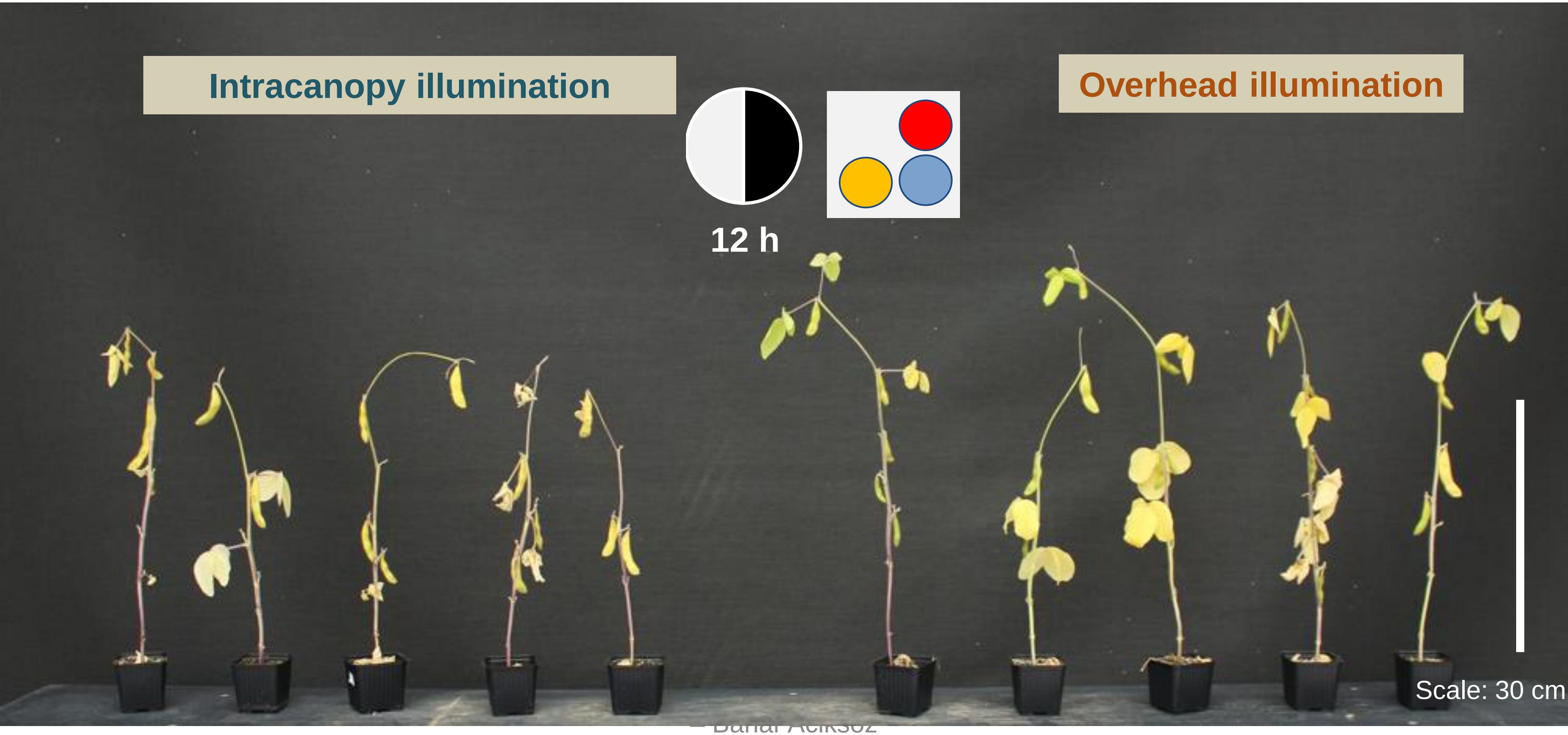
	PC1	PC2	PC3
Standard deviation	1.3155	1.0698	0.8893
Proportion of variance	0.4326	0.2861	0.1977
Cumulative Proportion	0.4326	0.7188	0.9165

- PC1, PC2 and PC3 explained 93% of observed traits

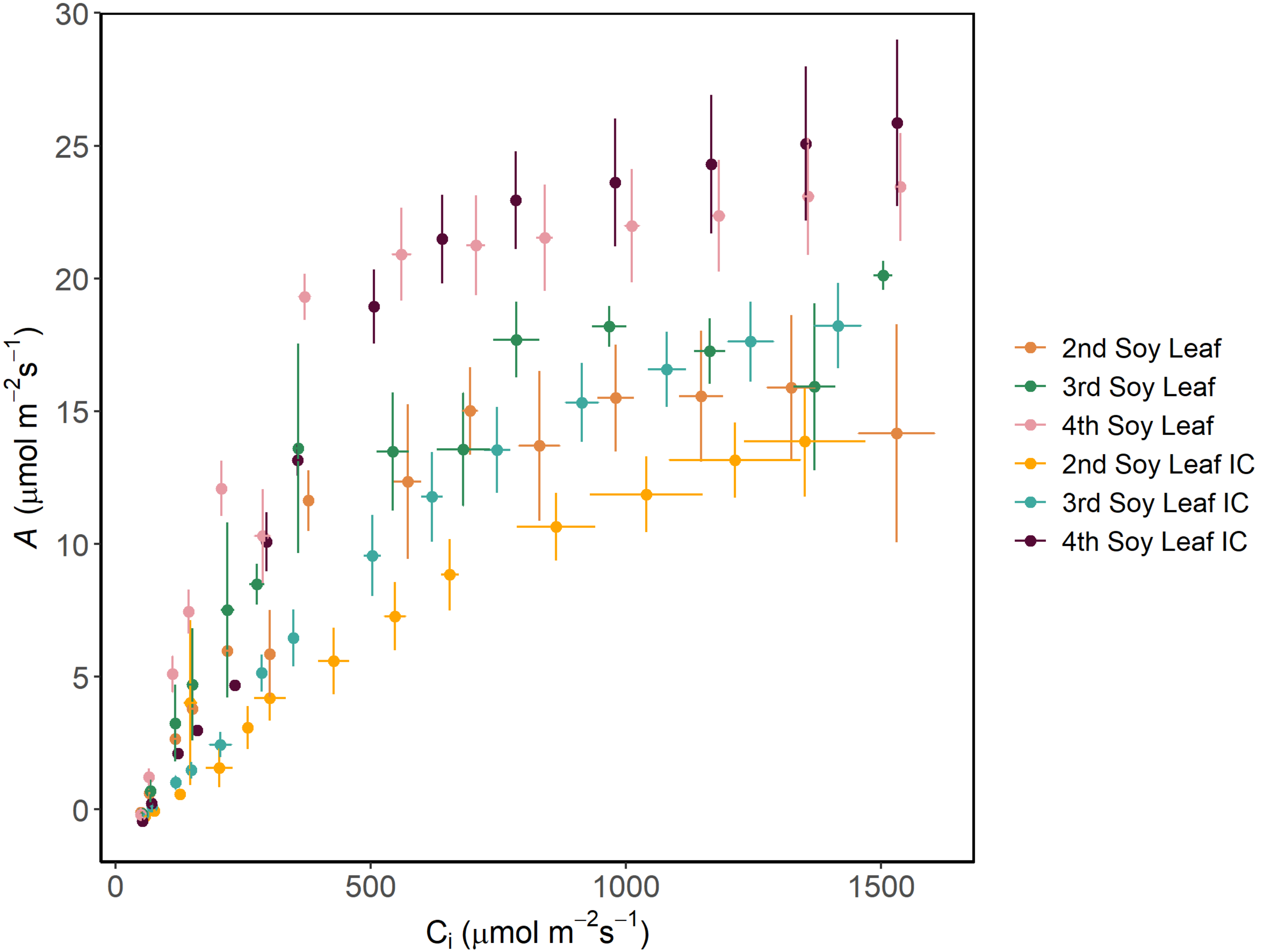
Soybean long-day speed breeding



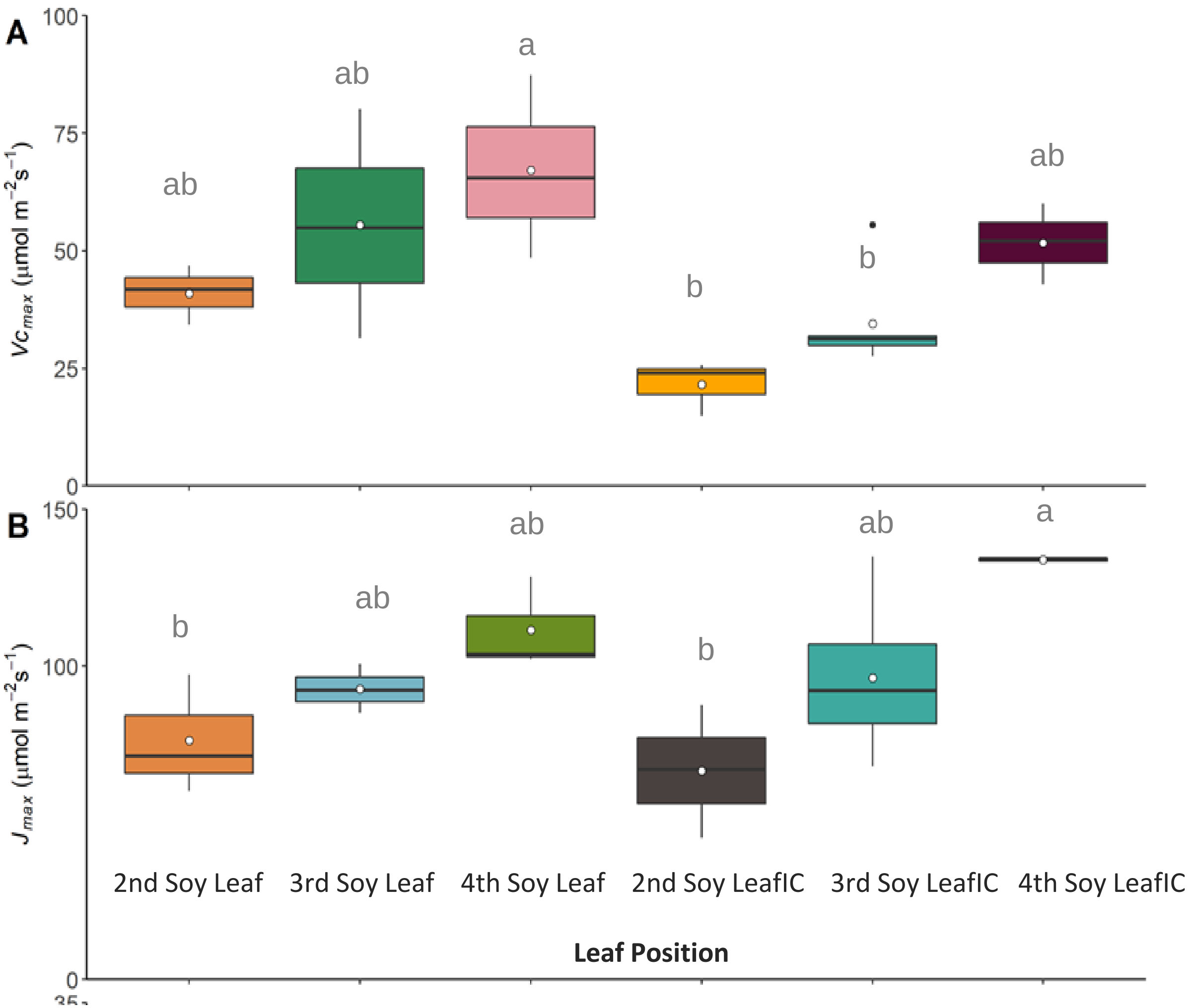
Intracanopy vs Overhead LED illumination under speed breeding on 55 DAS



Intracanopy vs Overhead LED illumination on photosynthetic capacity (A/C_i)



Intracanopy LED illumination on photosynthetic capacity



Max rate of velocity of Rubisco carboxylation (V_{cmax})
Intracanopy lighting increased significantly the V_{cmax} from lower to upper leaf.

However there was no consistent correlation between intracanopy (IC) and overhead light in Rubisco carboxylation.

Max rate of electron transport demand for RuBP generation (J_{max})
In overall the 2nd, 3rd, 4th leaves that were exposed to IC had a higher Jmax than 2nd, 3rd, 4th no IC. The highest J_{max} was recorded in 4th soyleaf with IC.

Take home messages

- After blooming long photoperiods of 16h and 22h on soybean shortened seed cycled from 120 d reported in the growth chamber to just 55 d (85-95% germination rate)

- Allowing up to 6-7 seed generations

- Light quality was not considered, moderate light intensity 500 PPFD

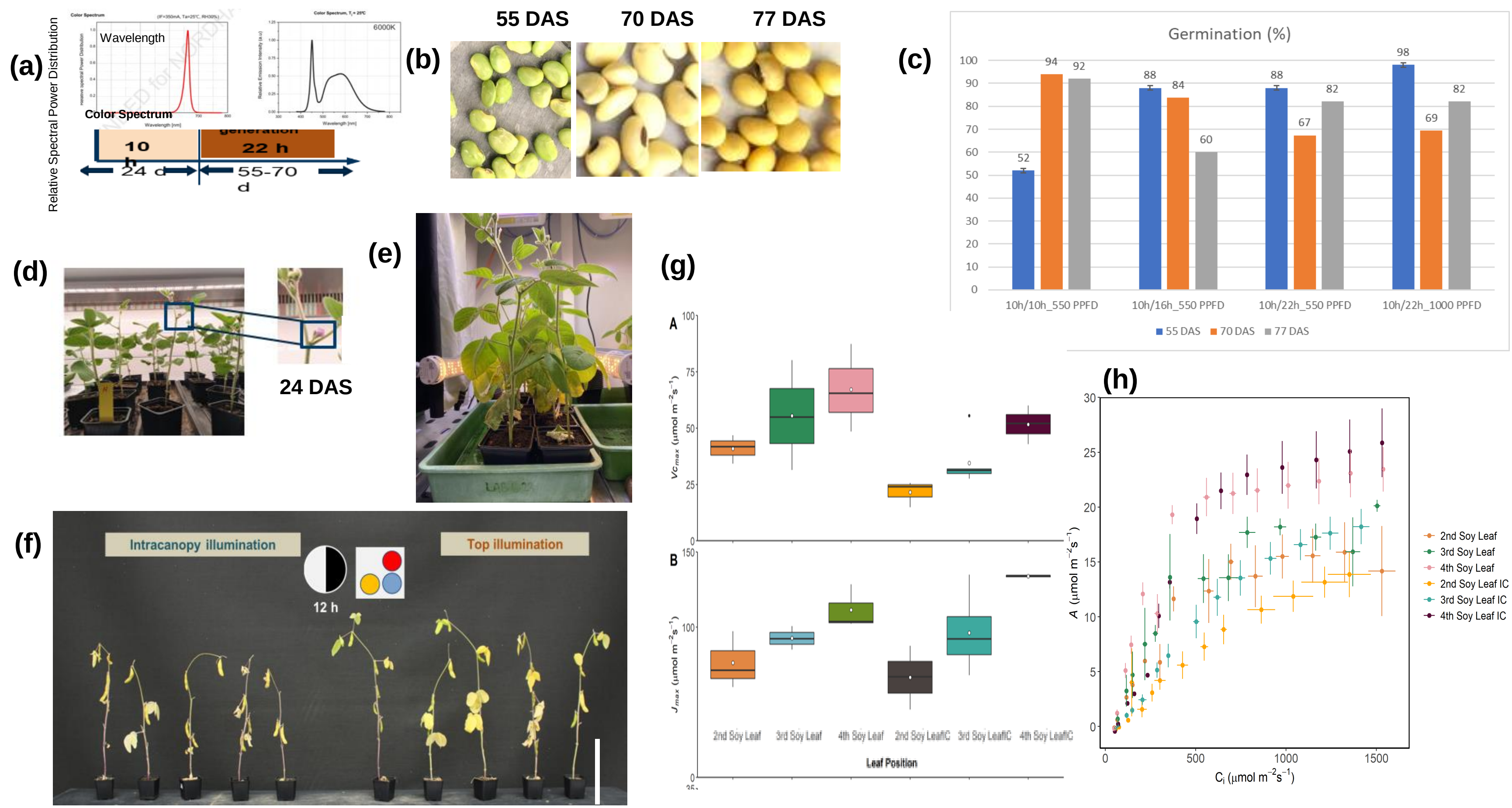
- CO_2 response (A/C_i) curves, Rubisco carboxylation (Vc_{max}) and maximum rate of electron transport (J_{max}) was affected by intracanopy light supplementation

Take home messages

- Immature seed storage
- Genotype dependence of current protocols
- Optimization for other short-day cultivars, accessions and experimental designs

THANK YOU!

Soybean speed breeding protocol



(a) LED light spectrum **(b)** immature seed harvest at staggered times **(c)** germination rate **(d)** first flowering **(e)** IC lights **(f)** overhead versus IC plant development **(g,h)** photosynthetic capacity of speed breeding

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MARIE CURIE ACTIONS
European Commission
Horizon 2020
European Union funding
for Research & Innovation

Treatment	SeedFW	Pod	ShootFW	Germinatic
10h 55DAS	0.7	3.8	2.4	52
16h 55DAS	1.2	5.2	3.9	88
22h 55DAS	1.3	4.6	3.9	88
22h + 55DAS	1.0	6.0	3.8	98
10h 70DAS	1.6	6.0	3.3	94
16h 70DAS	3.2	6.2	2.8	84
22h 70DAS	2.7	6.0	2.9	67
22h + 70DAS	3.7	4.8	3.6	69
10h 77DAS	1.4	6.5	2.8	92
16h 77DAS	1.7	5.5	3.7	60
22h 77DAS	1.6	5.8	3.4	82
22h + 77DAS	1.6	6.3	5.0	82

35 DAS

35 DAS