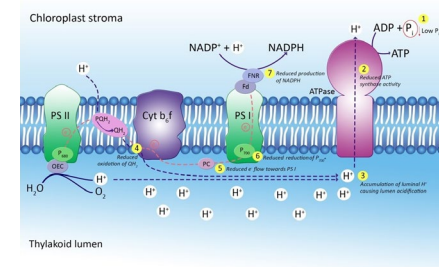
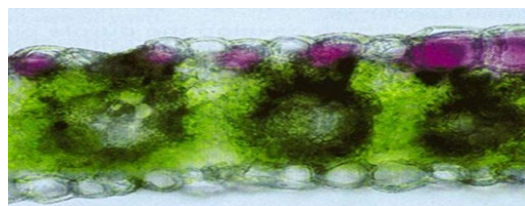


Linkøbing, Koncert och Kongress, Jan 17, 2019, 2019

The Functional Role of Phosphorus in Plants

- Fosforns roll i väksten

Hydrogen 1 H H ₂	Grundstof Atom nummer Symbol Den dominerende påvirkning Udgangsform																2 He	
3 Li	4 Be																	10 Ne
11 Na	Magnesium 12 Mg Mg ²⁺																	18 Ar
Potassium 19 K K ⁺	Calcium 20 Ca Ca ²⁺	21 Sc	22 Ti	23 V	24 Cr	25 Mn Mn ²⁺	26 Fe Fe ²⁺ /Fe ³⁺	27 Co	28 Ni Ni ²⁺	29 Cu Cu ⁺	30 Zn Zn ²⁺	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
37 Rb	38 Sr	39 Y	40 Zr	41 Nb Nb ₂ O ₅	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
55 Cs	56 Ba	57 La Hf	72 Ta	73 W	74 Re	75 Os	76 Ir	77 Pt	78 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra	89 Ac																





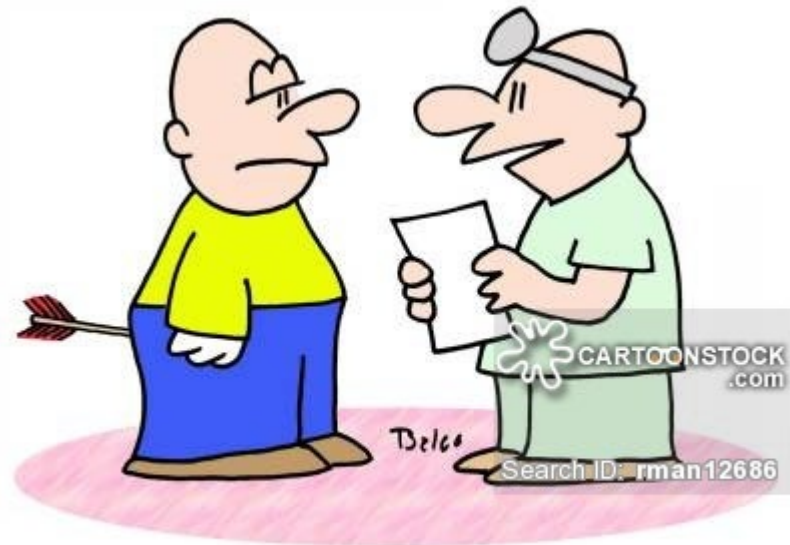
Agenda:



- Functional Overview
- P and Root Development
- P and Tillering (Timing of P fertilization)
- P and Carbohydrates
- P and Photosynthesis – Diagnosing deficiency in the field
- Phosphorus Fertilization – Present and Future

} hormones





"WHERE DOES IT HURT?"

Phosphorus Deficiency Symptoms

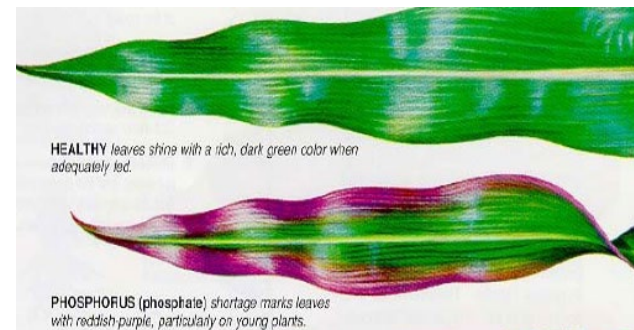
Function

- Cell energy supply
 - (Photosynthesis: NADPH, ATP)
- The Calvin Cycle
 - synthesis and export of carbohydrates
- P-lipids in biomembranes
- Hormones (AUX, CYT, SL)



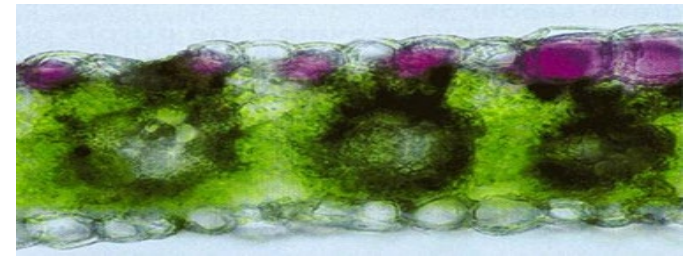
Symptoms

- Reduced growth rate
- Dark green leaf color (high chlorophyll concentration)
- Reduced tillering
- Accumulation of anthocyanins

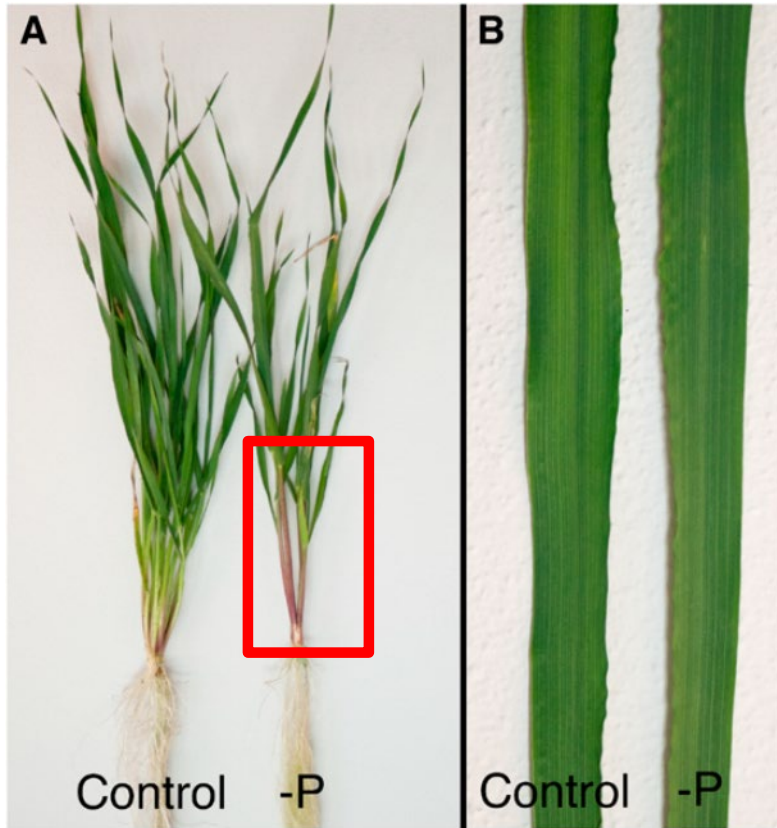


P Starvation and Anthocyanosis

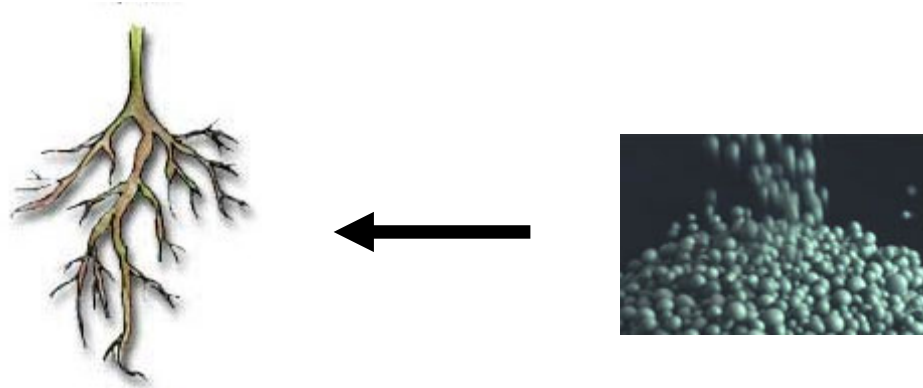
- *photoprotection*



Phosphorus deficiency is often never discovered

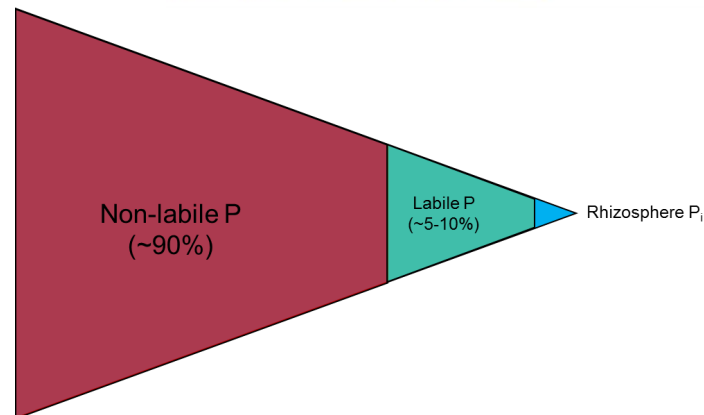
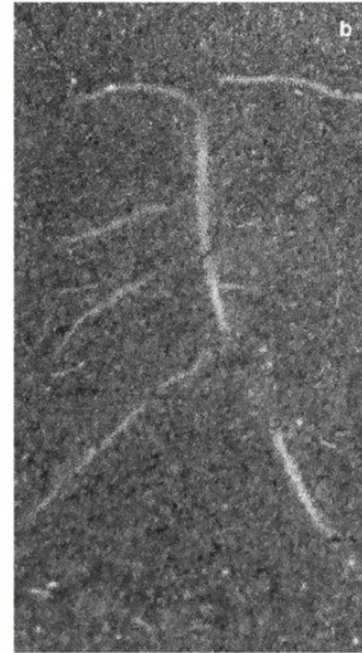
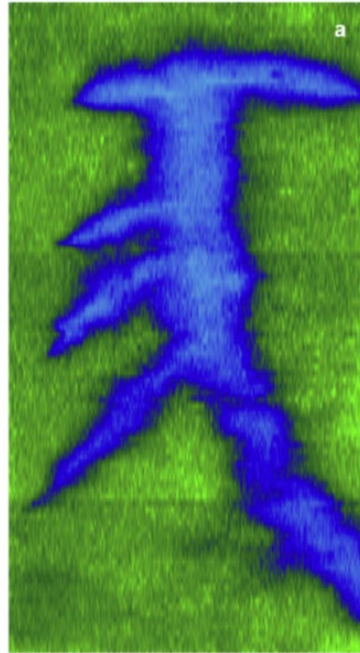
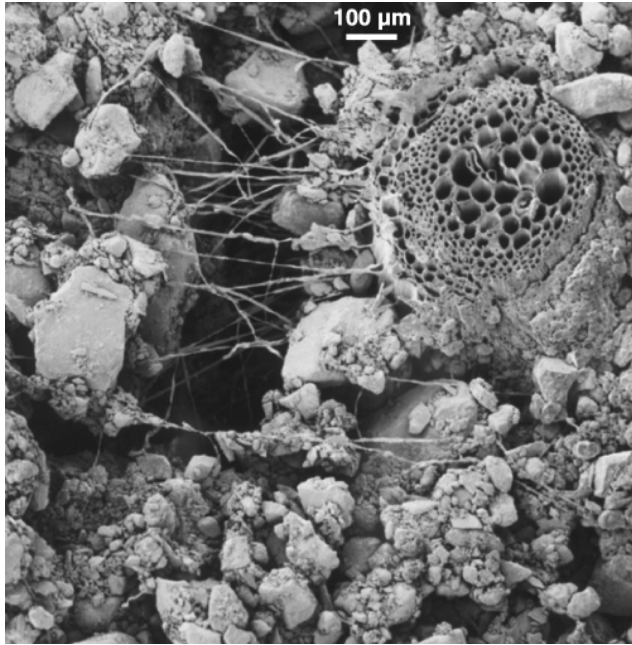


Phosphorus moves extremely slow in soil...

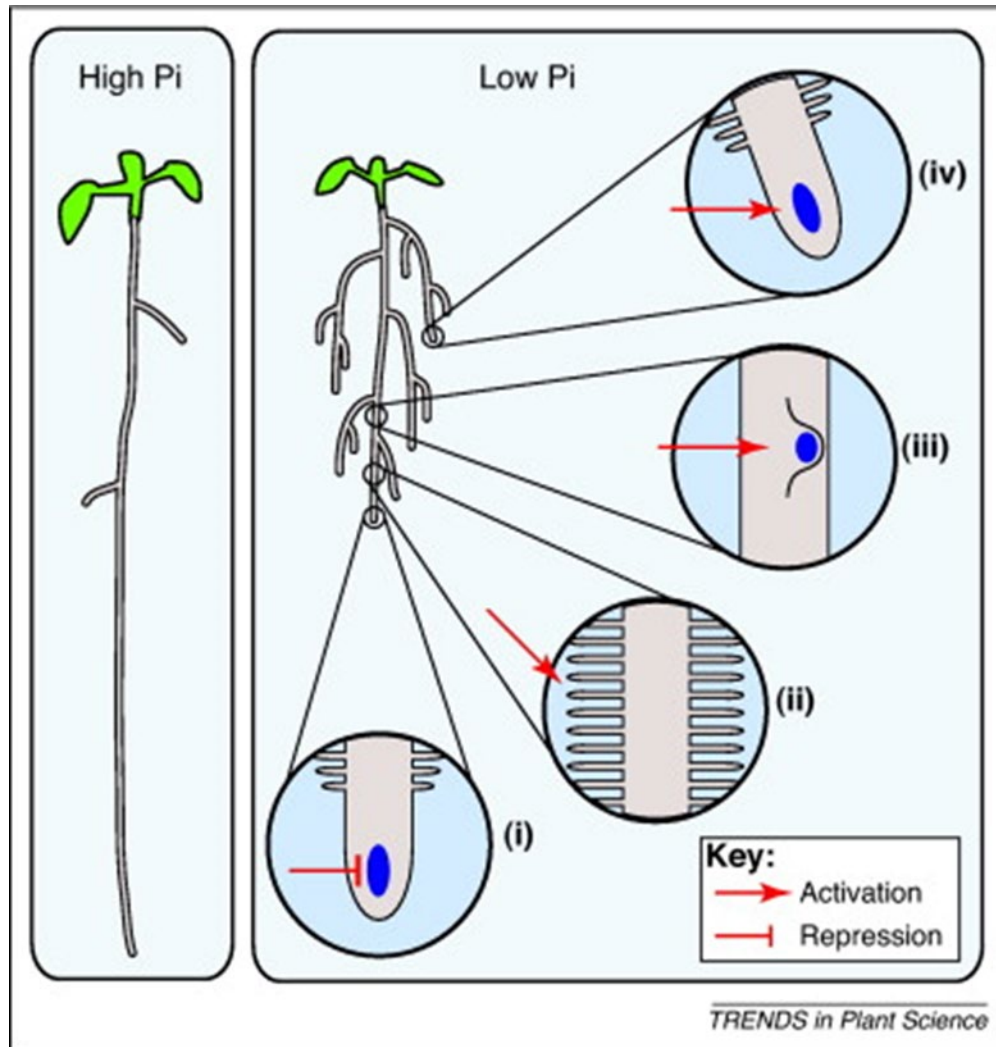


Nutrient	D_e ($\text{cm}^2 \text{s}^{-1}$)	Speed 1 mm	Speed 10 cm
N	2×10^{-6}	42 min	
P	5×10^{-9}	278 hours	320 years
K	10^{-7}	14 hours	16 years
Mn	10^{-10}	13.889 hours	Impossible

P is acquired from the rhizosphere



P and Root Architecture



Field trial with P deficiency in Northern Denmark

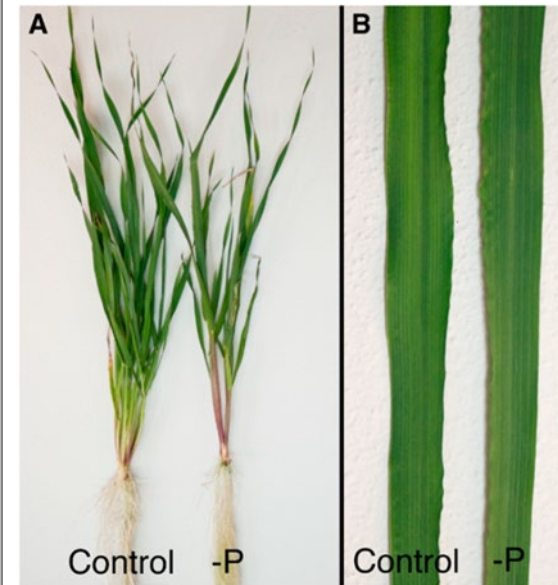
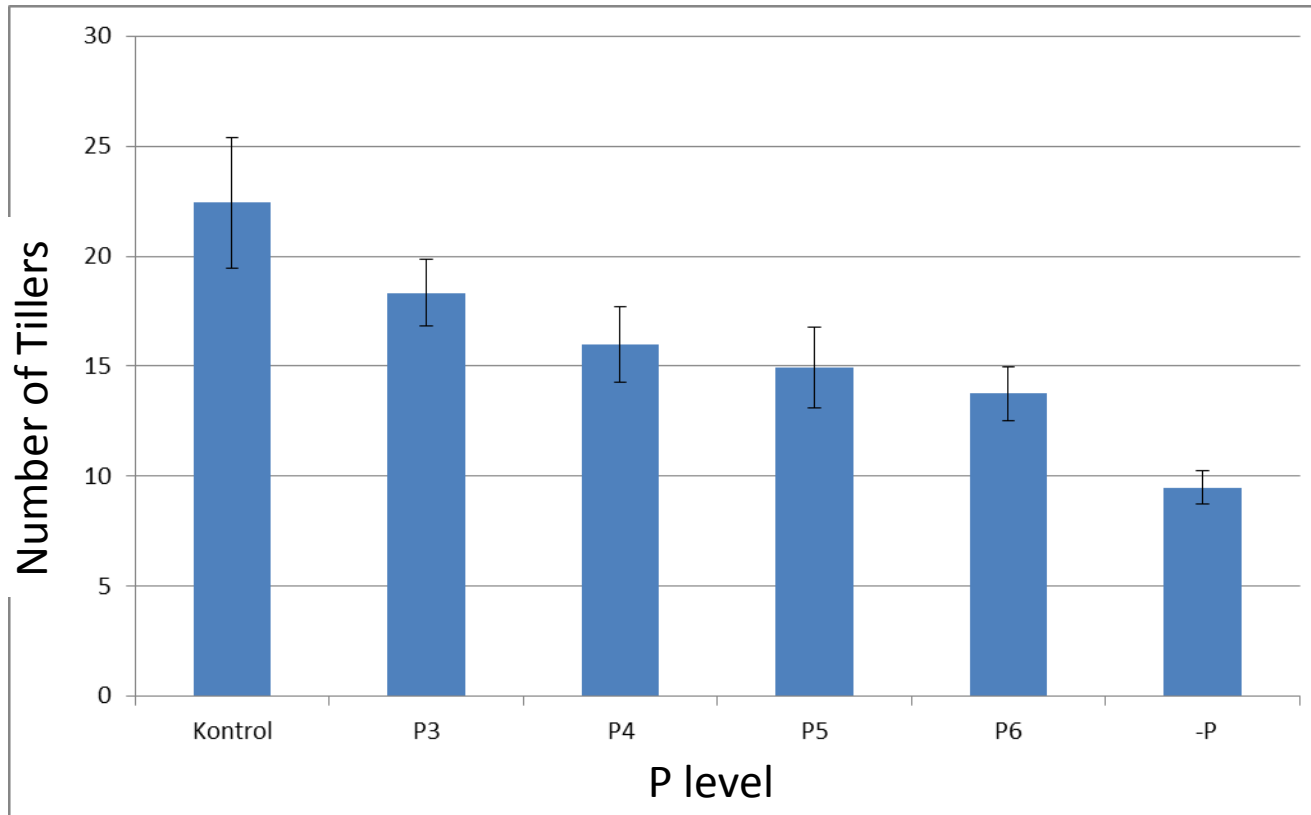


P deficiency and tillering

- 69 DAS

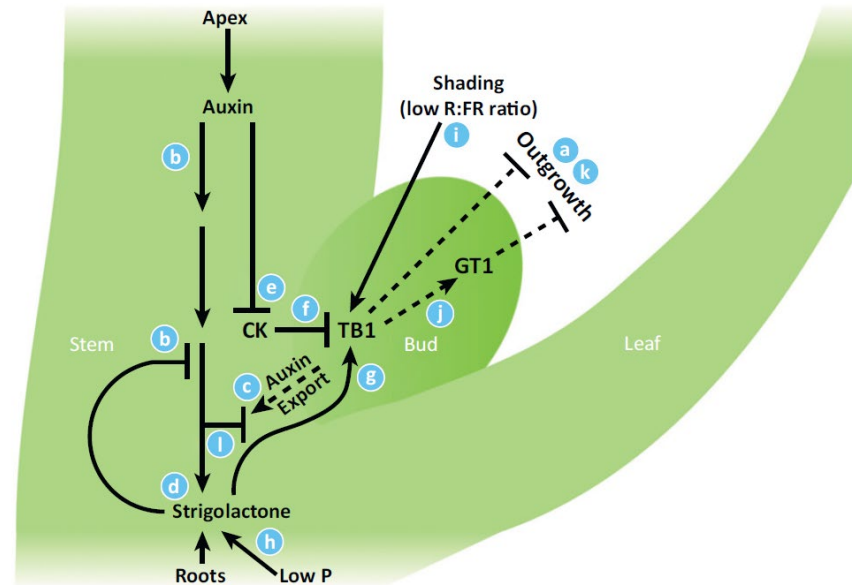
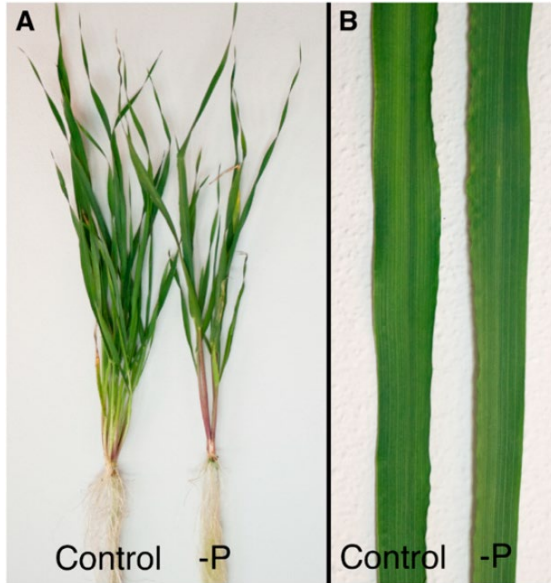


P deficiency and tillering

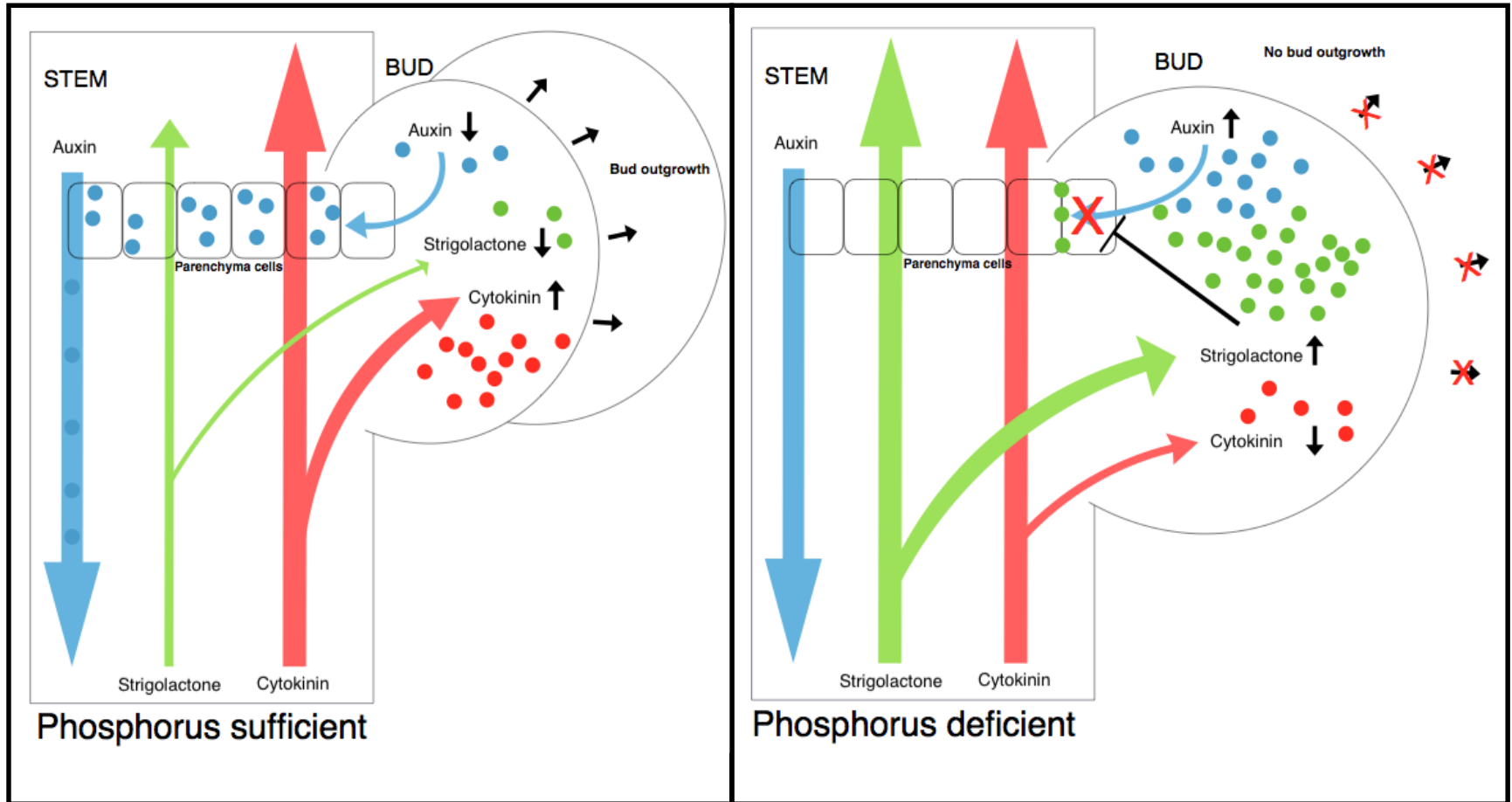


Phosphorus regulates tillering

- during a short period of 3-6 weeks after emergence



Phosphorus deficiency inhibits tillering due to AUX accumulation



Modified after Domagalska, M.A. & Leyser, O., 2011. Signal integration in the control of shoot branching. *Nature Reviews Molecular Cell Biology*, 12(4), pp.211–221.

Xi, L. et al., 2015. Impacts of strigolactone on shoot branching under phosphate starvation in chrysanthemum (*Dendranthema grandiflorum* cv. Jinba). *Frontiers in Plant Science*, 6, p.694.

Chlorophyll *a* fluorescence analysis can detect phosphorus deficiency under field conditions and is an effective tool to prevent grain yield reductions in spring barley (*Hordeum vulgare* L.)

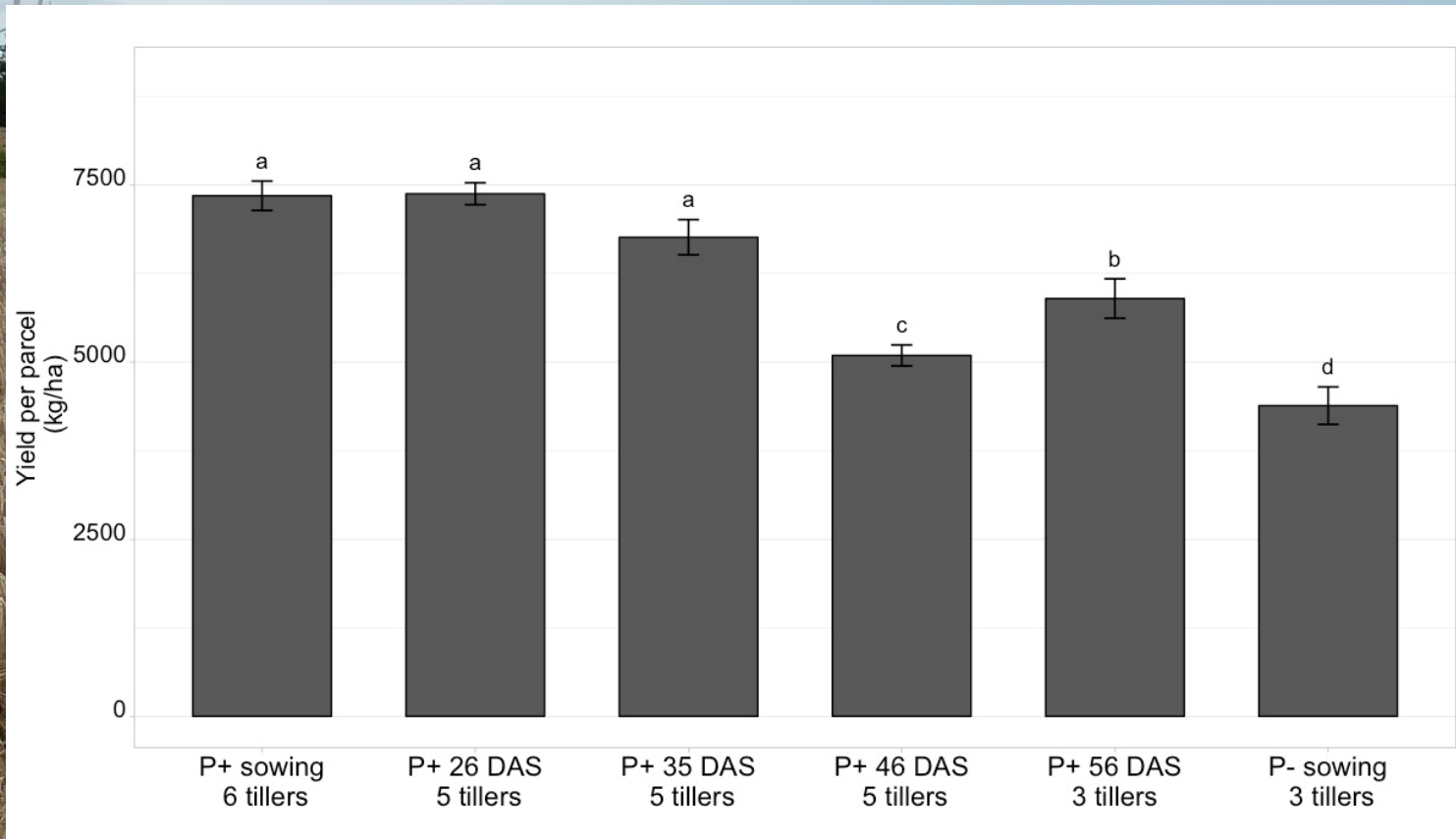
Andreas Carstensen • Augusta Egelund Szameitat • Jens Frydenvang • Søren Husted

Received: 31 May 2018 / Accepted: 13 August 2018
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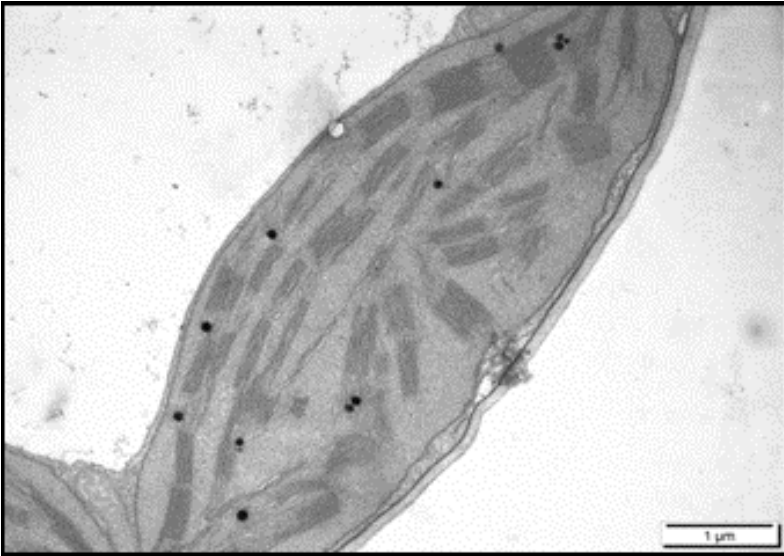
Height (cm)	Tillers
69 DAS	69 DAS
51.0 ^a ± 0.5	7.0 ^a ± 1.5
50.2 ^a ± 0.8	5.3 ^a ± 0.5
40.0 ^b ± 0.8	3.8 ^b ± 0.3
30.1 ^c ± 0.5	3.0 ^b ± 0.4
29.8 ^c ± 0.8	1.8 ^c ± 0.3
30.5 ^c ± 0.7	1.3 ^c ± 0.3



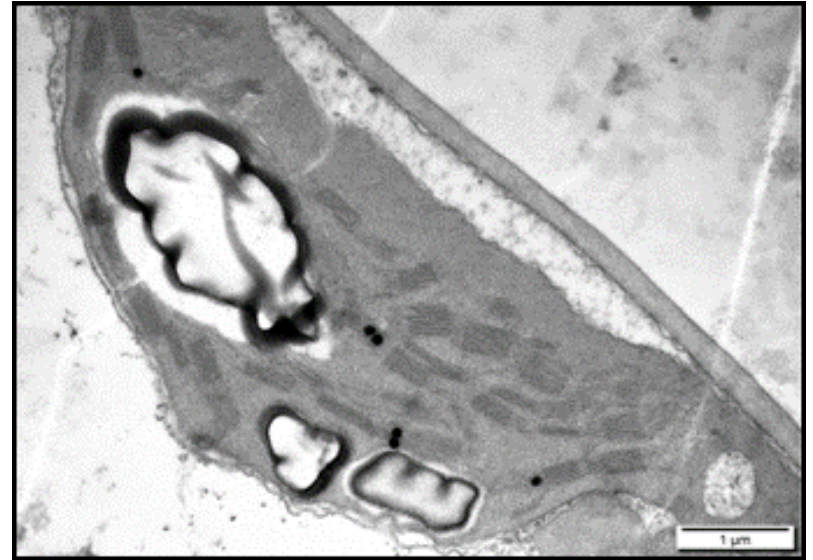
Harvest



P deficiency leads to starch accumulation in chloroplasts

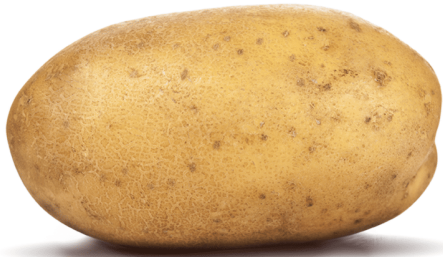
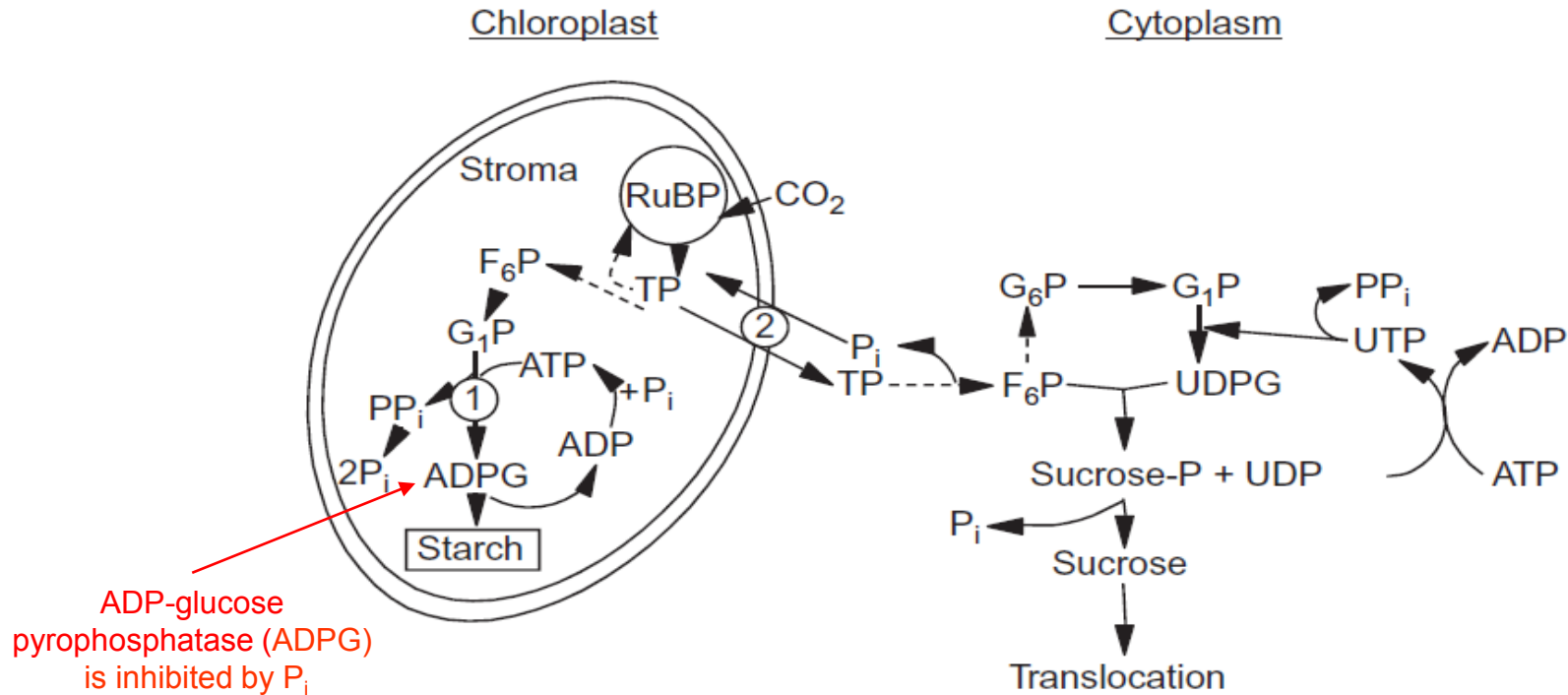


+P

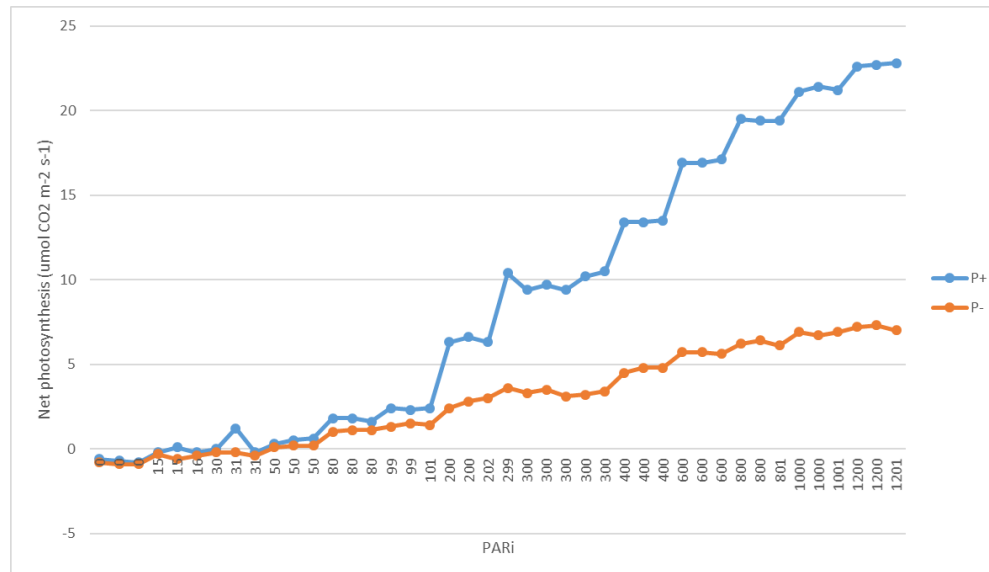
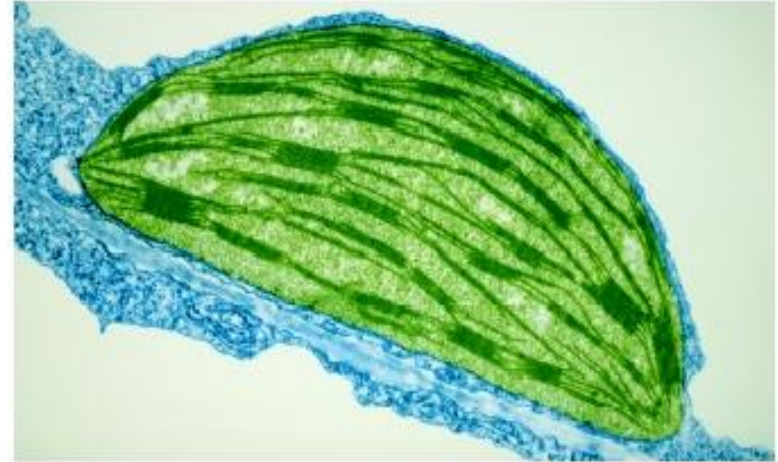
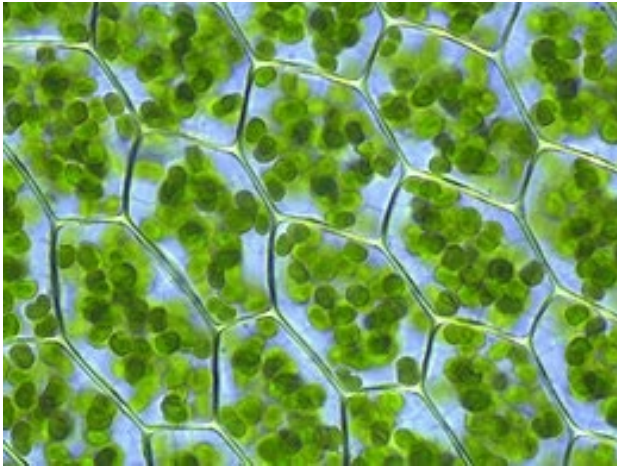


-P

Phosphorus regulates the carbohydrate metabolism

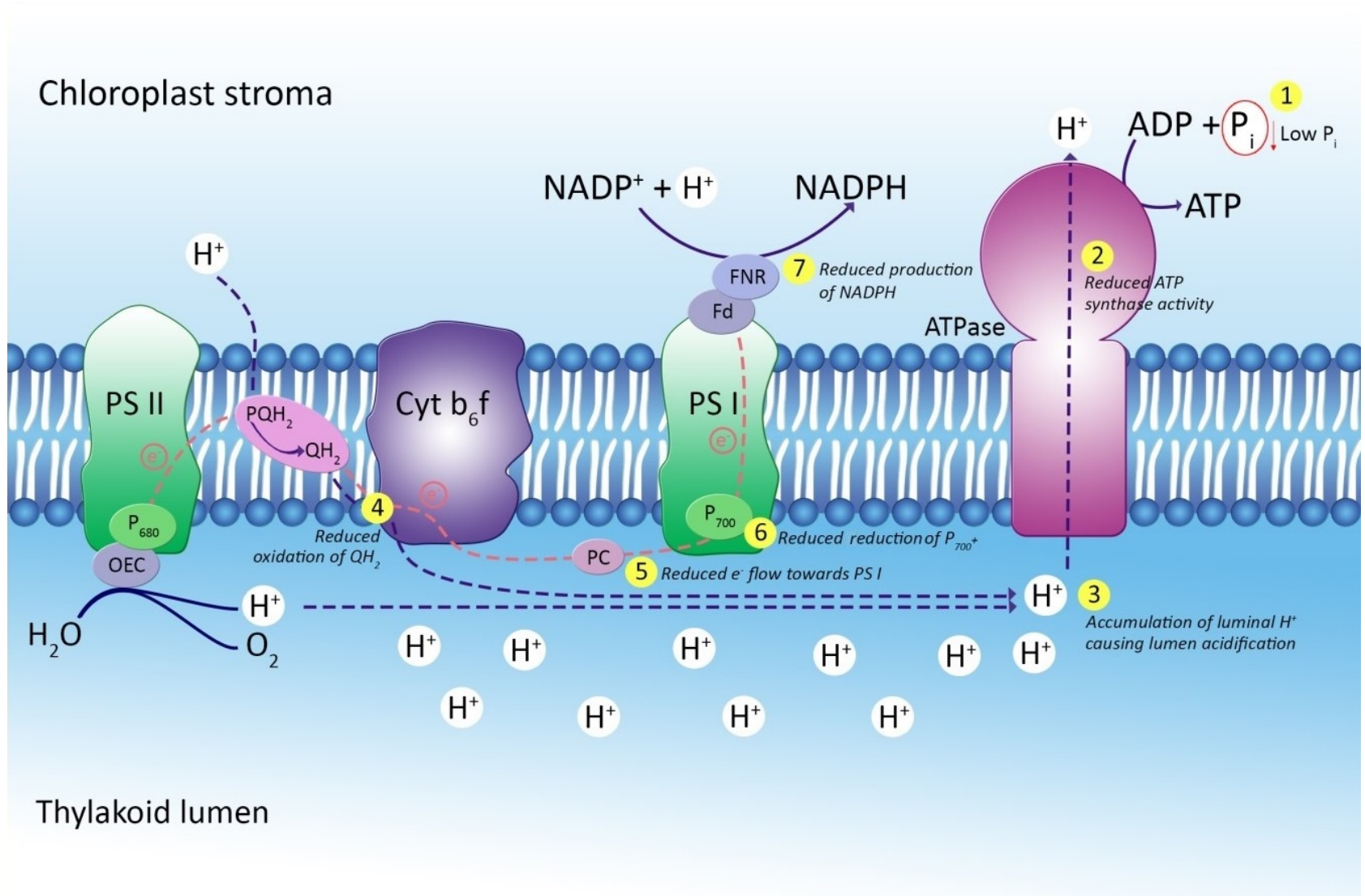


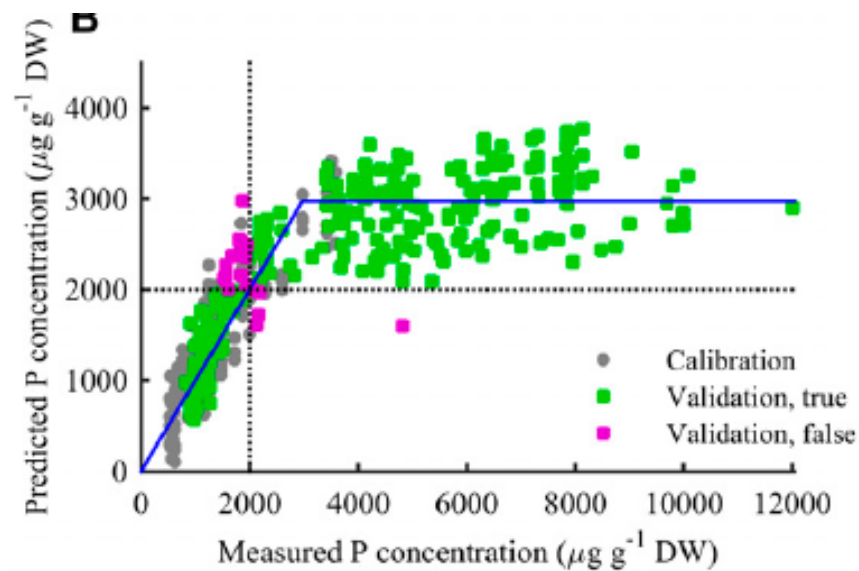
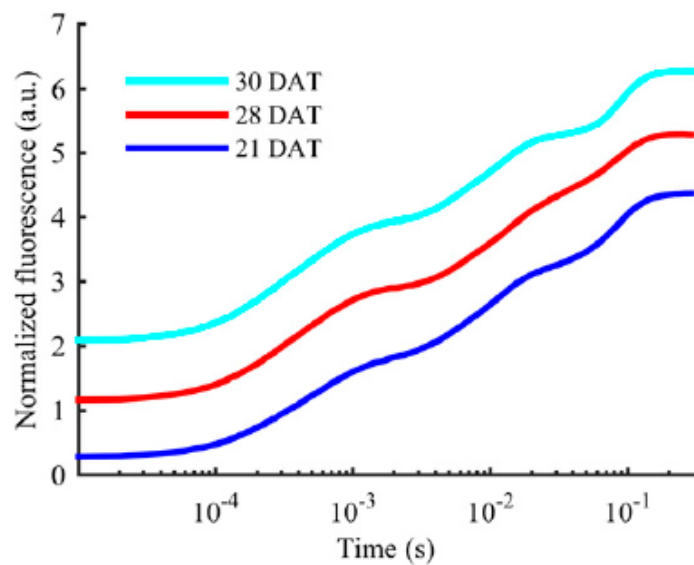
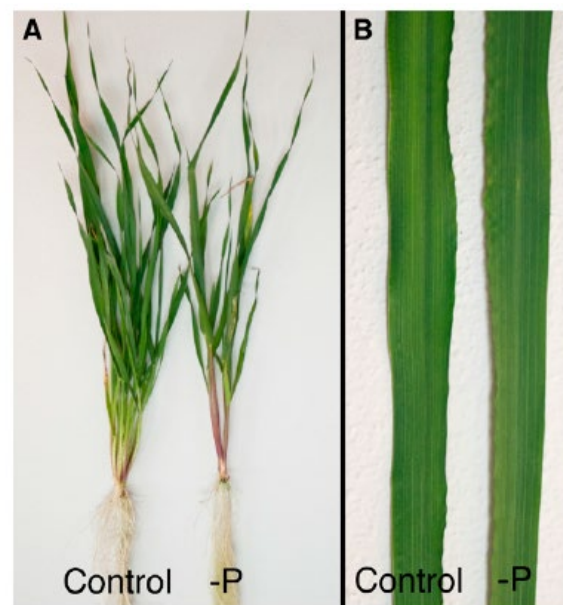
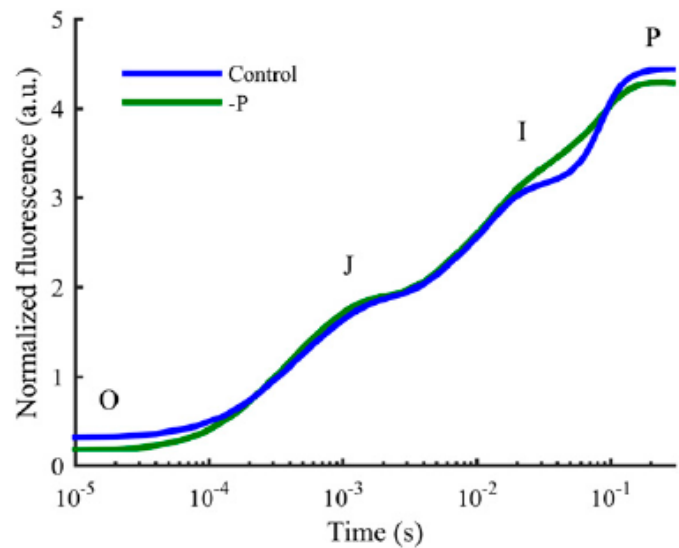
Phosphorus regulates photosynthesis



Phosphorus and the Light Reactions

- *what happens under P deficiency*





Is foliar P fertilization the future?



Placement of P fertilizers often advantageous

TABEL 23. Gødskning af vinterhvede om efteråret og om foråret (N17)

Vinterhvede	Efterår ved såning			Tidligt forår		kg N pr. ha i alt ift. norm	kg P pr. ha ialt	Råprote-in i kerne tørstof procent	Udbytte, kg N i kerne pr. ha	Signi-fikans-gruppe	Udbytte og merudb. hkg kerne pr. ha	Signi-fikans-gruppe
	Udbringnings-metode ¹⁾	kg N pr. ha	kg P pr. ha	kg N pr. ha ift. norm	kg P pr. ha							

2018. 4 forsøg

1. Standard				0		0	0	11,1	103	d	63,1	c
2. TSP ²⁾ - forår				0	22	0	22	11,3	105	bcd	0,3	c
3. TSP ²⁾ - forår m. reduceret norm				-20	22	-20	22	10,7	103	cd	2,6	bc
4. TSP ²⁾ - efterår	Placeret		22	0		0	22	10,9	111	ab	5,7	ab
5. DAP ³⁾ - efterår	Placeret	20	22	-20		0	22	10,5	113	a	9,4	a
6. Svovl. Amm. ⁴⁾ - efterår	Placeret	20		-20	22	0	22	11	106	abcd	3,0	bc
7. YaraMila Raps - efterår	Placeret	20	6	-20	17	0	23	10,9	105	bcd	2,7	bc
8. DAP ³⁾ - efterår	Iblandet udsæd	20	22	-20		0	22	10,8	111	ab	6,2	ab
9. Svovl. Amm. ⁴⁾ - efterår	Iblandet udsæd	20		-20	22	0	22	11,1	110	ab	4,1	bc
10. YaraMila Raps ⁵⁾ - efterår	Iblandet udsæd	20	6	-20	17	0	23	10,9	110	abc	5,6	ab
11. TSP ²⁾ - forår + DAP ³⁾ - efterår	Placeret	20	22	-20	22	0	44	10,7	110	ab	6,7	ab
LSD									6,8		4,2	

¹⁾ Udbringningsmetode om efteråret. Forårsudbringning er bredspredt i alle led.

²⁾ Triplesuperfosfat.

³⁾ Diammoniumfosfat.

⁴⁾ Svovlsur ammoniak.

⁵⁾ Med YaraMila Raps NPK 17-5-10 udbringes 6 kg kvælstof, 20 kg fosfor, 12 kg kalium pr. ha.

Conclusions...

- Phosphorus has a very low mobility in soil
 - Placement of P advantageous
 - Autumn application has proven valuable
- Timing of P application in spring is crucial
 - Tillering and ear setting
- Accurate determination of P status of soils are complicated
 - Plant analysis is a valuable alternative
- Current practise for soil fertilization is not sustainable
 - Foliar fertilization might be an alternative

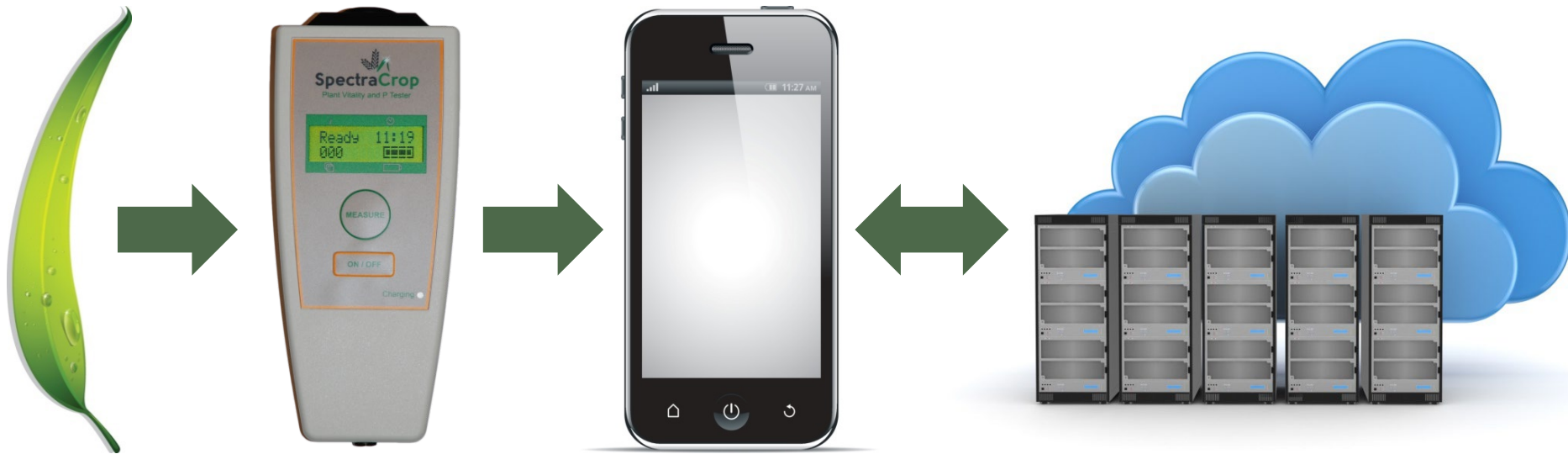
Thank you....



Fosformåleren



Resultatet evalueres på telefonen





Markforsøg med P mangel

↓ Phosphorus applied

