

Developing potato into a high-efficient, low maintenance and multipurpose crop

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Future challenge for agriculture.

9 billion people on the planet in 2050.

Norman Borlaug (2005):

- "By 2050 we have to produce 2x food compared to now."
- "We have to produce more food the next 50 years than the last 10.000 years!"



But it gets worse !

Agriculture have to meet the challenge while decreasing...

Fertilizers to protect the environment.

Pesticides to protect environment and biodiversity.

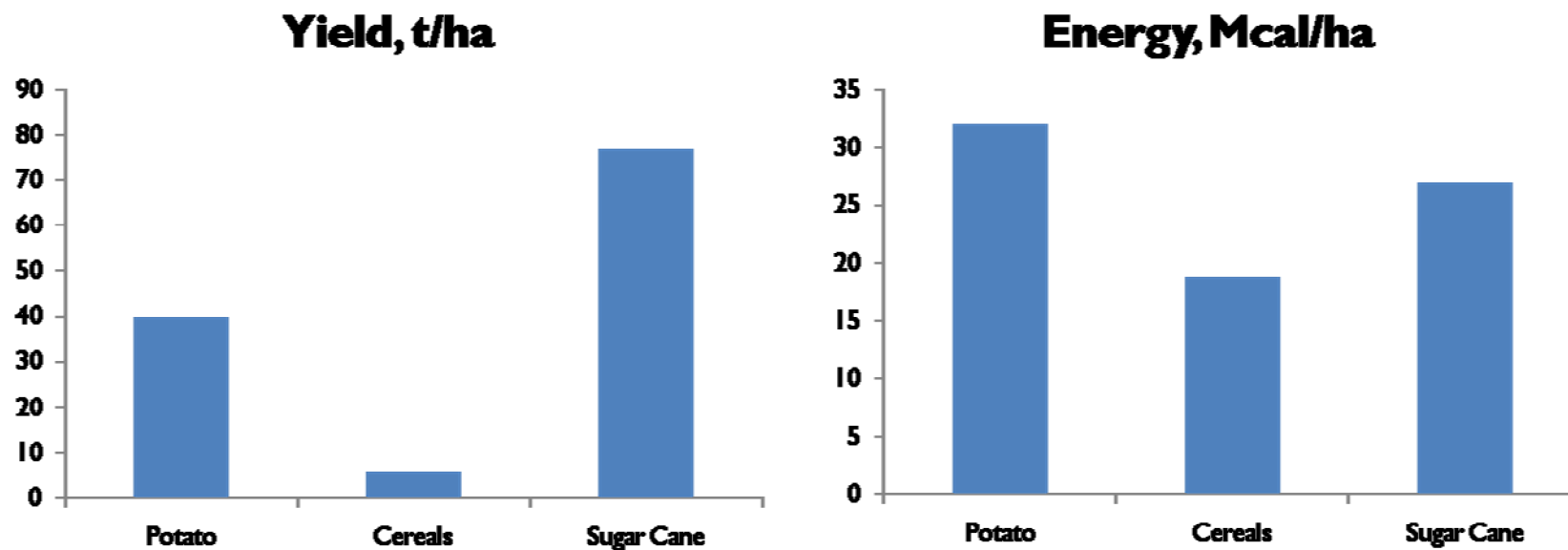
Water to conserve resources.

CO₂ emission (in fact Agri should contribute to CO₂ fixation).

Land use to make room for cities and deserts.

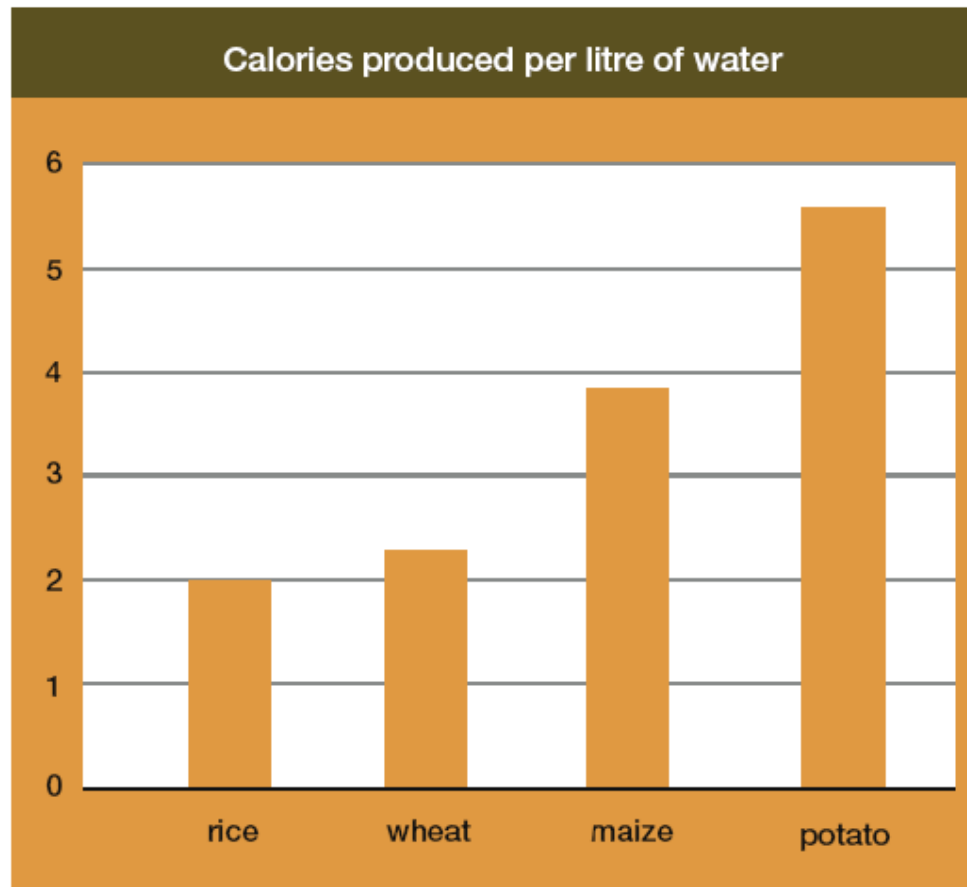
**Land use to make room for renewable precursors for energy,
chemicals and pharmaceutical**

We need to make the most of Agriculture - Energy



FAOSTAT 2007, Yield Potato and Cereals – Denmark, Sugar Cane - Brazil

We need to make the most of Agriculture - Water

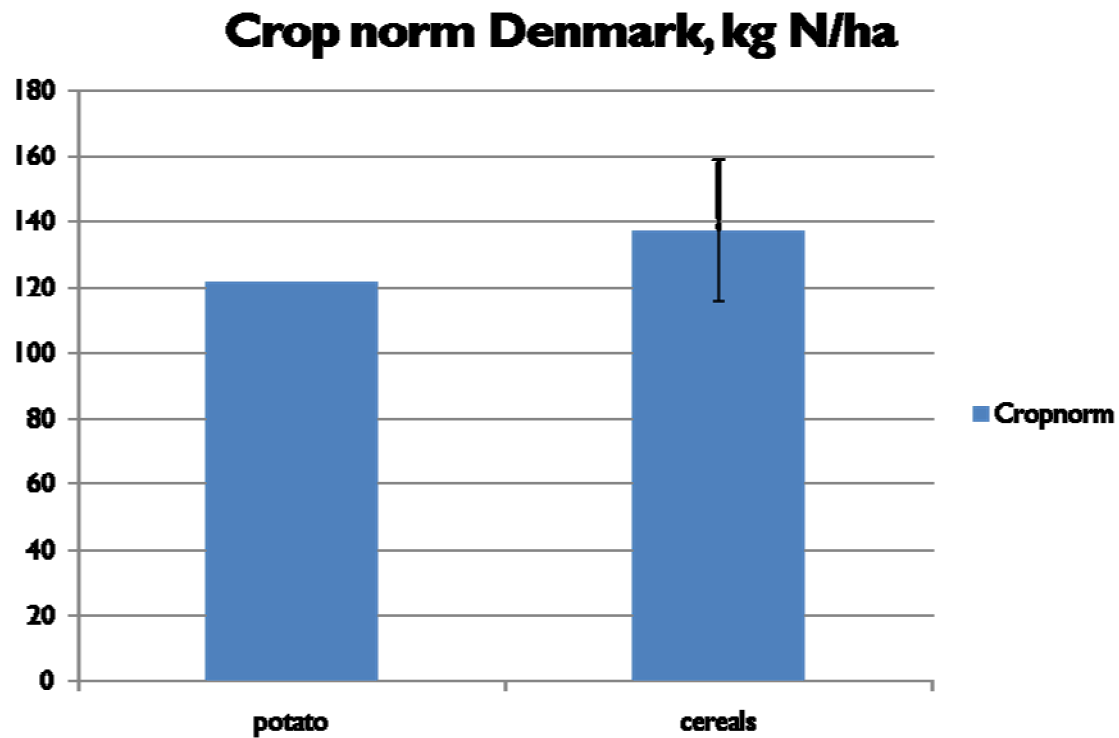


Information provided by FAO's Land and Water Division.

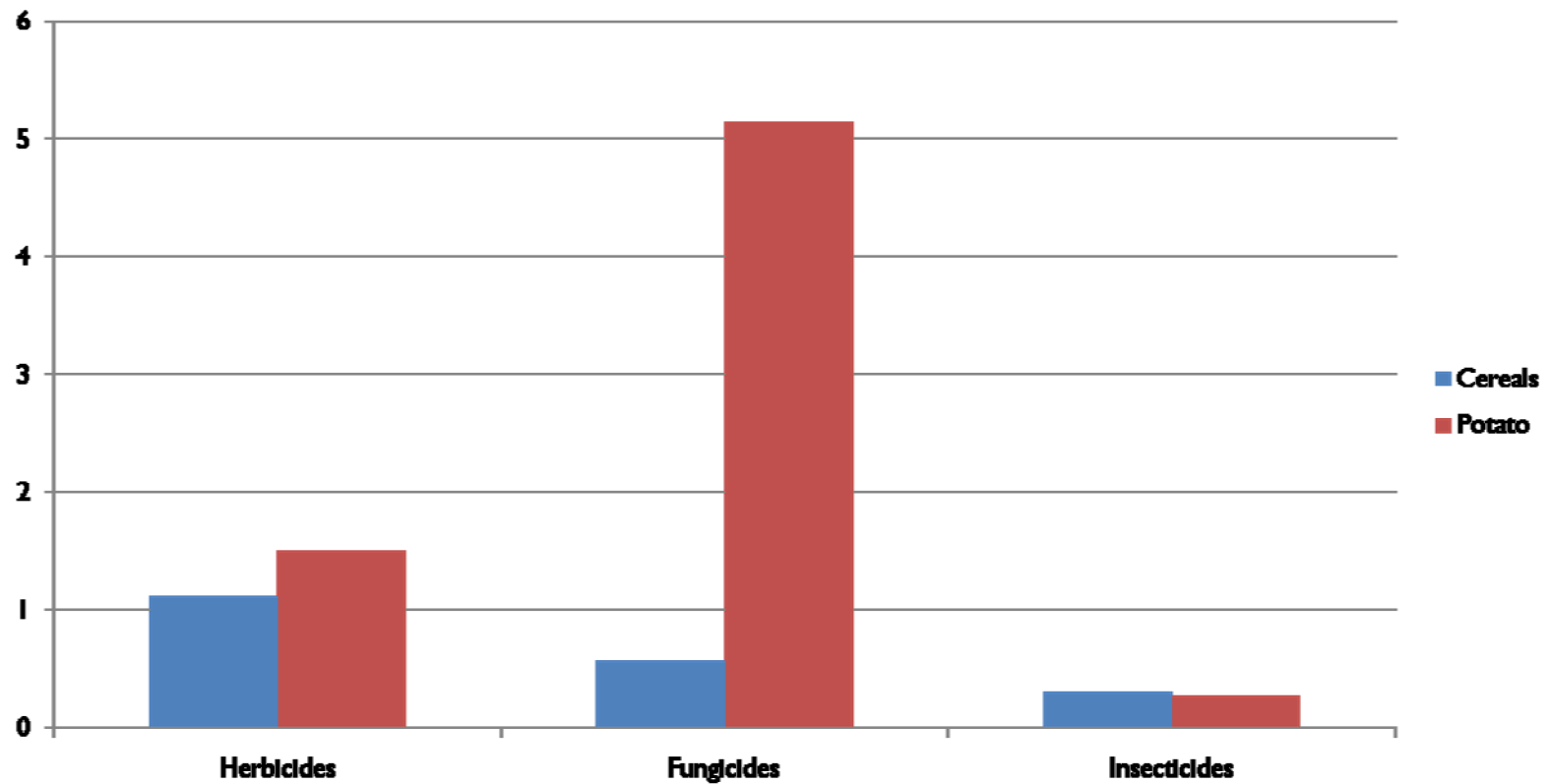
Water is not always used in a rational fashion...



We need to make the most of Agriculture - Fertilizer



We need to make the most of Agriculture - Pesticides



Potatoes are grown mostly for food in the world

World (CIP)	Yield, mio tonnes	Food	Feed	Processing	Seed	Other	Area, mio ha	Yield, tonnes/ha
1995-1997	295	54	19	12	8	8	18.4	16

Denmark, 2000	Area, ha	Yield, kg/ha	Farmer value	Retail value
Food	11000	36100	Ca. 54 mio €	Ca. 340 mio €
Starch	22642	47100	Ca. 63 mio €	NA
Seed	4522	30500	NA	NA

Basic Project hypothesis for improving potato as a staple crop

Assumptions:

Gene expression regulation is the most important factor in translating genotype to phenotype.

Elite cultivars are extremely in-bred (though very heterozygous).

Elite cultivars have phenotypic variation in yield, disease and drought resistance.

Possibility:

Pinpoint which genes and gene networks that are causal for the phenotypic variance by gene expression analysis of different elite cultivars under various conditions

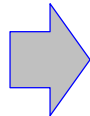
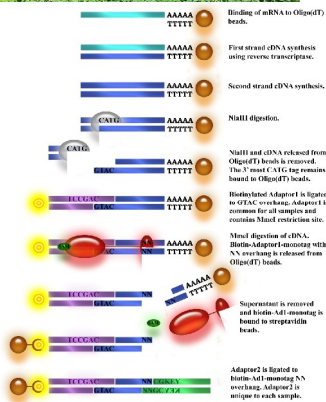
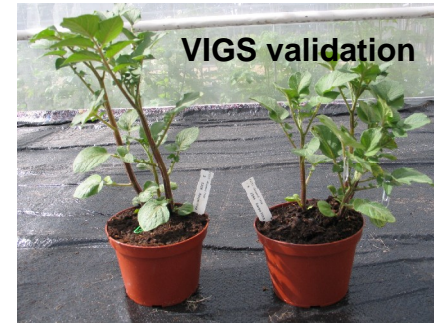
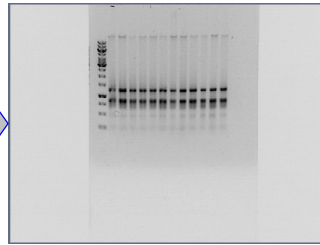
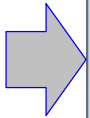
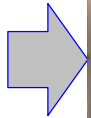
Output:

True breeding targets: genes or gene networks causal for phenotypic differences.

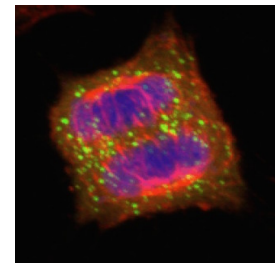
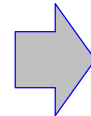
Implementation:

By GMO or precision breeding (MAS)

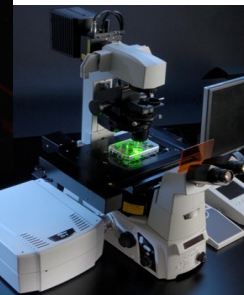
Project overview



Cand gene list

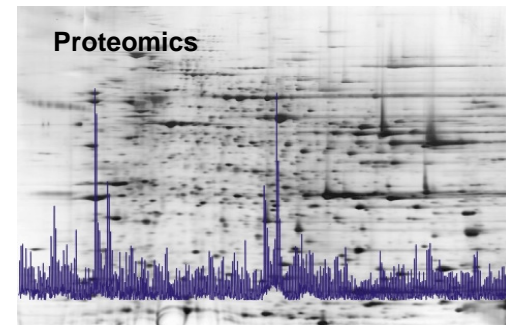


Imaging of GEX



Proof of concept GMO:

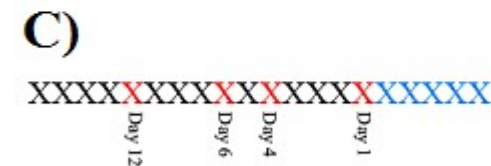
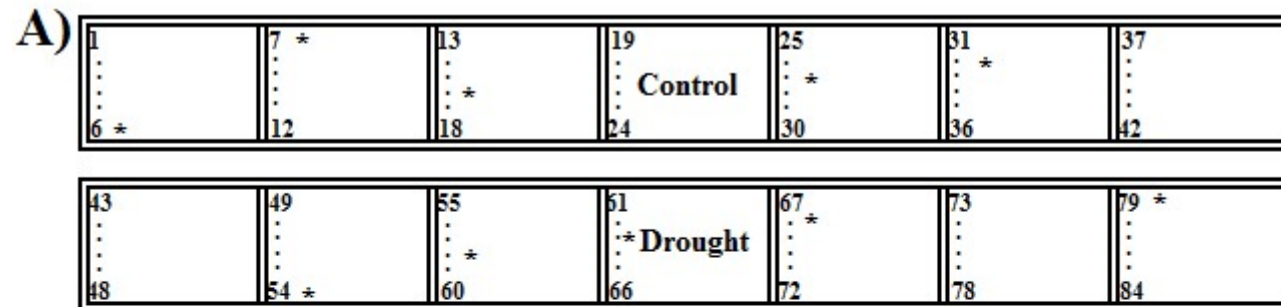
- Increased yield
- Disease resistant
- Drought resistant



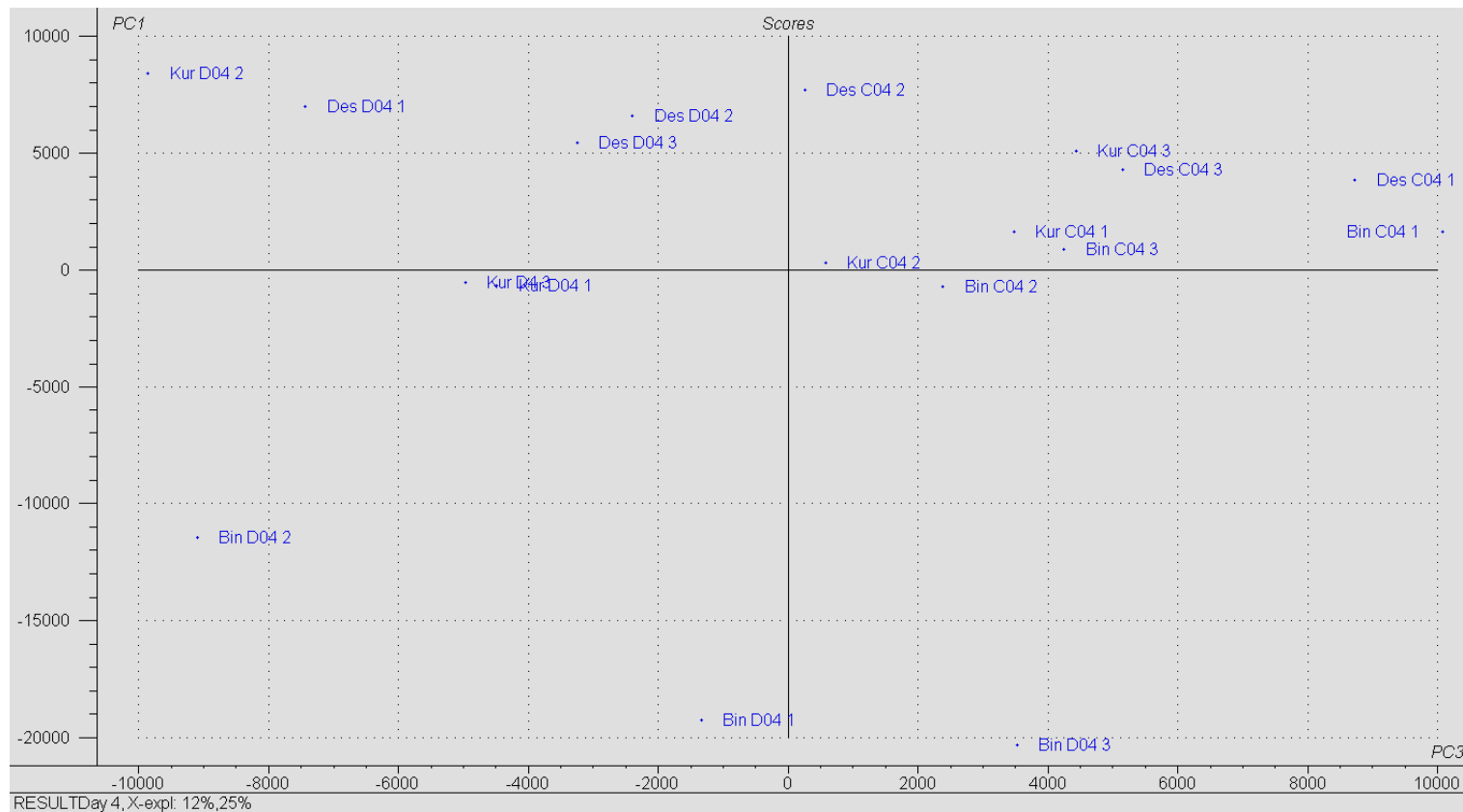
Proteomics

Mild Drought experiment setup – total 14 cultivars

	Day 1	Day 2	Day 4	Day 6	Day 8	Day 12	Day 15	Day 19
- water								
+water								

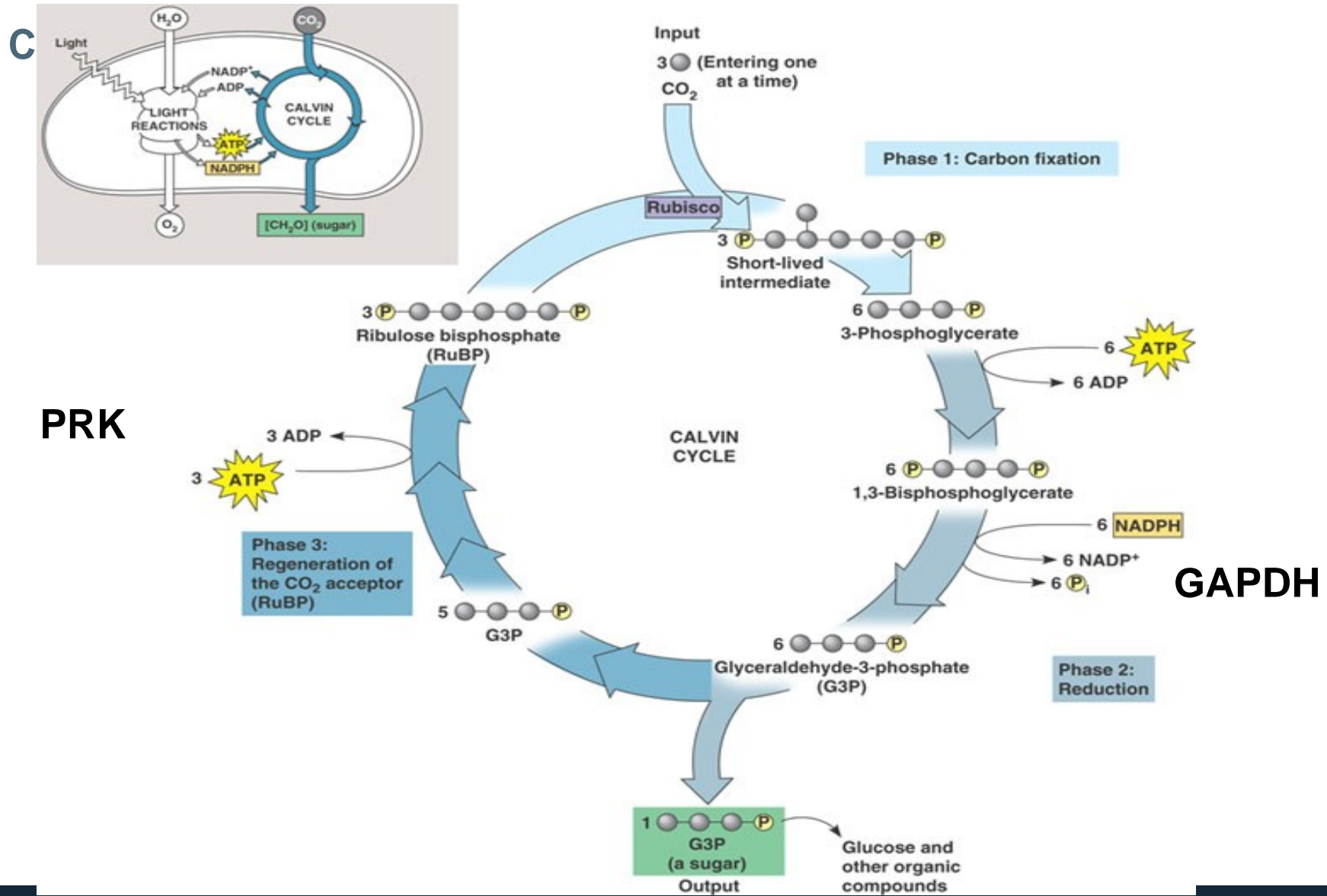


Example: Principal Component Analysis Day 4 –drought series

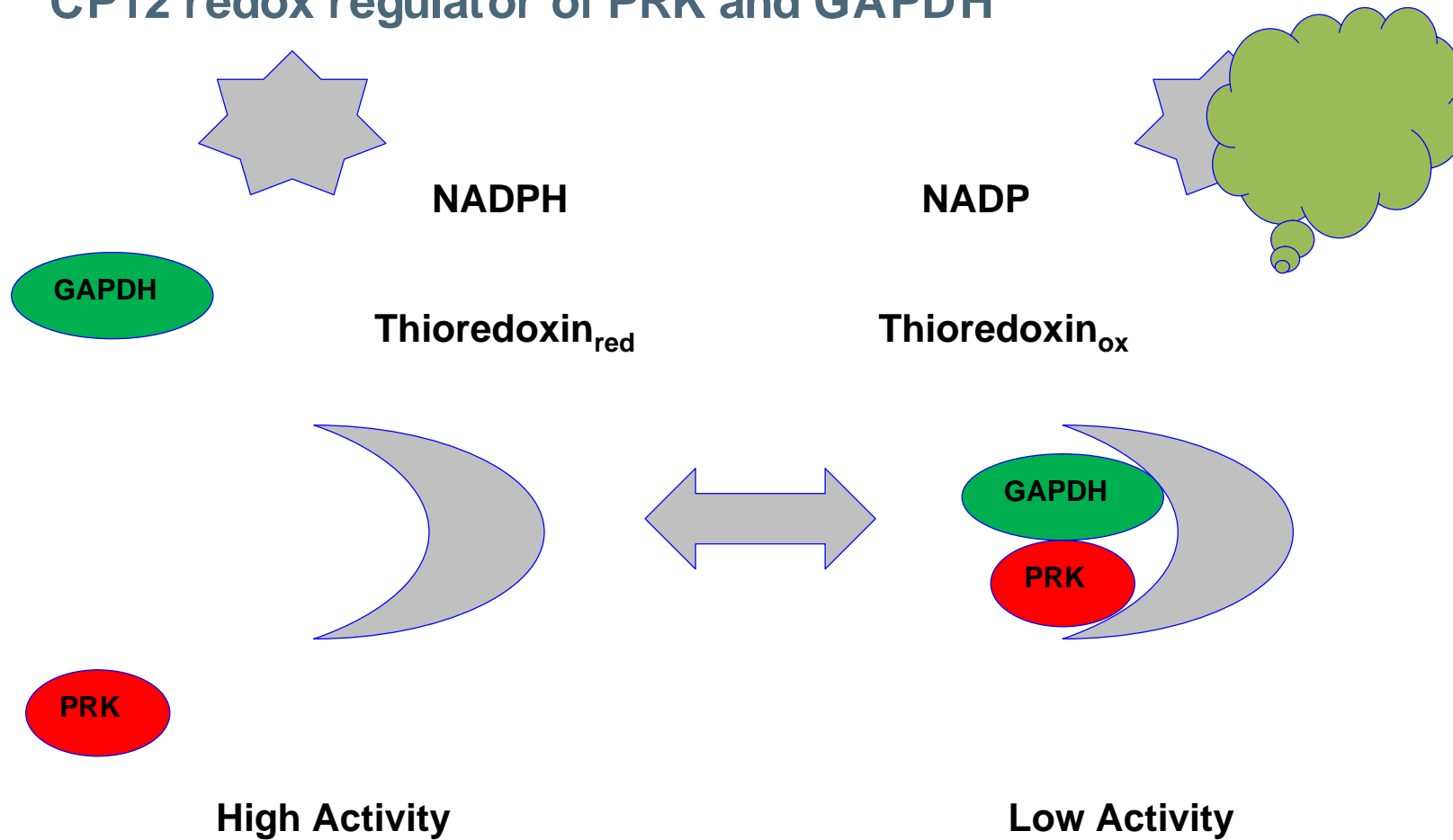


PCA loadings day 4

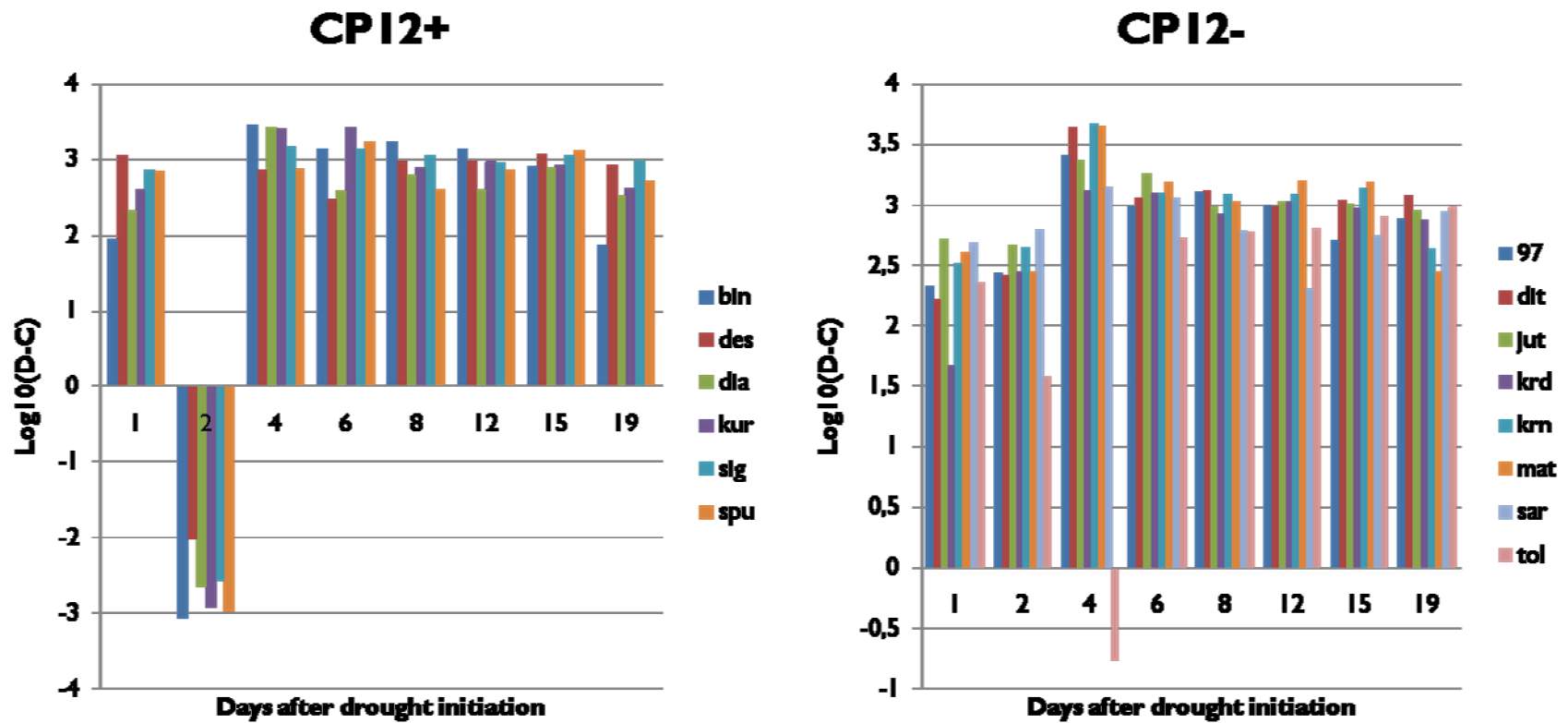
#Tag	Day_1_PC_01	Primary Annotation ID	Primary Annotation Name
TACTGGGATTTGTATCT	-1,76E-01	TC165108	Pre-pro-cysteine proteinase precursor
TAATTTATACATTATAA	-1,67E-01	TC168114	Cysteine proteinase 3 precursor
AGCATCTCTGCATCTGG	-0,129	TC180044	Metallothionein-like protein type 2 B
CAAGGGACAAGAAGAAG	-1,29E-01	TC179723	CP12 precursor
AATGGAAGTGAATGAAG	-1,28E-01	TC163991	NA
TACTAATAGATTTCTAA	-1,15E-01	TC164521	Chlorophyll a-b binding protein 6A
TCTCTACCTGAAGATGG	-9,69E-02	TC190223	Carbonic anhydrase
ATTTGTACTTATGGCAT	-9,40E-02	TC164981	Light-induced protein
AATAAGAATCTTTCTTT	-8,70E-02	TC180534	2-oxoglutarate-dependent dioxygenase
AGCATTTACTTTTCATA	-8,61E-02	TC181212	Ferredoxin I precursor
AGAACTAATAATAGTAA	-8,52E-02	TC191874	Ribulose biphosphate carboxylase small chain 2C
TTATTTTCTACTTGTAT	-7,18E-02	TC165906	chr scaffold_232 wgs
AGAACTAATAATCATCT	-6,60E-02	unknown	NA
GATGATTTTTGAAGCTA	8,66E-02	TC163804	chr18 scaffold_137 wgs
TTTGGATTCTTCGTTCA	8,84E-02	TC166272	Chlorophyll a-b binding protein 13
GATAATAAAATGGTGAA	8,86E-02	TC191617	Phosphoribulokinase
TTTGGATTTTTTGTTC A	8,87E-02	TC192573	Chlorophyll a-b binding protein 3C
GTATTGGAAA ACTGATA	1,20E-01	TC163877	Probable peroxisomal (S)-2-hydroxy-acid oxidase 2
CTTGTTCAAGAGCAAGA	1,23E-01	TC187943	Ribulose biphosphate carboxylase/oxygenase activase 2
CAAATGAAATAATTATA	1,26E-01	TC172942	Protein induced upon tuberization
GGGAGGACAACCTGAGA	1,27E-01	TC164121	Fructose-biphosphate aldolase
TATAAATTATAATTAAG	1,32E-01	TC179123	chr scaffold_87, wgs
TTTGGATTCTTTGTTCA	0,166	TC192573	Chlorophyll a-b binding protein 3C
TAATGTAGCCAAATCAA	1,88E-01	TC168267	Fructose-biphosphate aldolase
TAATCTTTTCAAAAATA	0,62	TC178472	Photosystem II 10 kDa polypeptide



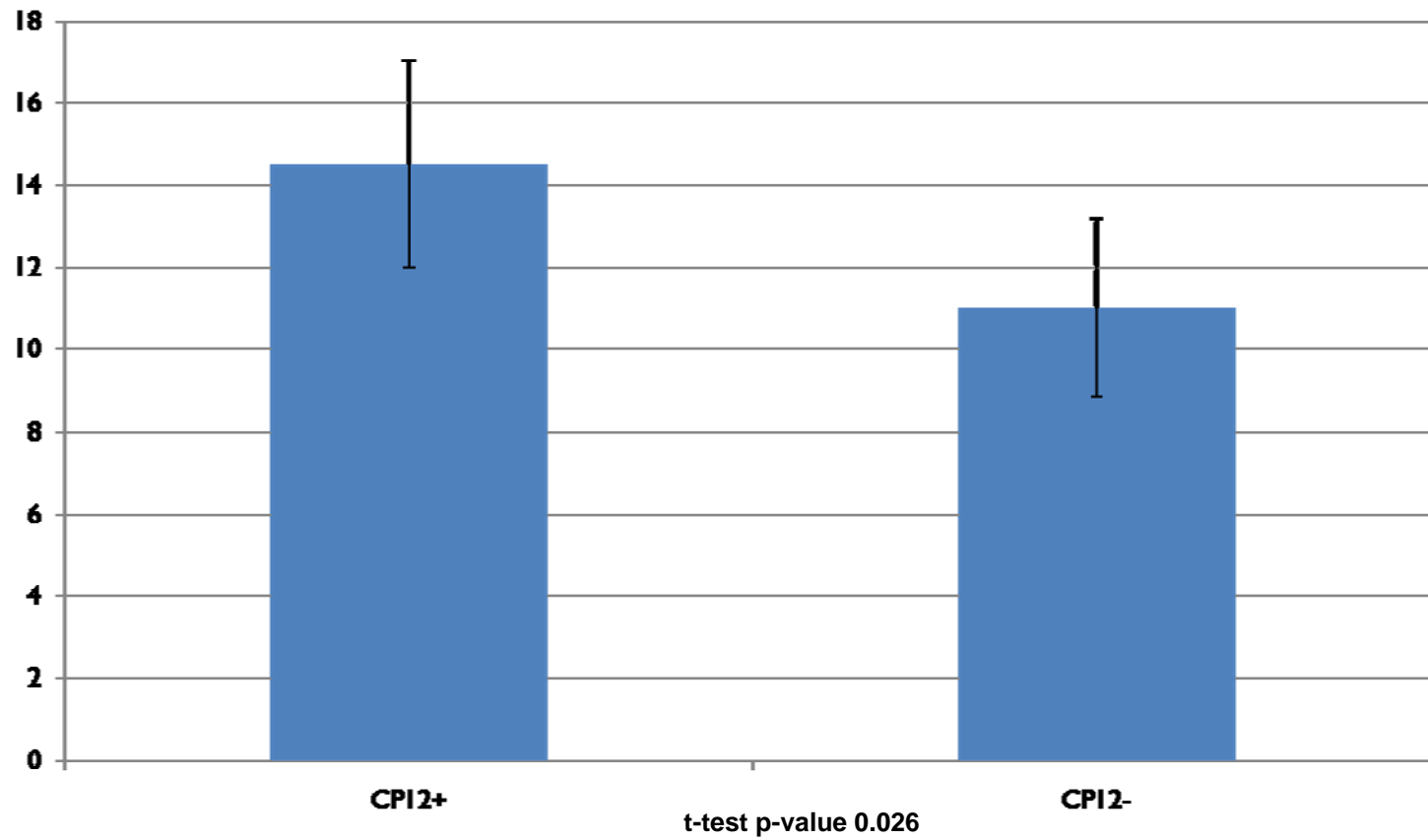
CP12 redox regulator of PRK and GAPDH



Different regulation of CP12 among different cultivars



Yield 2008 –32% difference



If a single day of down regulation will cause a 32% difference – then abolishing the response all-together.....



Collaborators on the project

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