Towards efficient vegetable production systems

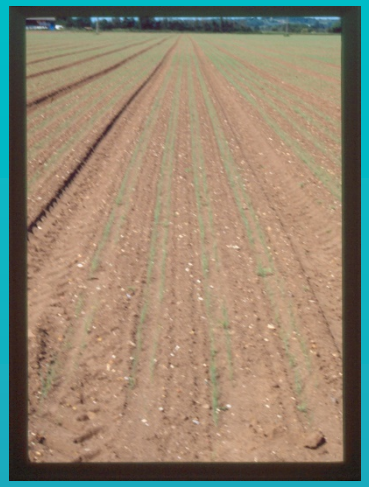
Bill Finch-Savage

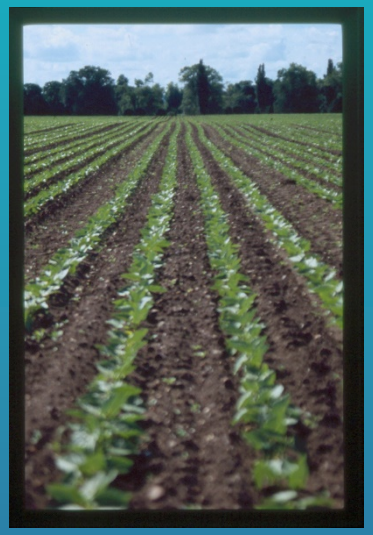
18th December 2019 / Celebrating 70 years of research at Wellesbourne

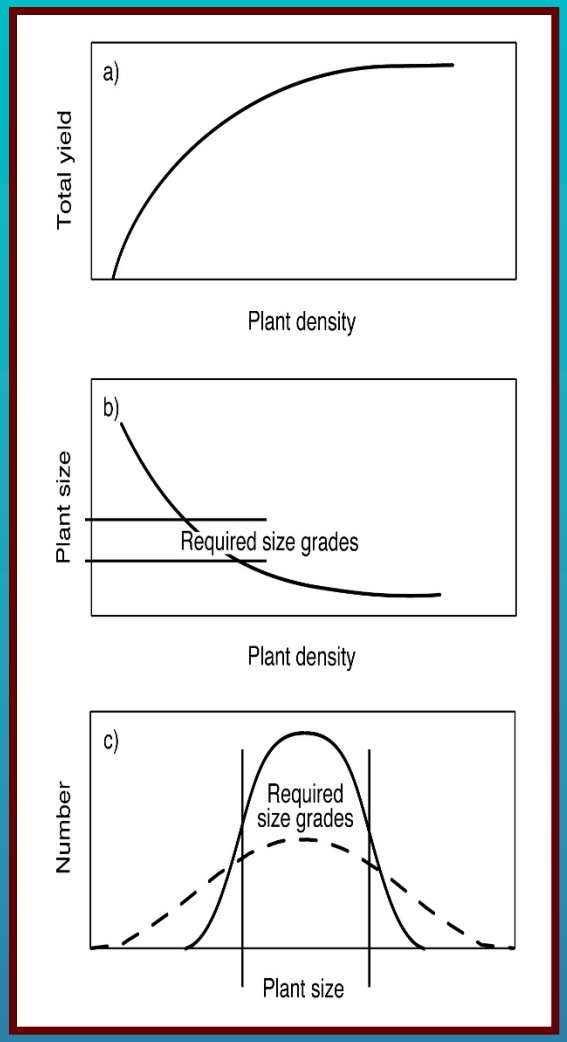
WARWICK
THE UNIVERSITY OF WARWICK

1950-1970s: Programme to increase yield and profitability via optimisation of field vegetable production systems. J. Bleasdale, P. Salter, D Gray, D. Wurr

Plant density
Plant arrangement
Rectangularity
Bed systems
Many vegetable crops





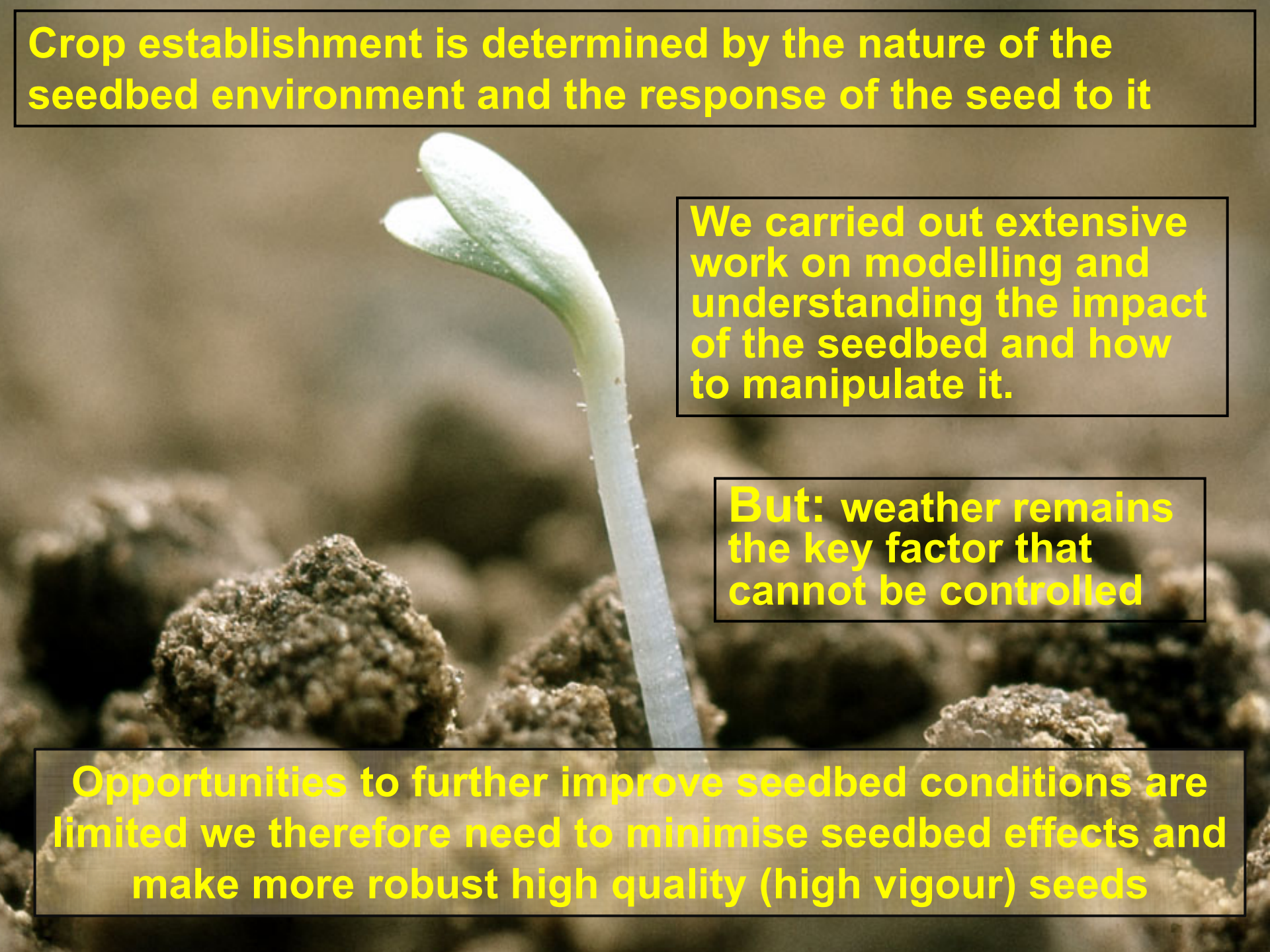


Density determines total yield

Density determines mean plant size and therefore size grades

Variation determines proportion of yield in high value grades and harvest efficiency (marketable yield)

Variability in plant size at harvest and therefore marketable yield is greatly influenced by crop establishment



Crop establishment is determined by the nature of the seedbed environment and the response of the seed to it

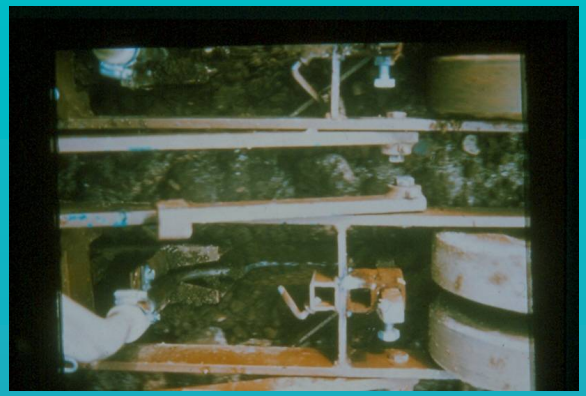
We carried out extensive work on modelling and understanding the impact of the seedbed and how to manipulate it.

But: weather remains the key factor that cannot be controlled

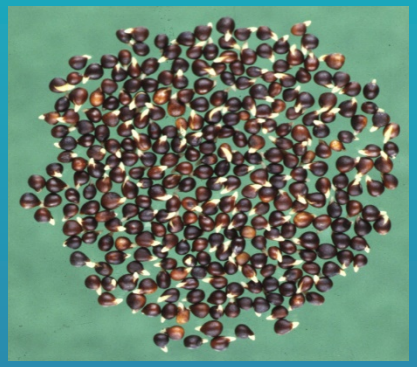
Opportunities to further improve seedbed conditions are limited we therefore need to minimise seedbed effects and make more robust high quality (high vigour) seeds

Minimise Seedbed effects: Pre-germinated seed technology

1970s Fluid Drilling (I Currah *et al*.): Fluid Drilling Ltd. Founded 1976



1980s: Low Moisture Content Germinated Seeds (WE Finch-Savage)



(12) UK Patent (19) GB (11) 2 175 488 (13) B

(54) Title of Invention

Seed treatment

(51) INT CL⁴: A01C 1/00

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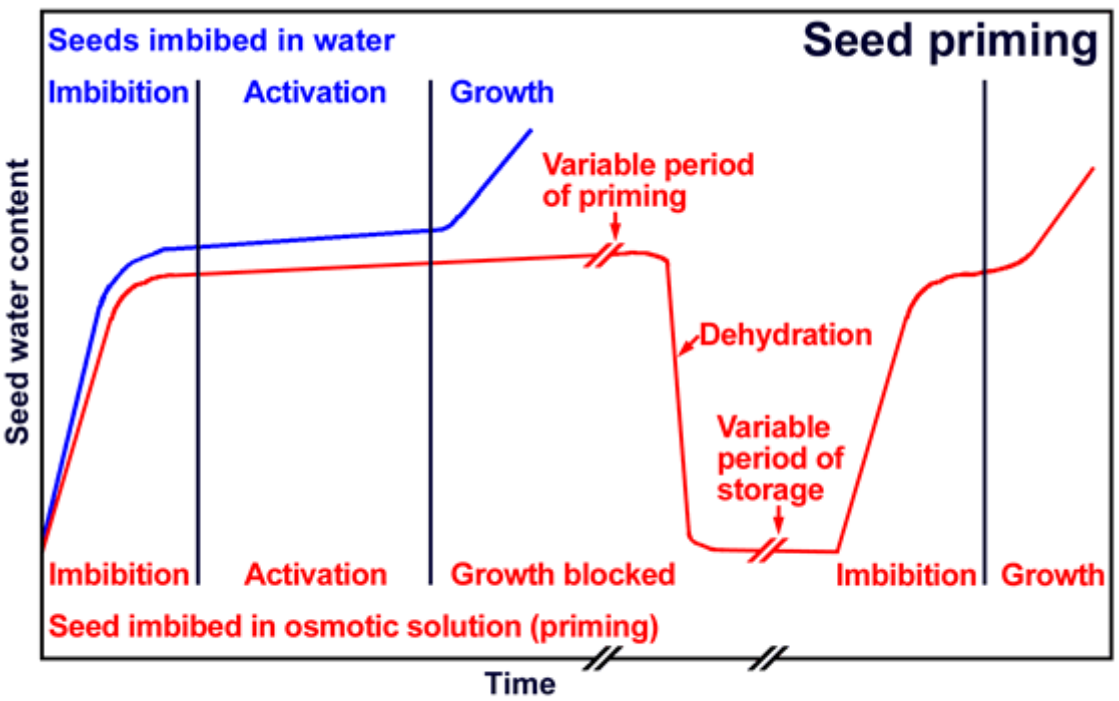
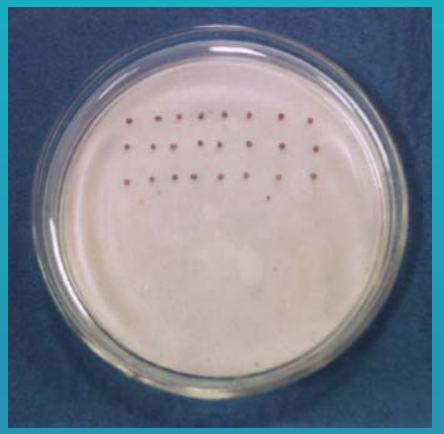
More robust seeds: Physiological enhancements

1960s Seed Hardening, Austin RB and Longden PC
1970s Hormone treatment TH Thomas
1970s Osmotic Seed Priming (W Heydecker, Nottingham University)
P. Brocklehurst and D Gray at NVRS



Osmotic priming

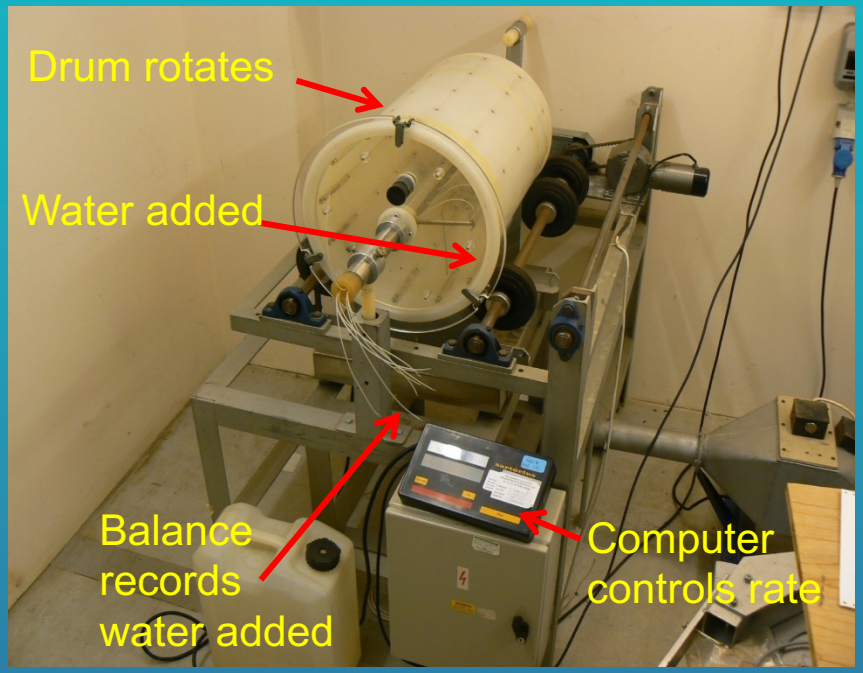


1983 Bulk Priming in Polyethylene Glycol, D. Gray in collaboration with University of Birmingham showed large scale priming was possible

So how could it be made a commercial reality?

JUST ADD WATER

H. Rowse 1986: Patented Drum Priming technology



1990

News Grower Magazine March 1st 1990

Primed seeds on the market five years after conception

Ann Flaherty

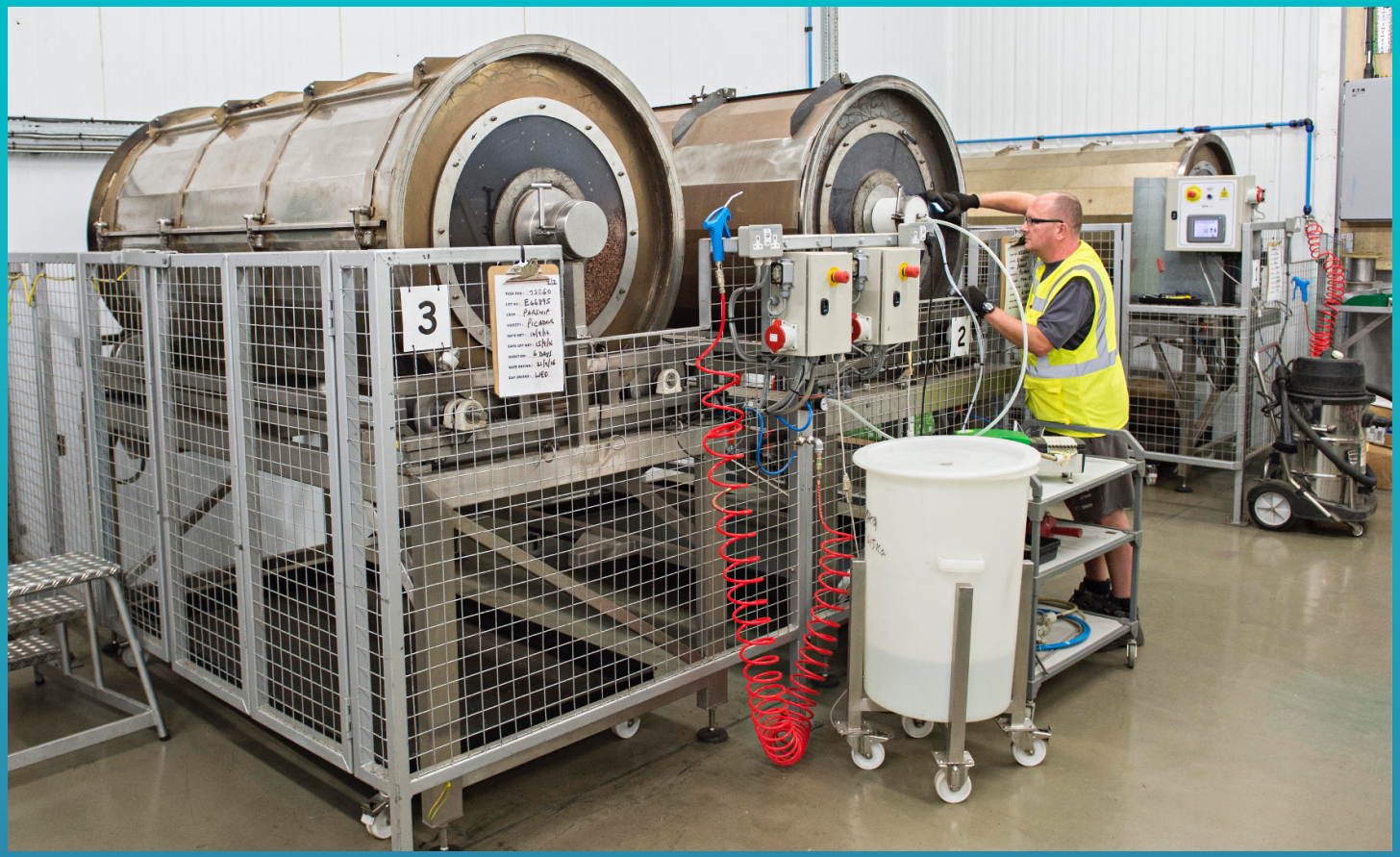
THE MOVE by research stations towards a more commercial outlook was very clear at IHR Wellesbourne's members' day. Of the five projects discussed one which involved non-osmotic priming of seeds was already in the marketplace and a license was being sought for a second piece of work on an identification test for bacteria and viruses.

The idea of non-osmotic priming — a seed treatment which increases the speed and uniformity of plant establishment by controlling hydration without using osmotic substances like polyethyleneglycol — was first conceived at Wellesbourne five years ago.

Studies on the effects of weather patterns on seedling establishment led to the development of a computer simulation model. The model predicted that under conditions of moderate water stress, seeds develop in the soil to the point of germination but no further until the stress is relieved, after which germination is extremely rapid and uniform. By controlling the extent of seed hydration it was noted that

Dr Hugh Rowse (left) of IHR Wellesbourne and Howard Vaughan of Booker Seeds compare the growth of primed seed (left) with natural seed. Booker have bought a license to use the drum priming system developed by Wellesbourne.

Commercial reality: 2019



Elsoms seeds Ltd

Range of species (parsnip onion carrot parsley etc). From 11 Tonnes in 2012 to 16 in 2015 to 25 Tonnes in 2017. Anticipate continued increase in total weight and numbers of species

2000s: Genetics of seed vigour and performance, WE Finch-Savage

Trait to gene analysis in *B. oleracea* identified two QTL containing three genes

QTL	Genes
Speed of Germination (SOG) 1	***BoLCVIG1*** = Encodes protein of unknown function (*At3g01060*) ***BoLCVIG2*** = Encodes Polypyrimidine Tract Binding Protein 1 (AtPTB1), regulates alternative mRNA splicing
Speed of Germination (SOG) 2	***BoCYP707A2*** = Encodes ABA catabolic enzyme (*At2g29090*)

Mechanism:

***BoCYP707A2* determines abscisic acid (germination inhibitor) content**
***BoLCVIG1* determines sensitivity to abscisic acid**
***BoLCVIG2* regulates the presence of the BoLCVIG1 active variant**

Morris K, Barker GC, Walley PG, Lyn JR and Finch-Savage WE. (2016) *New Phytologist* **212**: 964-976

Vigour Improvement: incorporate beneficial alleles of the three genes

Vigour Test: 10 days at 5°C ------then------- 5 days at 20°C
Low temperature stress----------induction of secondary dormancy

	Female with selected alleles		Female with standard alleles	
	10d 5°C	+5d 20°C	10d 5°C	+5d 20°C
Male 1	35	96	0	6
Male 2	28	96	0	10
Male 3	72	94	19	44
Male 4	9	96	0	4
Male 5	43	100	0	8
Male 6	28	99	0	4
Male 7	69	97	35	58
Mean	41	97	8	19

Syngenta: Paul van den Wijngaard and T. Bruggink

Patent applications:
EP2013/053845 (Modulation of seed vigour)
EP1315154.3 (Plants with improved traits)

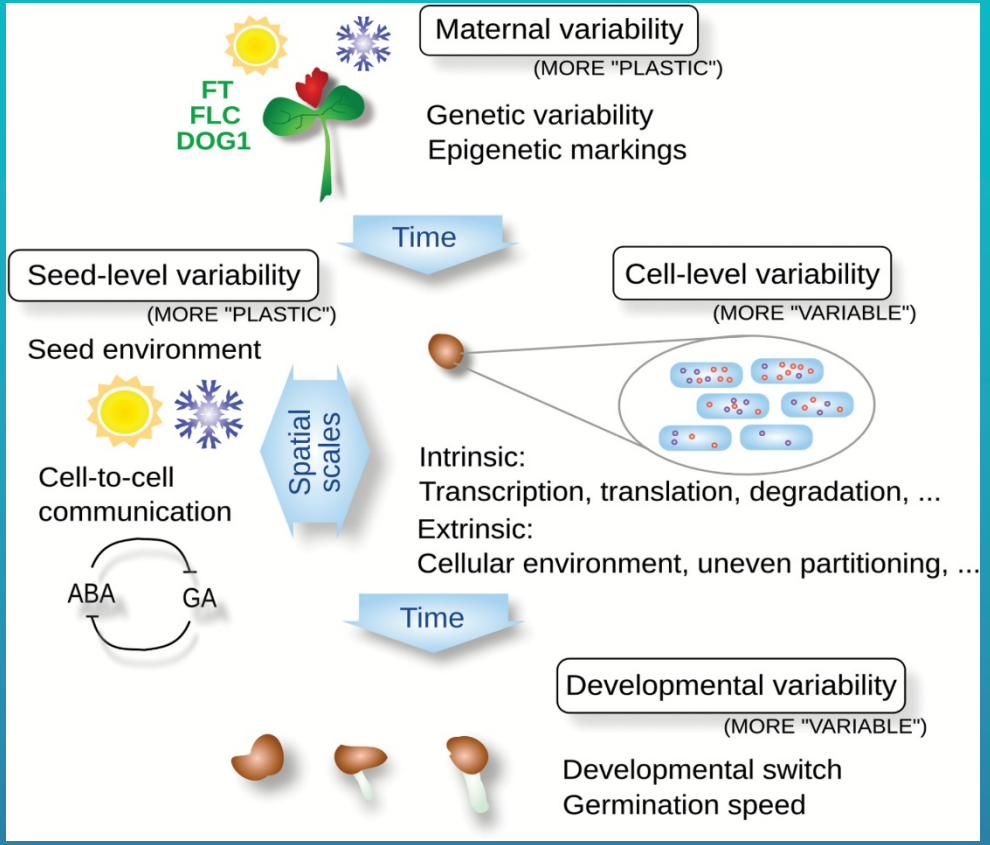
Future work on variability in the Bassel Lab:

To study at basic level the interactions between molecular components within cells and interactions between cells to see how genetically identical individuals end up different.

Biological bet hedging

Schematic depicting the sources and scales of variability observed in seeds ranging from the maternal environment (plastic), seed-level variability (plastic), cell-level variability (variable) to developmental variability.

Mitchel, Johnston, Bassel (2017)
Journal of Experimental Botany
68:809-817



They suggest that understanding these underlying mechanisms of variability (bet hedging) in seeds, will lead to strategies that increase seed population uniformity to enhance agricultural production across variable climatic conditions

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