1.4 Re-creating Wheat: Enhancing genetic diversity to deliver drought tolerance

Major research at Punjab Agricultural University (PAU) aims to increase the genetic diversity of wheat by incorporating genes from early grass progenitors into the modern 'hexaploid' wheat genome. These are being selected to increase drought tolerance and lower demand for water overall. The key approaches at PAU allow modern genetic approaches to be allied with traditional breeding and evaluation under field conditions for more rapid development of wheat varieties which are resilient under the extreme heat and drought conditions more frequently being encountered due to climate change.

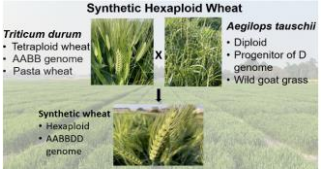
Modifying wheat using traditional breeding approaches is challenging and time consuming

Wheat breeding is complicated because traits are carried by genes across six sets of chromosomes. There are also distinct regional requirements: the growing season in India demands fast-maturing varieties, in contrast to the UK.

Pioneering researchers at PAU are using at least three contrasting approaches to increase genetic diversity and screen drought tolerance traits within advanced wheat varieties, which can then be delivered direct to farmers:

- **Synthetic wheats**
- **Chromosomal segmentation substitution**
- **Mapping populations**

Group	Pedigree/Combination	No. of Synthetics
Group-1	PBW114-*Aegilops tauschii* 14102	23
Group-2	PBW114-*Aegilops tauschii* 14128	63
Group-3	PBW114-*Aegilops tauschii* 14170	29
Group-4	PBW114-*Aegilops tauschii* 9809	18
Group-5	PBW114-*Aegilops tauschii* 9810	32
Group-6	PBW114-*Aegilops tauschii* 3761	8
Group-7	PBW114-*Aegilops tauschii* 14328	69
Group-8	PBW114-*Aegilops tauschii* 14576	7
Group-9	PDW233-*Aegilops tauschii* 9796	1
Group-10	PDW233-*Aegilops tauschii* 14135	4



Screening of synthetic hexaploid wheat under drought stress

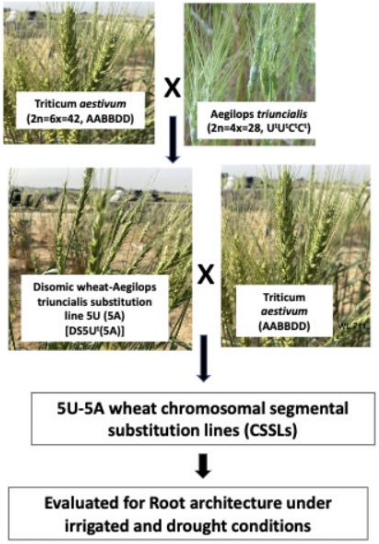
Selecting for Previously Neglected Root Traits

Root characteristics are substantially connected to drought stress. Studies on synthetic wheats (recrossing durum wheat and with wild goat grass lines) have opened up tremendous opportunities to understand the complex architecture of drought tolerance mechanisms.

An initial synthetic wheat population, was screened for phenotypic plasticity for drought tolerance using hydroponic solutions. Traits being selected included longer roots, increased root growth and biomass. The outputs provided a unique example of success using wild relatives in mainstream breeding at a large scale.

Using an alternative approach, the chromosome segmentation substitution lines initially incorporate copies of chromosomes from a wild grass relative (*Aegilops triuncalis*), with genes then crossed into elite wheat varieties. Lines were identified which had longer, thinner roots with a higher biomass, greater ability to seek out water and sustain productivity under drought.

Development of Chromosomal Segmental Substitution lines (CSSLs)



FUNDING CALL:	Growing Research Capacity: UKRI GCRF
COUNTRY:	India
TITLE:	Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies (TIGR^{2}ESS)
GRANT NO:	BB/P027970/1
LEAD INVESTIGATOR, CO-INVESTIGATORS & PARTNERS:	Achla Sharma, Parveen Chhuneja, Satinder Kaur, Raveneet Kaur, Himanshu Sharma. NIAB and Rothamsted Research

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