



Focus Group 'Production of protein crops under climate change'

Sevilla, Spain
27-28 May 2025

A close-up photograph of a variety of grains and legumes. In the center, a wooden spoon is filled with light-colored, oval-shaped grains. Surrounding the spoon are different types of seeds and grains, including dark brown lentils, white and yellow lentils, and various types of rice and wheat. The background is a soft-focus mix of these grains, creating a rich, textured appearance.

Mini Paper 2: Crop options and their needs for improvement to increase plant protein production

Donal MURPHY-BOKERN

Fokion Papathanasiou, Mathijs Hast, Fred Stoddard



Crop options and their need for improvement to increase plant protein production

European CAP Network

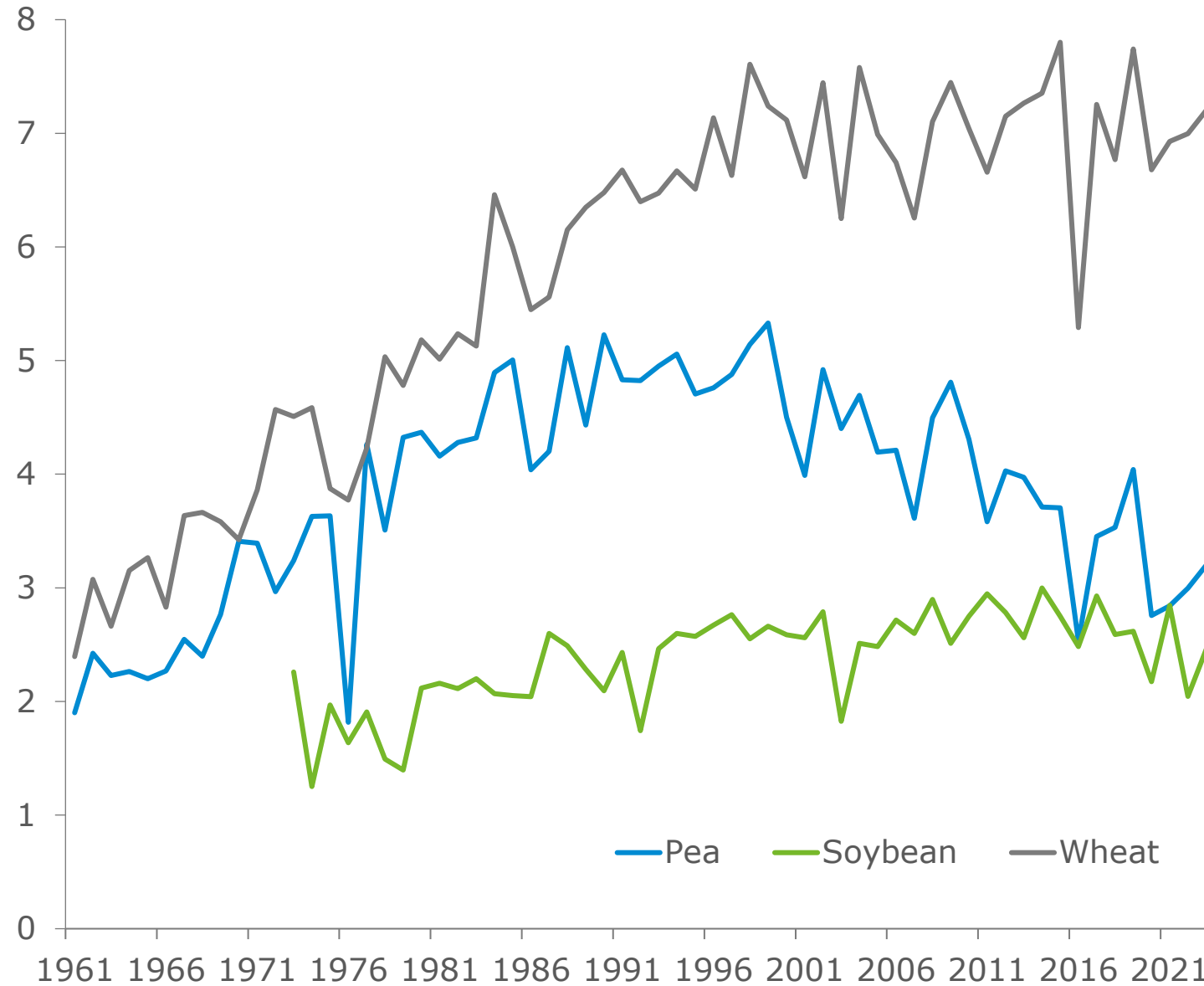
Focus Group: Production of protein crops under climate change

Donal Murphy-Bokern, Fokion Papathanasiou, Mathijs Hast, and Fred Stoddard



Funded by the
European Union

Changes in the average grain yield (t/ha) of wheat, pea and soya bean in France, 1961 to 2023



What is the theme of the Focus Group?

Protein crops (plants) or crop (plant) protein?

We assume the theme is protein crops (not plant protein).

In line with the CAP, we regard legumes as the protein crops.

We have followed the framework we outlined at first FG meeting.

'Protein' is a mass noun:

Protein crops are rich in protein, they are not 'proteins'

'A protein' is a pharmaceutical product

EU CAP Network Focus Group

Production of protein crops under climate change

Mini Paper 2

Characterisation and genetic improvement of protein crops

Donal Murphy-Bokern
Fokion Papathanasiou
Mathijs Hast
Fred Stoddard

May 2025



**Boosting innovation in breeding for the next generation of
legume crops for Europe**

Characterisation and genetic improvement of protein crops

Donal Murphy-Bokern

Fokion Papathanasiou

Mathijs Hast

Fred Stoddard

Legume Generation Report 8



Legume Generation (Boosting innovation in breeding for the next generation of legume crops for Europe) has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No.101081329. It also receives support from the governments of the United Kingdom, Switzerland and New Zealand.



Legumes in Cropping Systems

Edited by **Donal Murphy-Bokern,**
Frederick L. Stoddard and **Christine A. Watson**



Contents

Introduction	3
It all starts with a seed	4
What is plant breeding?	4
Legume breeding in a resource-constrained and changing world	5
Priority traits	6
Breeding for climate change	7
The top-ten legume species in Europe	9
The cool-season starch-rich legumes	9
Chickpea	10
Faba bean	10
Lentil	11
Pea	12
Cool-season oilseed legume – the lupins	12
The warm-season legumes	13
Common bean	13
Soya bean	14
The fine-seeded forage legumes	14
The clovers	14
Lucerne (Alfalfa)	15
The vetches	16

Characterisation of legume crops

Agricultural legumes (*Faboideae*)

Defined by the flower shape

Generally characterised by:

- Biological nitrogen fixation
- Indeterminate growth
- Relatively low dry matter and nitrogen harvest indices
- Visited by pollinators
- Mostly self-pollinated, thus in-bred
- Pods
- Toxic or anti-nutritional compounds in raw seeds

Cool season

Origin: Europe and Asia

Frost-hardy as young plants, base temperature near zero

Long days stimulate flowering (long day)

Mostly hypogeal germination (below surface)

Climbing species (pea and vetches) use tendrils

Warm season

Origin: Tropics and sub-tropics

Frost sensitive with a high base temperature (ca 7°C)

Minimum night length for flowering (short day)

Climbing using vining

Epigeal germination (above surface)

Fine seeded

Oil-rich

Protein-rich
Epigeal germination
Consumed after industrial processing

Carbohydrate-rich

Consumed as grown after cooking

Carbohydrate-rich

Origin: South(Central America)
Consumed as grown after cooking

Oil-rich

Origin: China
Protein-rich
Consumed after industrial processing

Clovers

Lucerne (Alfalfa)

Lupins

Pea*

Faba bean*

Chickpea

Lentil

Vetches

Phaseolus beans*

Soya bean*

Forage

Industrial protein and oil

Pulses

Industrial protein and oil

* Also consumed as a vegetable when immature



Photo: Fred Eickmeyer

The top ten legume crops

Faba bean



Photo: Carola Blessing, The Legume Hub

Pea



Photo: AgroBioInstitute (Bulgaria),
The Legume Hub



Photo: Carol Blessing, LTZ
Semi-leafless pea

Soya bean



Photos: Donal Murphy-Bokern,

Lupins



Photo: Moritz Reckling, ZALF

Chickpea



Photo: Donal Murphy-Bokern

Lentil



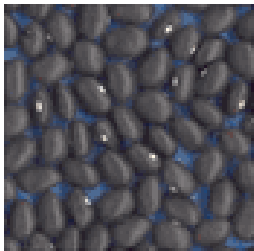
Photo: Elizabeth Ninou



Photo: Pulse Australia

Phaseolus beans

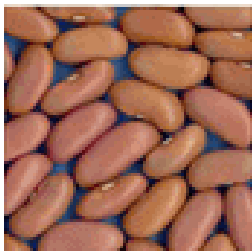
Michigan Dry Bean Classes



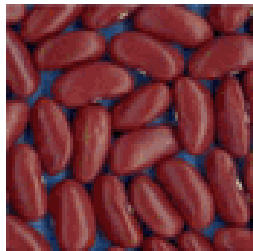
Black beans



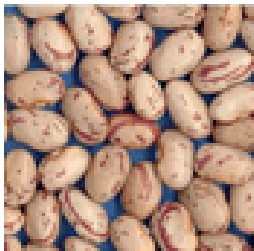
Navy beans



Light Red Kidney beans



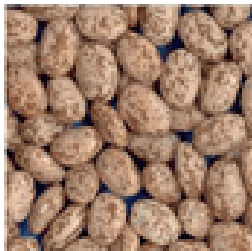
Dark Red Kidney beans



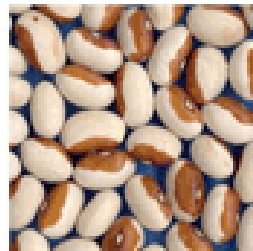
Cranberry beans



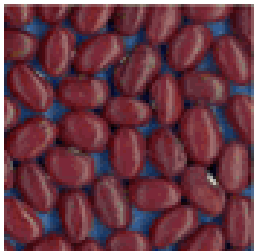
Great Northern beans



Pinto beans



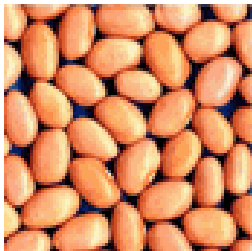
Yellow eye beans



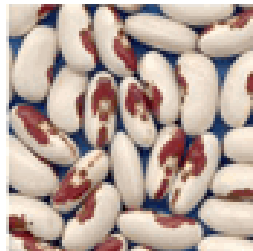
Small Red beans



White Kidney beans



Pink beans



Soldier beans



Vetches



Photo: Thuenen
Institute



Lucerne

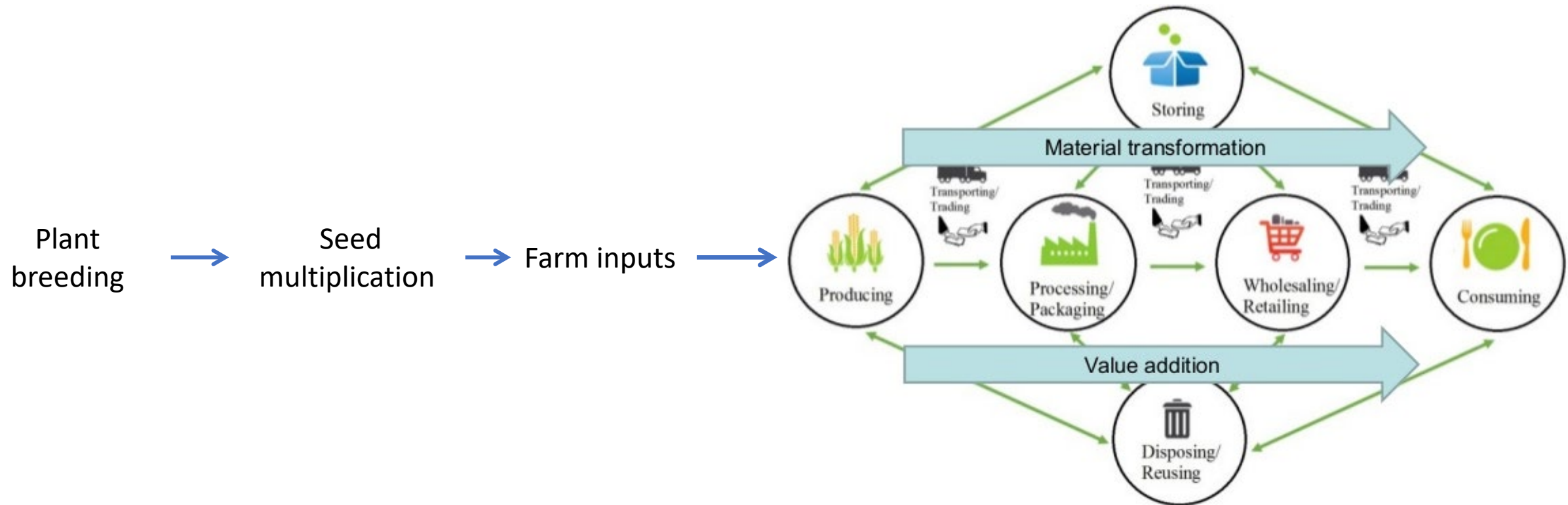


Photos: Bernadette
Julier, INRAE

Clovers



The position of plant breeding in agri-food value chains



Activity in plant breeding businesses* (inbred cereals and grain legumes)

Generating variation

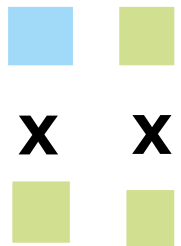
Stabilisation

Selection

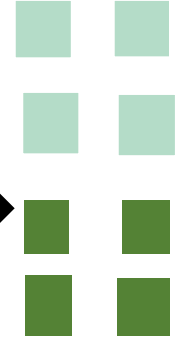
New germplasm
– seed banks,
landraces etc.



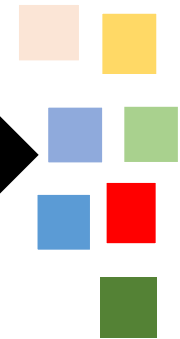
Crossing
between
selected
pure-
breeding
parents



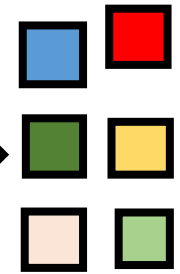
Self-
pollination
within the
uniform F1
progeny
(F1:F2)



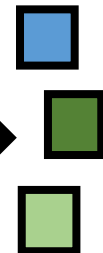
New
variation
in second
generation
progeny
(F2)



Repeated
reproduction
to produce
stable lines



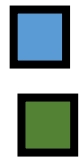
Selection
of lines



Multiplication
and testing
as cultivars,
registration



Farm-level
testing,
demonstration,
and
multiplication



**Farm
production**

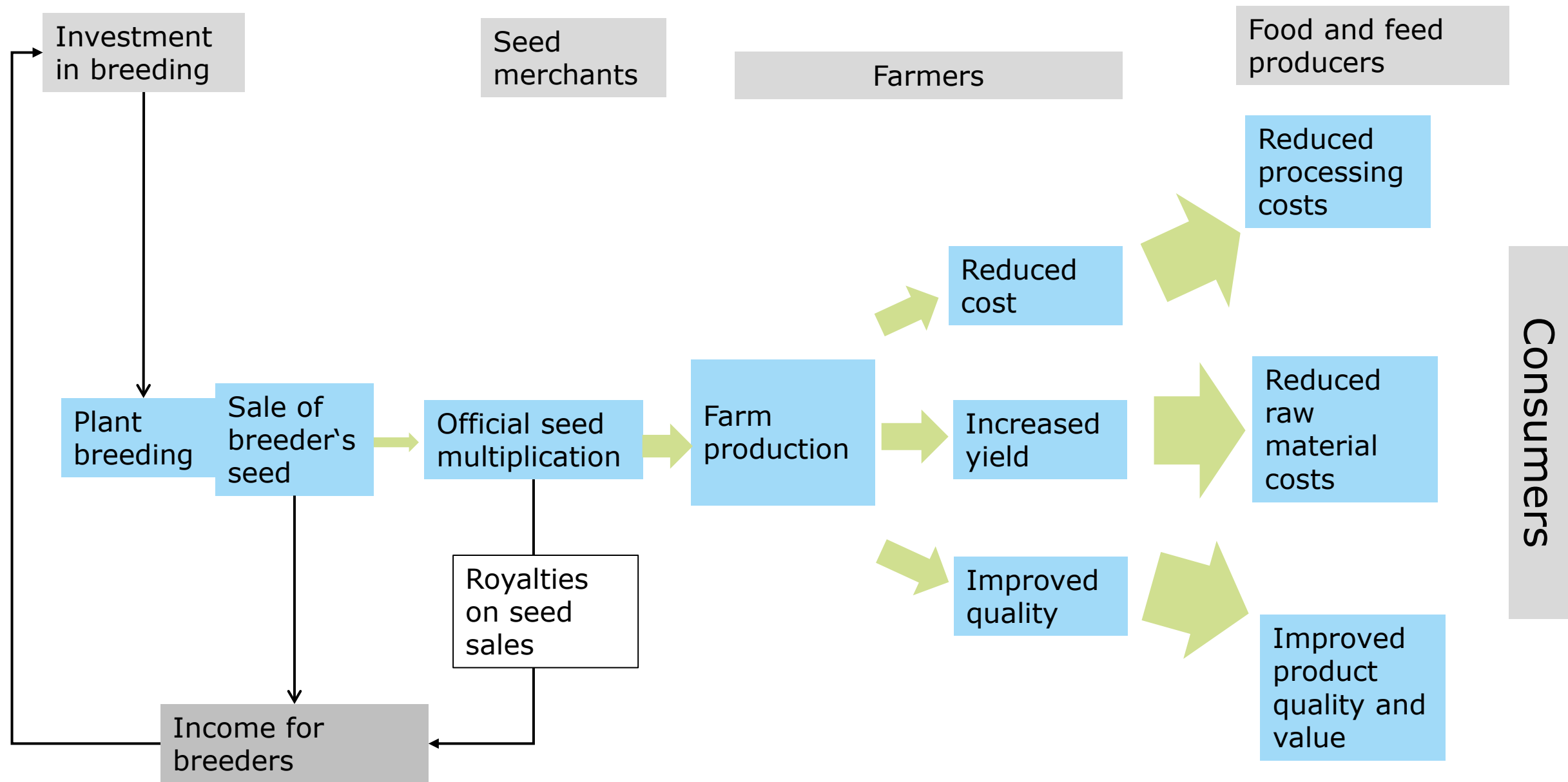
Parent
selection



Existing elite
cultivars

* Breeding businesses here includes cultivar testing organisations who provide cultivar data for registration. These are public organisations in most countries.

The generation and distribution of value from plant breeding



THE BREEDING OF CROP IDEOTYPES

C. M. DONALD

Waite Agricultural Research Institute,
The University of Adelaide, South Australia

Received 17 November, 1967

SUMMARY

Most plant breeding is based on “defect elimination” or “selection for yield”. A valuable additional approach is available through the breeding of crop ideotypes, plants with model characteristics known to influence photosynthesis, growth and (in cereals) grain production. Some instances of the successful use of model characters of this kind are quoted.





Priority 1 Breeding for yield

Fundamental rather than incremental change needed

Extending the growing season – frost tolerance

Harvest index

Canopy function



Breeding for climate change

How does climate change affect plants

These are annual plants: climate and weather

Warmer or colder?

Drier or wetter?

Breeding targets (traits) for climate change

Earliness of harvest

Insensitivity to long days

Frost tolerance for autumn sowing

Early growth and vigour under cool conditions: reduced base temperature

Tolerance of summer chilling

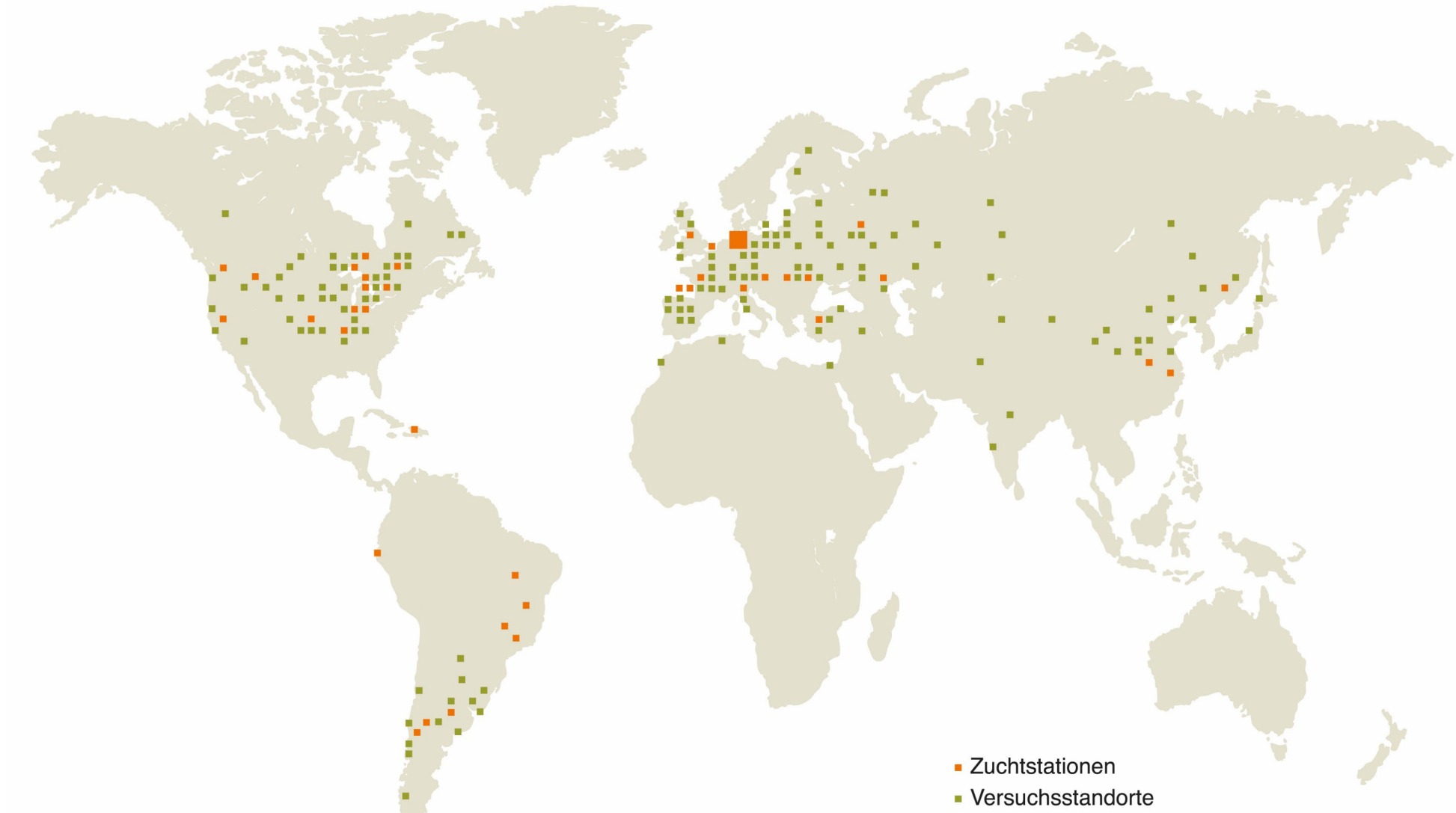
Tolerance and survival of heat stress

Tolerance of drought and water-logging

Breeding for climate change

Züchtungs- und Vertriebsaktivitäten der KWS Gruppe in über 70 Ländern

KWS



Participatory breeding

Participatory plant breeding

and

Participatory varietal selection

Organic breeding

'Organic' provides a particular selection environment

Unlike with cereals, nitrogen scarcity not an issue for legumes

Phosphorous uptake



Legume Generation (Boosting innovation in breeding for the next generation of legume crops for Europe) has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No.101081329. It also receives support from the governments of the United Kingdom, Switzerland and New Zealand.

EU CAP Network Focus Group 'Production of protein crops under climate change'

2nd meeting | 27-28 May 2025 | Sevilla, Spain

All information on the Focus Group is available on the webpage:

<https://eu-cap-network.ec.europa.eu/events/focus-group-production-protein-crops-under-climate-change-2nd-meeting>

