Legume Generation

Developing European soya in a warming world

Donau Soja General Assembly and Networking Event

4 September 2025

Donal Murphy-Bokern

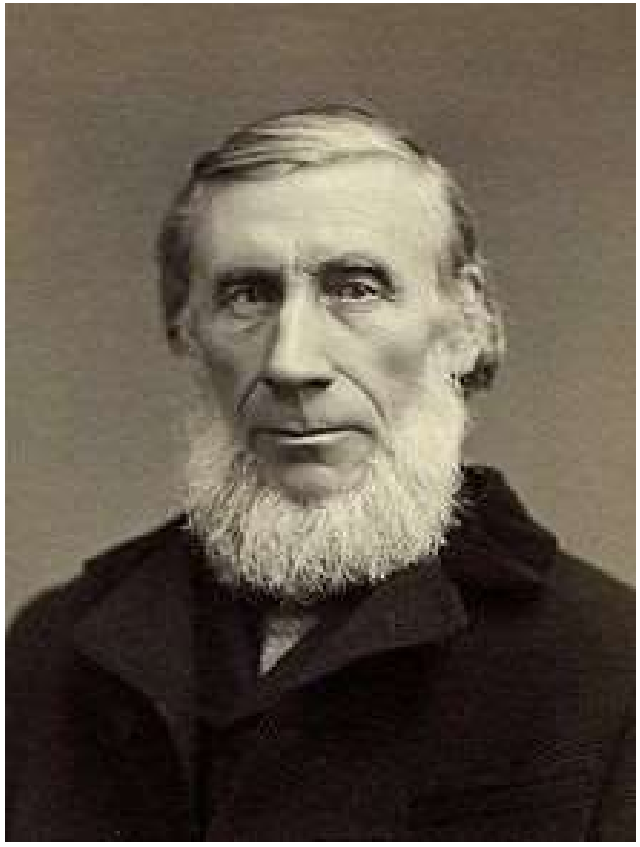
(with support from Johann Vollmann, BOKU)

Funded by the European Union


BREAD

John Tyndall (1820-1893)

The father of climate science



The Rodney & Otamatea Times
WAITEMATA & KAIPARA GAZETTE.
PRICE—10s per annum in advance
WARKWORTH, WEDNESDAY, AUGUST 14, 1912.
3d per Copy.

Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

Bundesforschungsanstalt für Landwirtschaft (Johann von Thünen Institut - TI)

Federal Agricultural Research Centre, Braunschweig, Germany


CLIMATE
CHANGE

Kurz notiert

Männer gehen aufeinander los

Wolfenbüttel. Ein Streit zwischen zwei Bekannten ist in Wolfenbüttel am Samstagabend eskaliert. Nach Angaben der Polizei warf ein 39-Jähriger seinem 40 Jahre alten Freund zunächst einen Einrichtungsgegenstand an den Kopf. Der Ältere reagierte darauf mit Faustschlägen ins Gesicht sowie mit Beleidigungen und Bedrohungen. Die hinzugerufenen Beamten trennten die Männer und sprachen Platzverweise aus.

Mann verweigert die Behandlung

Bremerhaven. Wegen eines Verletzten auf einer Geburtstagsfeier ist die Polizei in Bremerhaven ausgerückt. Aufgrund von Sprachbarrieren war die Einsatzlage vor Ort zunächst unklar. In einer Wohnung fanden die Polizisten jedoch eine Blutlache und Glasscherben: Ein angetrunkener 23-Jähriger war laut Polizei auf seiner Geburtstagsfeier aggressiv geworden. Aus Wut hatte der Mann den Angaben zufolge den Glaseinsatz einer Zimmertür zerschlagen. Helfen lassen wollte sich der 23-

„Coolcation" – der neue Reisetrend?

Durch Hitze am Mittelmeer werden kühlere Regionen beliebter / Niedersachsen könnte profitieren

Von Lennart Stock und Britta Körber

Viel zu warm: Sommerurlaube an der Nordsee könnten mit zunehmender Hitze am Mittelmeer beliebter werden. Foto: dpa / Dittrich

Wilhelmshaven. Während im Mittelmeerraum Menschen bei weit über 30 Grad schwitzen, zeigte sich der norddeutsche Sommer zuletzt eher kühl und wechselhaft. Doch angesichts drückender Hitze im Mittelmeer sehen manche Touristiker hierzulande genau darin eine Chance – auch in Niedersachsen. Die Tourismus-Agentur Nordsee (Tano) ließ etwa während der Hitzewelle in Deutschland Anfang Juli erstmals in den Städten Freiburg, Karlsruhe und Köln Werbung auf großen Anzeigenflächen für eine Abkühlung bei einer „Sommerbrise an der Nordsee" schalten.

„Das, was früher mal vor Jahrzehnten das Mittelmeer war, das können wir jetzt sein", sagt Mario Schiefelbein, Geschäftsführer der Marketingorganisation für die niedersächsische Nordseeküste zwischen Ems und Elbe, mit Blick auf das Sommerklima am Meer. Bei einem lauen Wind an der Küste würden viele die Hitze besser vertragen. „Das ist für uns ein Riesenvorteil. Ich glaube, wir können Menschen dazu bringen, mal den Urlaub Richtung Nordsee zu planen

schen Wittmund ist. Der Klimawandel müsse ernst genommen werden. Klimaveränderungen der vergangenen Jahre wirkten sich schon jetzt auf das Reisever-

nach gebe es noch keine signifikanten Hinweise auf einen echten Reisetrend oder spürbare Verschiebungen von wärmeren Regionen. „Ob und wann ein sol-

Tage geben, die vor allem bei hoher Luftfeuchtigkeit von vielen Menschen als belastend empfunden werden. Denn durch den Temperaturanstieg steigt auch

von Gradierwerken sein. Im Harz würden schon heute im Sommer Führungen unter Tage für Abkühlung sorgen, etwa in Tropfsteinhöhlen. Und auch

"Prediction is very difficult, especially if it's about the future."

-- Niels Bohr
Physics Nobel prize 1922

Leaders | Climate tipping-points

The shutdown of ocean currents could freeze Europe

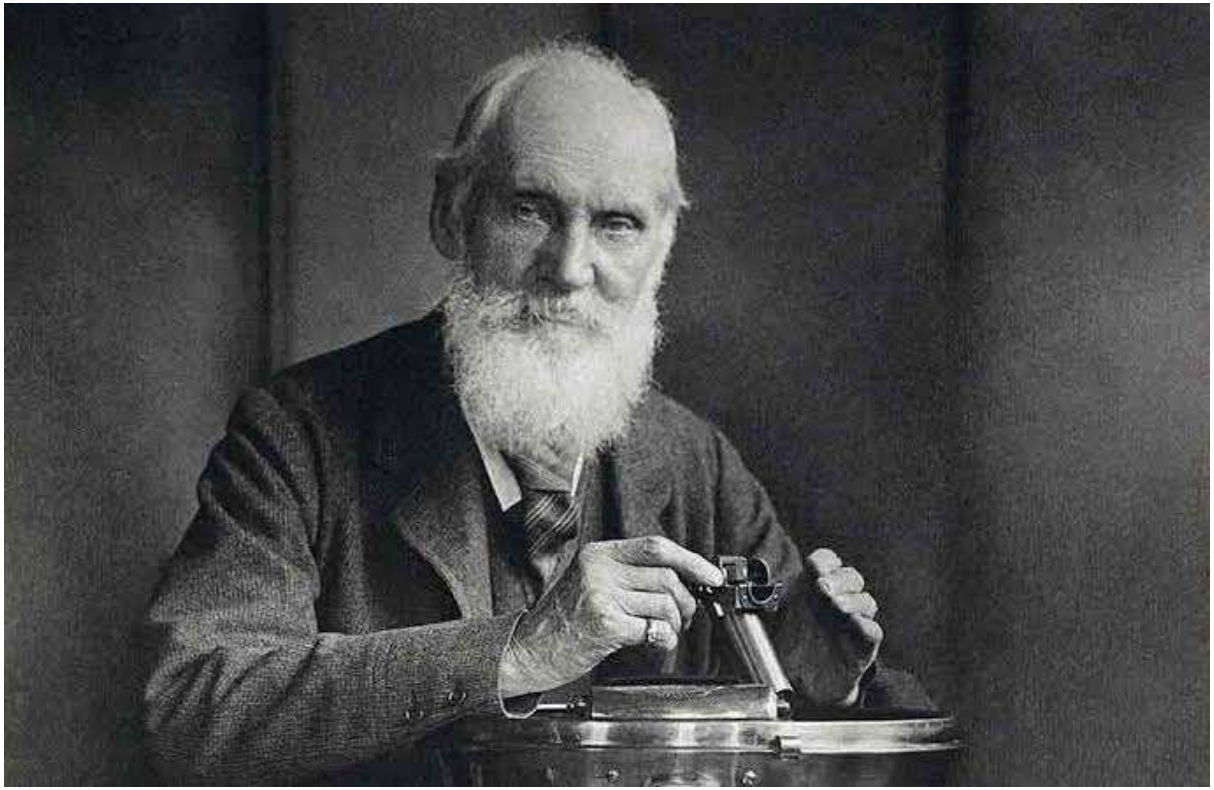
When climate change poses a strategic threat, it needs a strategic response

PHOTOGRAPH: GETTY IMAGES

If you want to understand something, use numbers

"When you can measure what you are speaking about, and express it in numbers, you know something about it"

Lord Kelvin



It is not enough that legumes are ‘nice’

Being profitable is also not enough

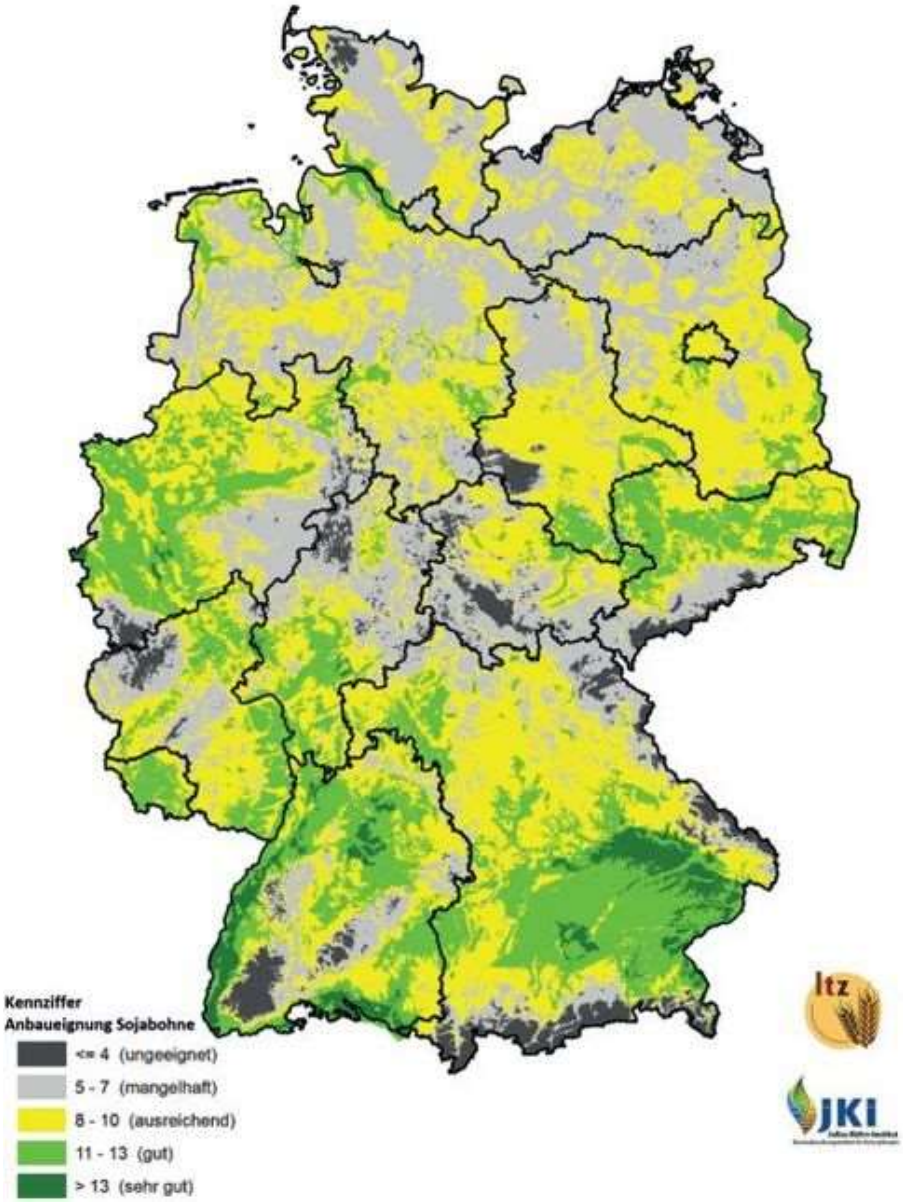
Legumes must be competitive for land against the crops farmers seem to prefer to grow.

((Yield x Value) – Cost) + Breakcrop effect

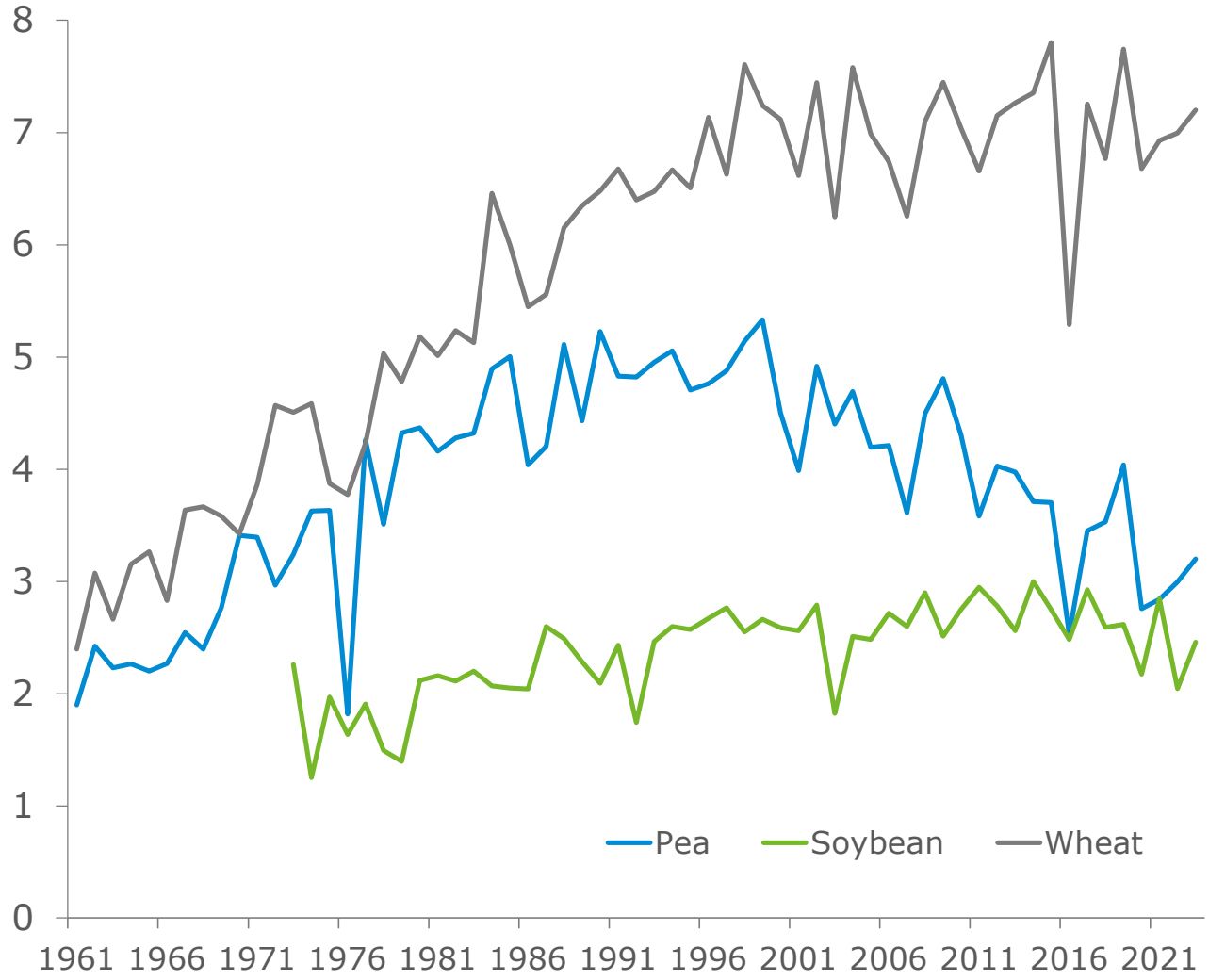
Suitability for soybean production in Germany

(from Roßberg and Recknagel 2017, Journal für Kulturpflanzen)

Being more suitable is not enough, what matters is on-farm competitiveness

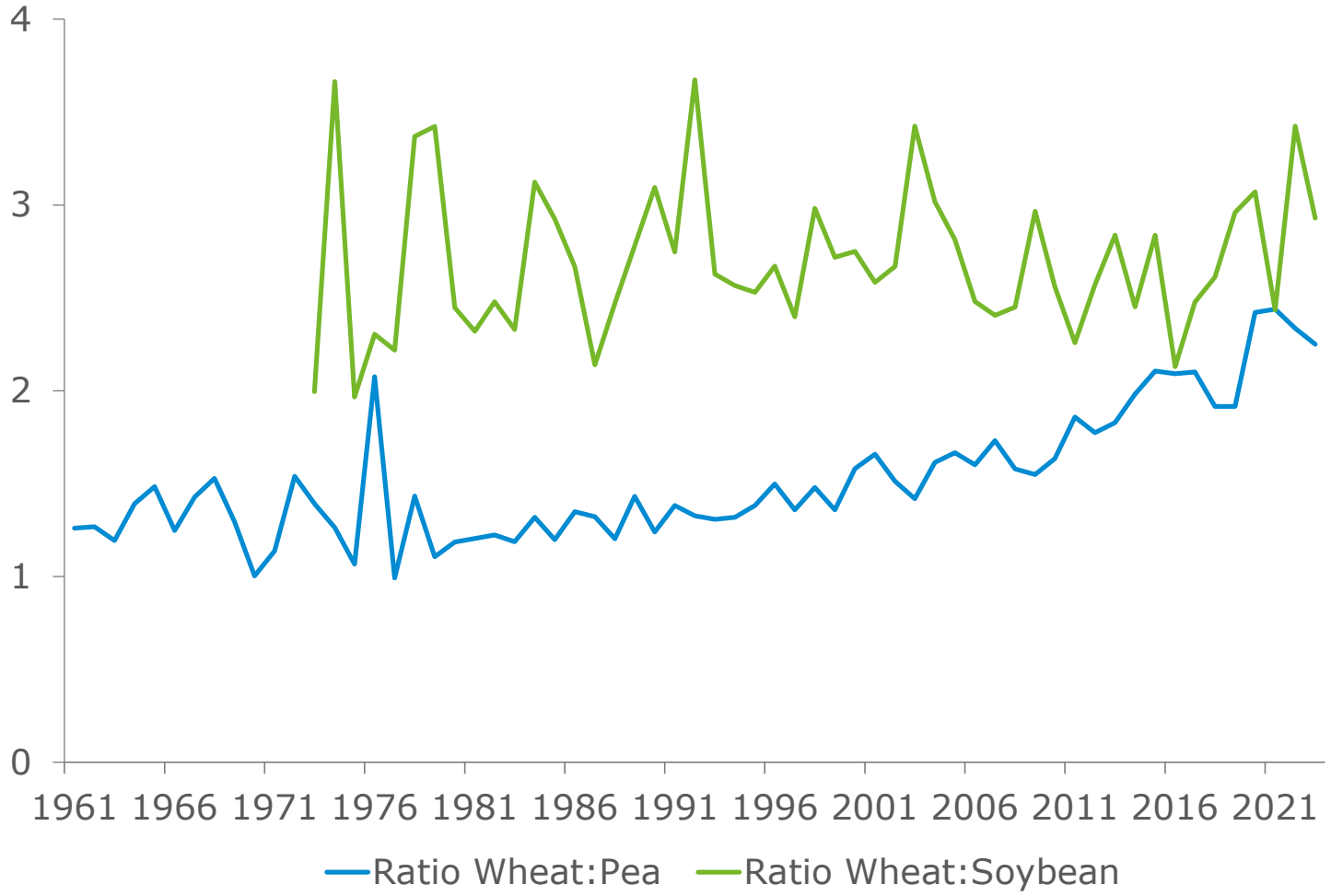


Changes in the average grain yield (t/ha) of wheat, pea and soybean in France, 1961 to 2023



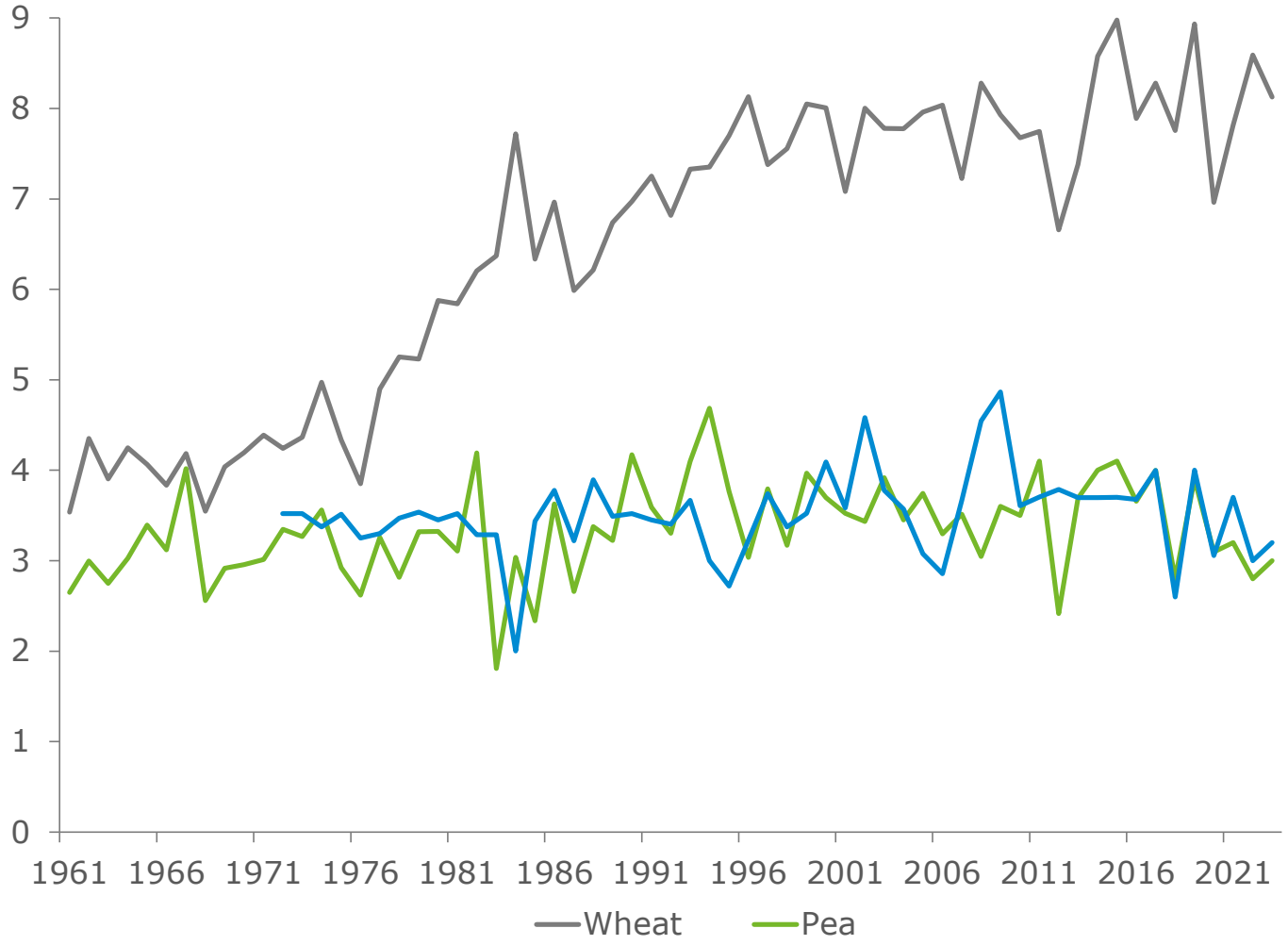
From FAOSTAT

Changes in the ratio of wheat yield to the yield of pea and soybean in France, 1961 to 2023



From FAOSTAT

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



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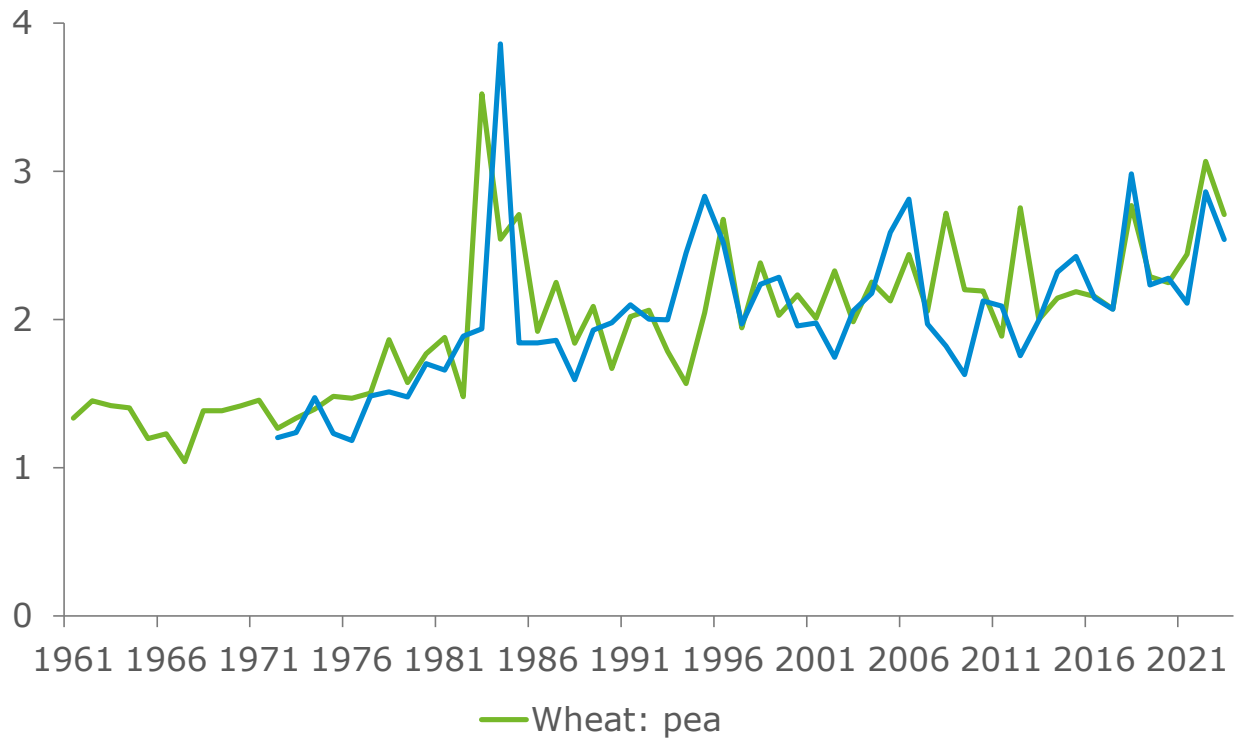
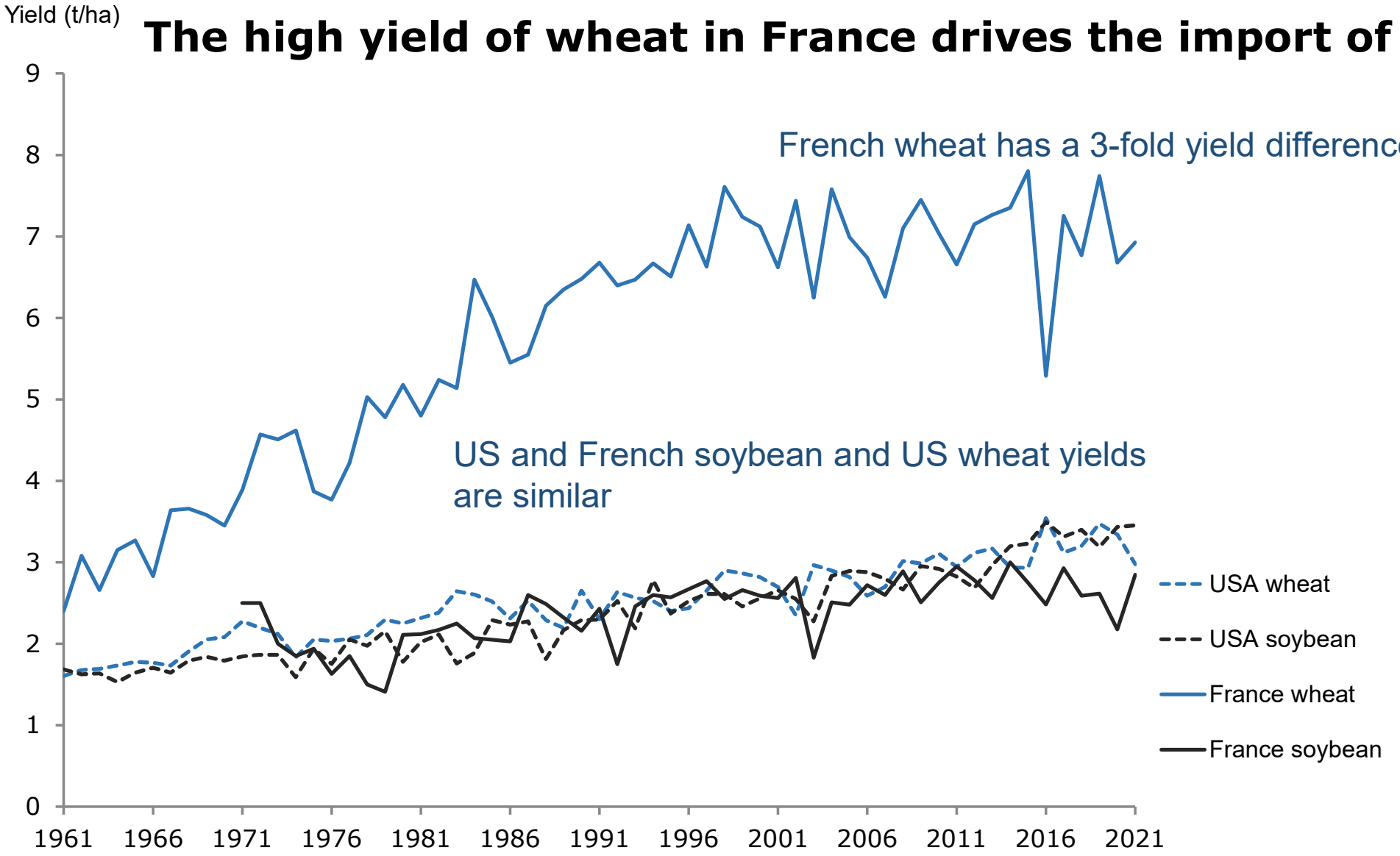


From FAOSTAT

The high yield of wheat in France drives the import of soya

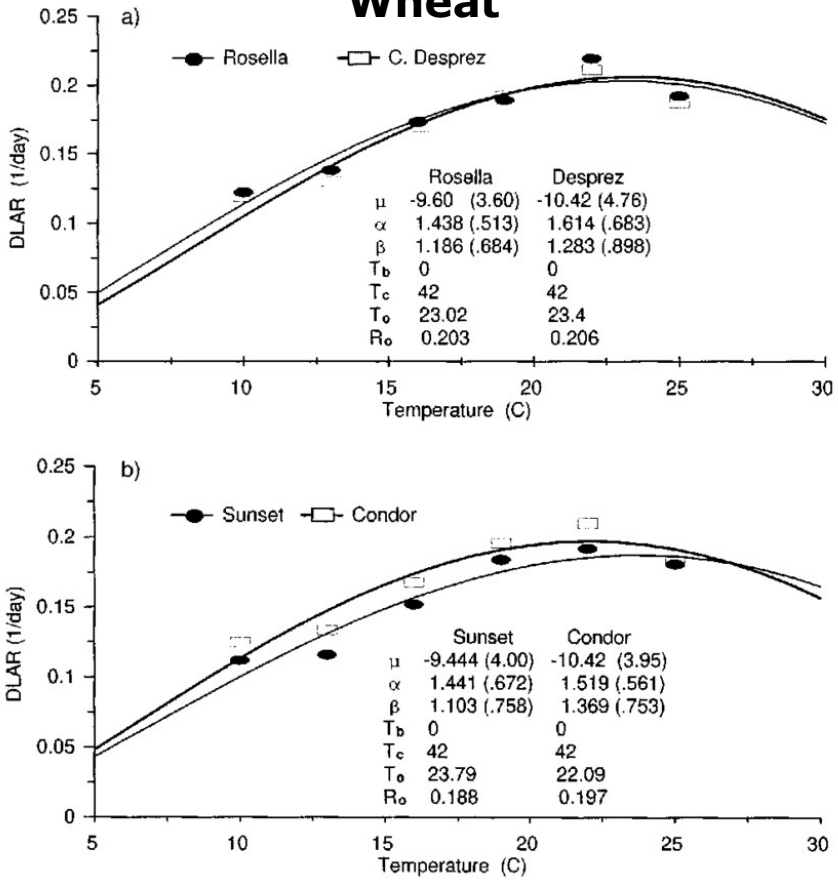


Why does trade happen?

Read David Ricardo

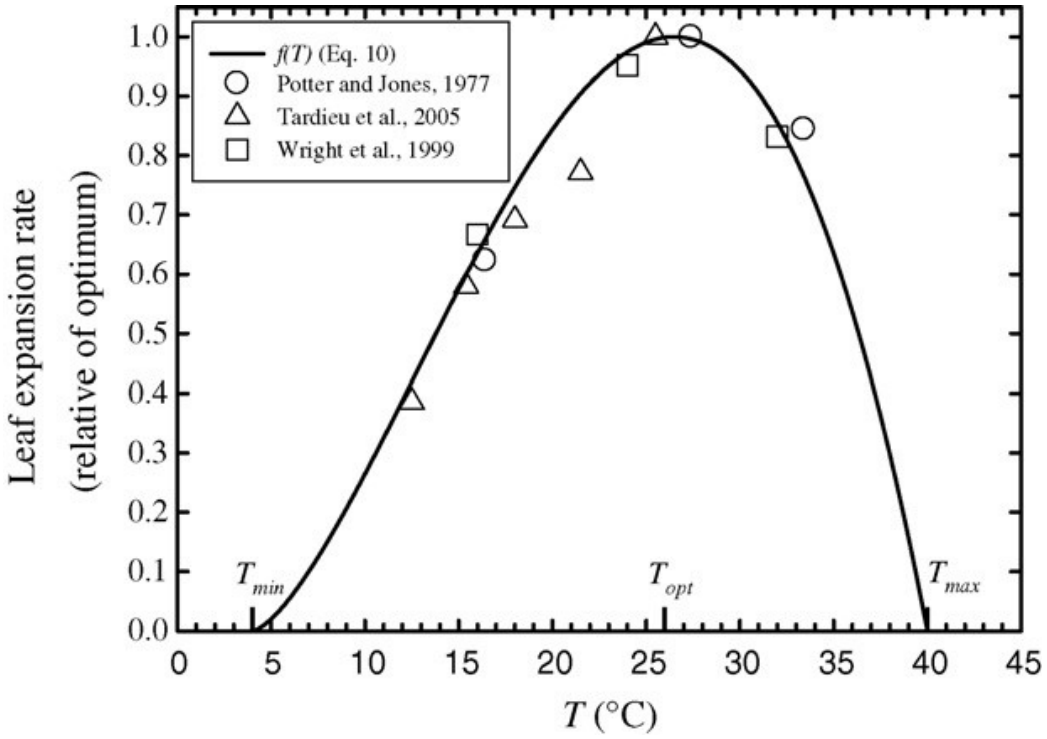
Effect of temperature on leaf emergence in wheat and soybean

Wheat



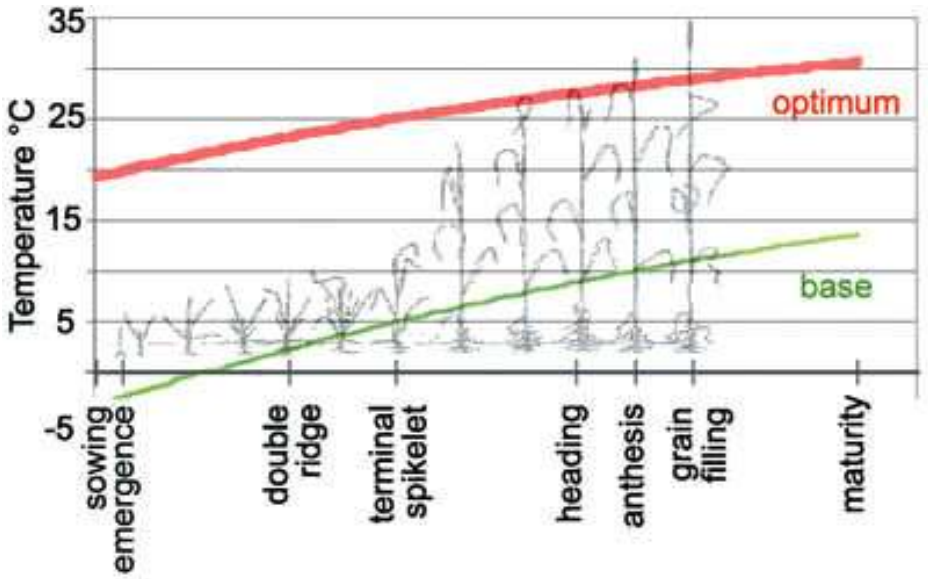
Jame, Cutforth and Ritchie (1999). Temperature response function for leaf appearance rate in wheat and corn Canadian Journal of Plant Science

Soybean

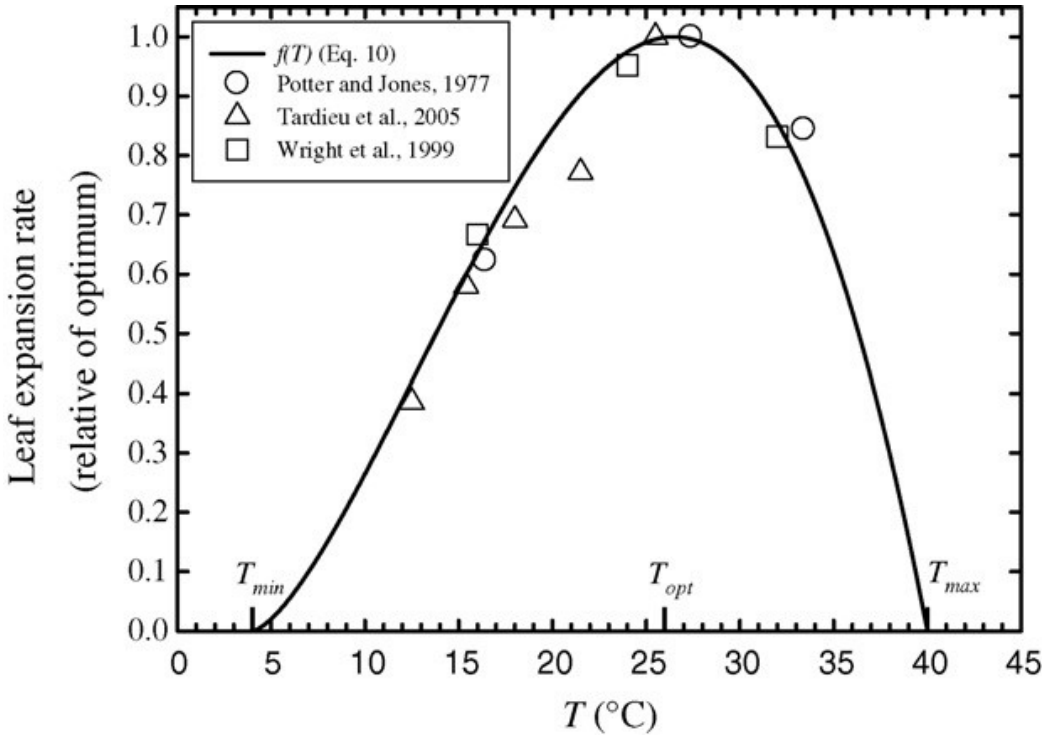


Setiyono et al. 2008. Leaf area index simulation in soybean grown under near-optimal conditions. Field Crop Research

Effect of temperature on leaf emergence in wheat and soybean



Rawson, H. and Gómez Macpherson, H. 2000. Section 6: Explanations of plant development. In: Irrigated wheat, managing your crop. FAO (Section 6: Explanations of plant development)



Setiyono et al. 2008. Leaf area index simulation in soybean grown under near-optimal conditions. Field Crop Research

There is great flexibility in time to maturity in soybean

Growing degree days integrates time and temperature
One degree day is one day with an average temperature of 1°C above a base

Winter wheat:
1800 – 2200 (base 0°C
1300 – 1600 (base 5°C)

1000 – 1300 (base 10°C)

A 25-30% variation in
progress to maturity

There is greater flexibility in time to maturity (growing degree days) in soybean

Winter wheat:
1800 – 2200 (base 0°C
1300 – 1600 (base 5°C)

1000 – 1300 (base 10°C)

A 25-30% variation in progress to maturity in wheat

200+% variation in soybean

Maturity group (MG)	Growing degree days (base 10°C)
OOO	1000 - 1200
OO	1100 - 1300
O	1200 - 1400
I	1300 - 1500
II	1400 - 1600
III	1500 - 1700
IV	1600 - 1800
V	1700 - 1900
VI	1800 - 2000
VII	1900 - 2100
VIII	2000 - 2200
IX	2100 - 2300
X	2200 - 2400

Yield (t/ha) of soybean and wheat in the decade 2014-2023 in seven European counties (FAOSTAT)

Predicted optimistic yield

Probably irrigated crops

	Soybean	Wheat
Austria	2.89	5.66
Belgium	2.90	8.69
France	2.59	7.00
Ireland	-	9.51
Italy	3.54	3.91
Serbia	2.78	4.66
Ukraine	2.27	4.11

Yield (t/ha) of soybean and wheat in the decade 2014-2023 in seven European counties (FAOSTAT)

Predicted optimistic yield

Probably irrigated crops

	Soybean	Wheat	Wheat:soybean
Austria	2.89	5.66	1.96
Belgium	2.90	8.69	3.00
France	2.59	7.00	2.70
Ireland	-	9.51	10.00+
Italy	3.54	3.91	1.10
Serbia	2.78	4.66	1.68
Ukraine	2.27	4.11	1.81

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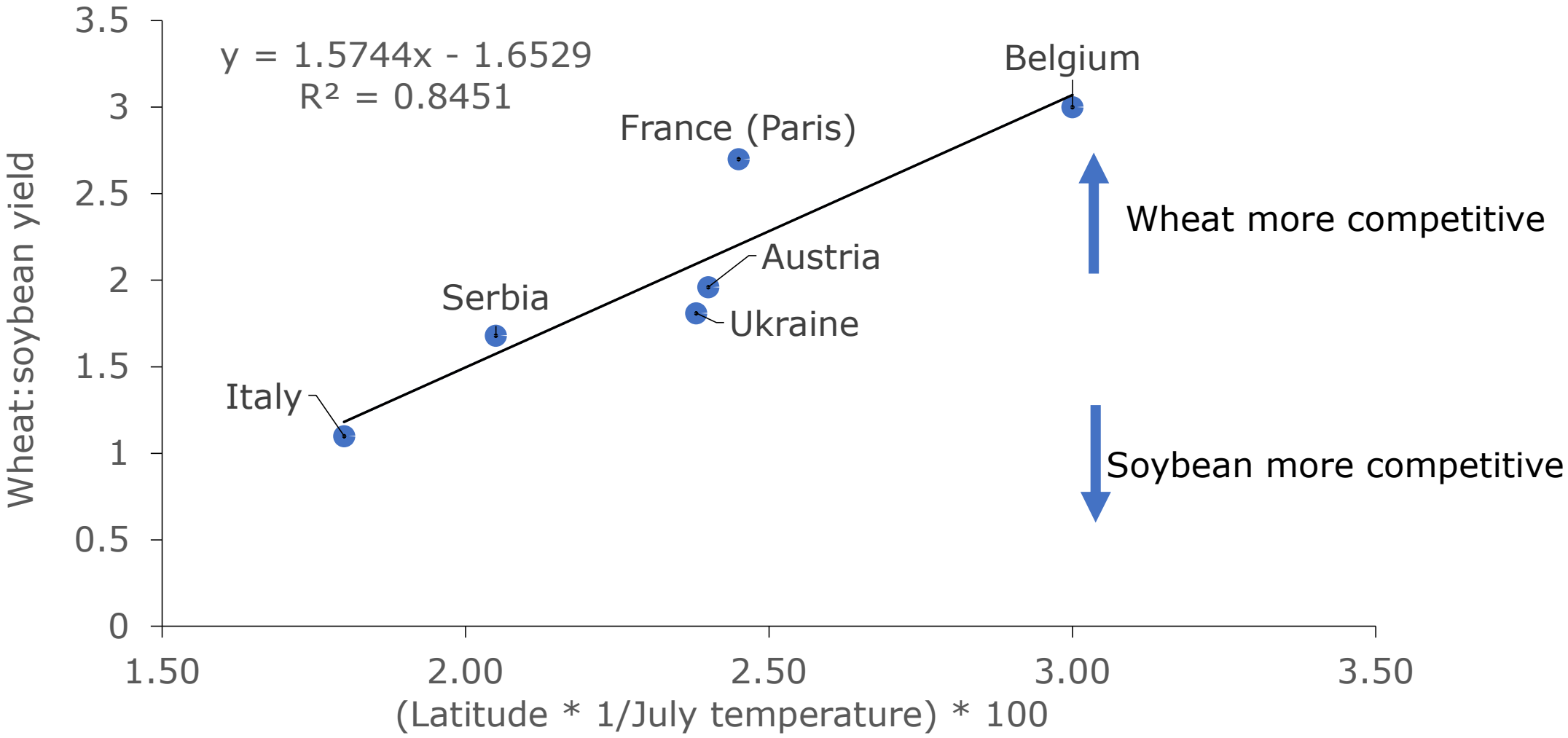
July temperature and latitude

	July temp.	Latitude	Wheat:soybean
Vienna	20	48	1.96
Brussels	17	51	3.00
Paris	20	49	2.70
Dublin	15	53	10.00+
Milan	25	45	1.10
Belgrade	22	45	1.68
Kiev	21	50	1.81

A July temperature and latitude index		(Latitude *1/July temperature) *100	Wheat:soybean
(Latitude * 1/July temperature) * 100	**Vienna**	2.40	1.96
	Brussels	3.00	3.00
	Paris	2.45	2.70
	Dublin	3.53	10.00+
	Milan	1.80	1.10
	Belgrade	2.05	1.68
	Kiev	2.38	1.81

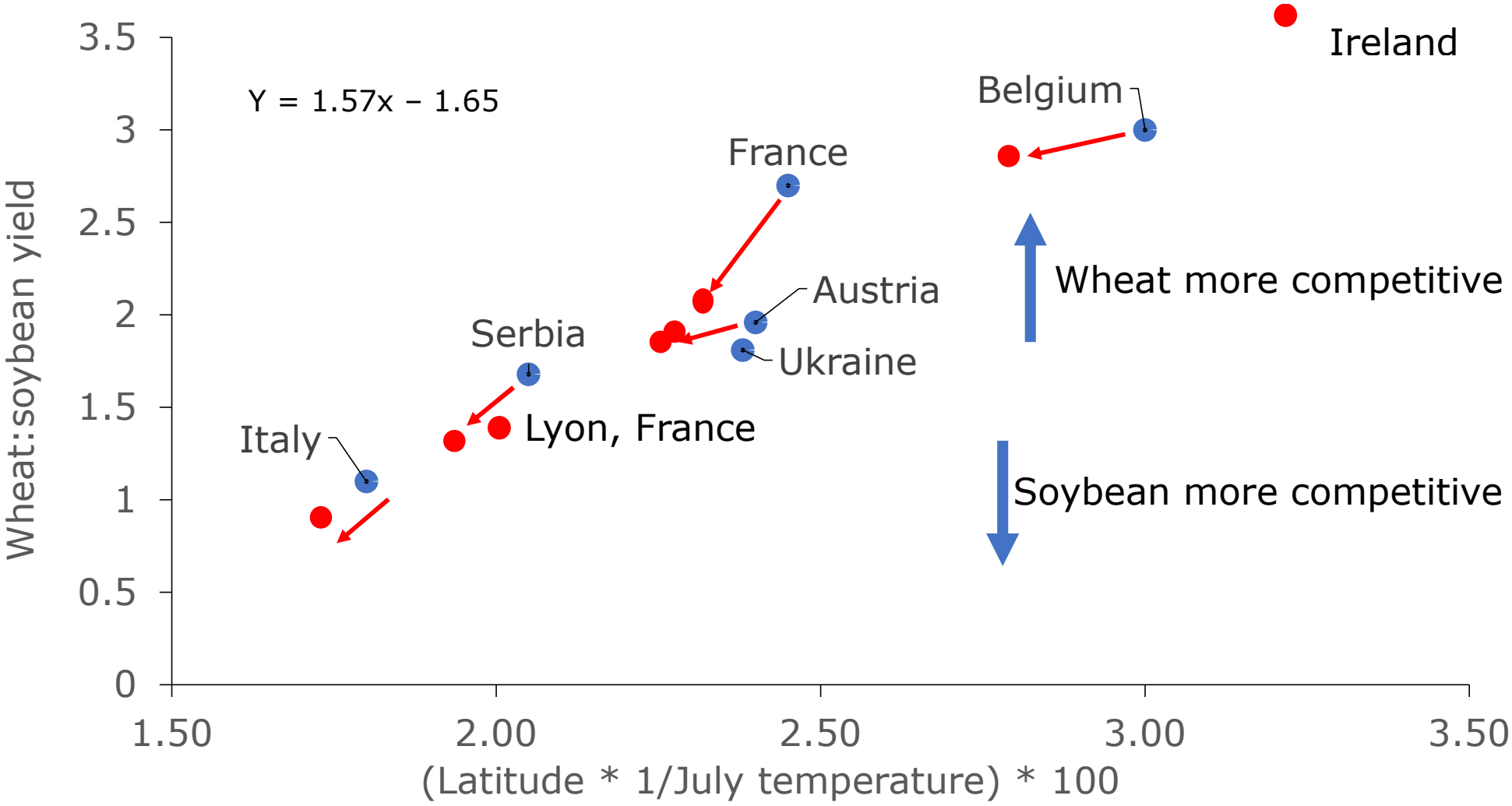
The competitiveness of wheat vs soybean as predicted by the average temperature in July and the latitude.



The combination of mean July temperature and latitude (Latitude * 1/July temperature) * 100		**Current climate**	**+ 1°C**
	Vienna	2.40	2.28
	Brussels	3.00	2.83
	Paris	2.45	2.33
	Dublin	3.53	3.31
	Milan	1.80	1.73
	Belgrade	2.05	1.96
	Kiev	2.38	2.27

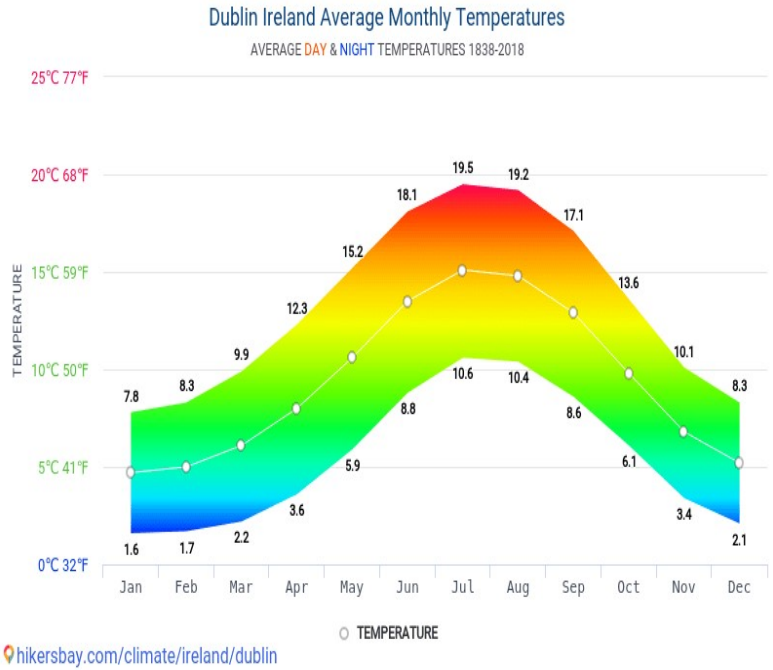
The combination of mean July temperature and latitude (Latitude * 1/July temperature) * 100		July temp. +1°C	Latitude	The combination	Wheat:soybean yield
	Vienna	21	48	2.28	1.94
	Brussels	18	51	2.83	2.80
	Paris	21	49	2.33	2.01
	Dublin	16	53	3.31	3.55
	Milan	26	45	1.73	1.07
	Belgrade	23	45	1.96	1.43
	Kiev	22	50	2.27	1.92

The prediction of the effect of +1°C on the ratio of wheat to soybean yield



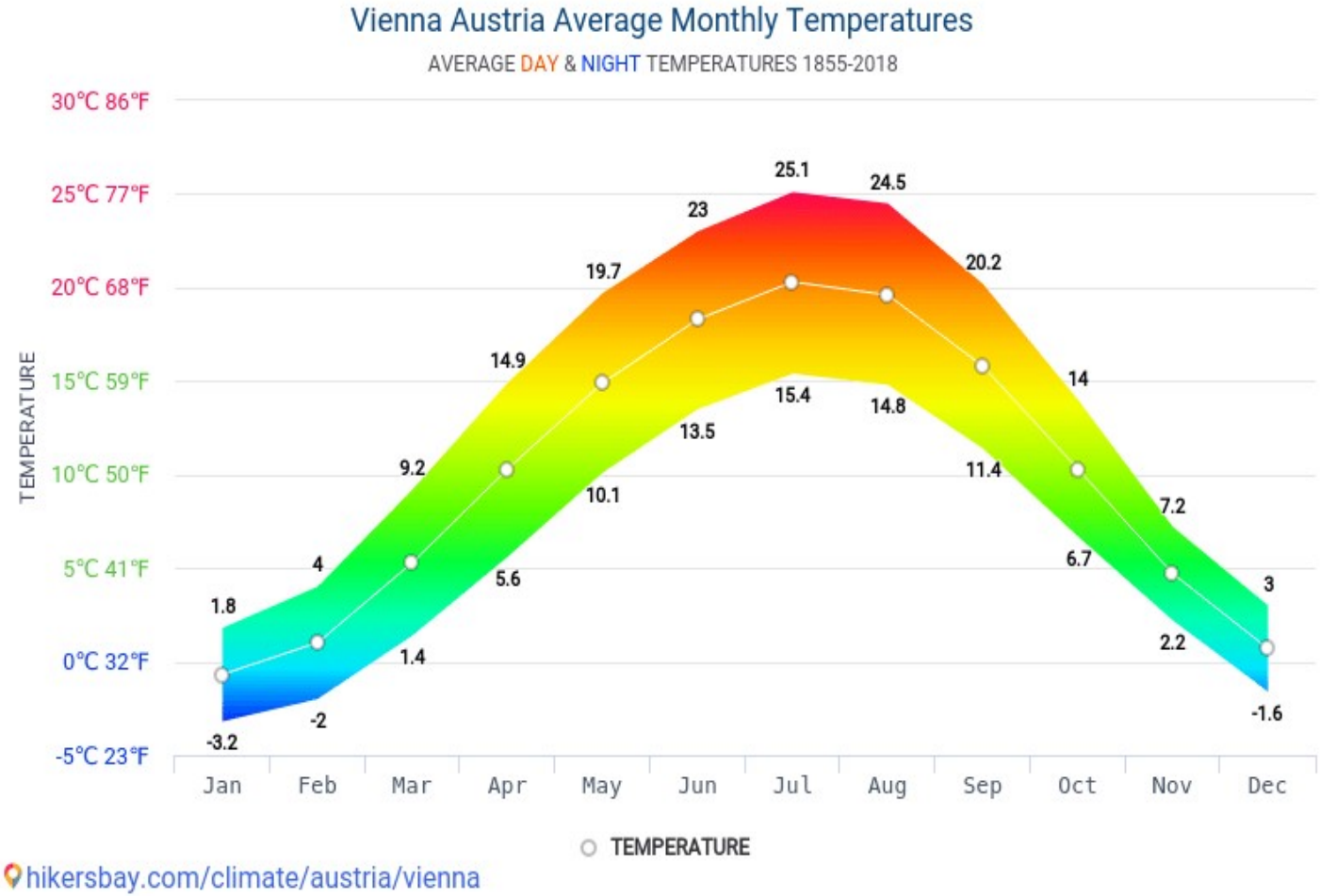
Ireland

Trying to grown a poor crop of soybean costs 10 t/ha of wheat

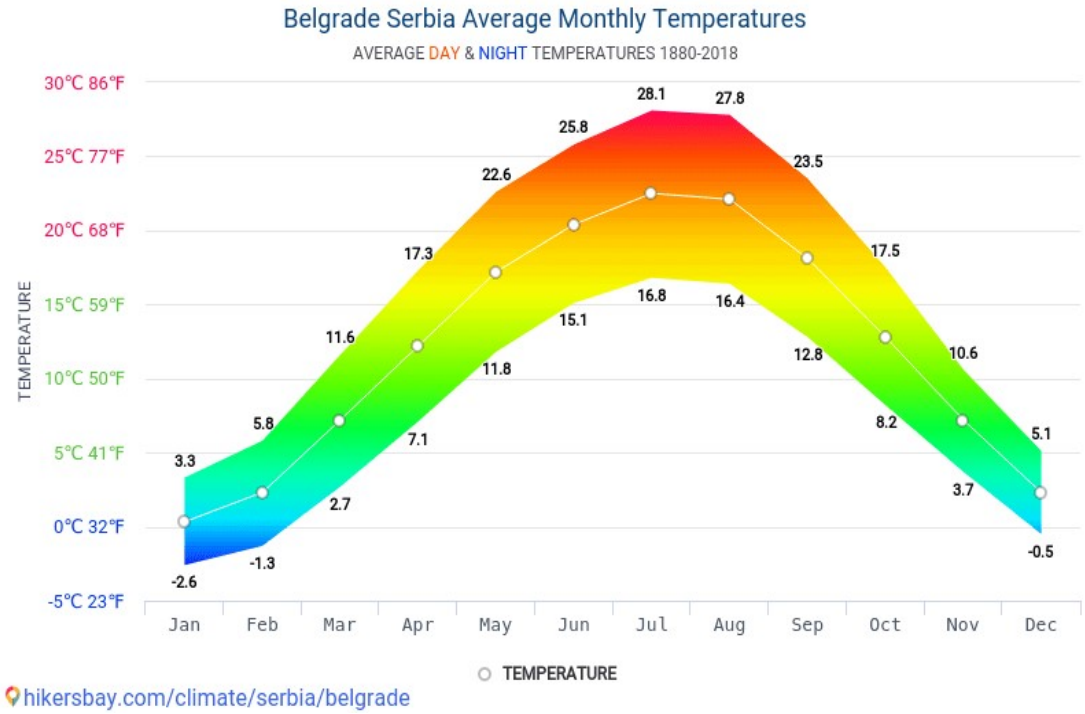


Austria

Wheat/soybean: 1.96

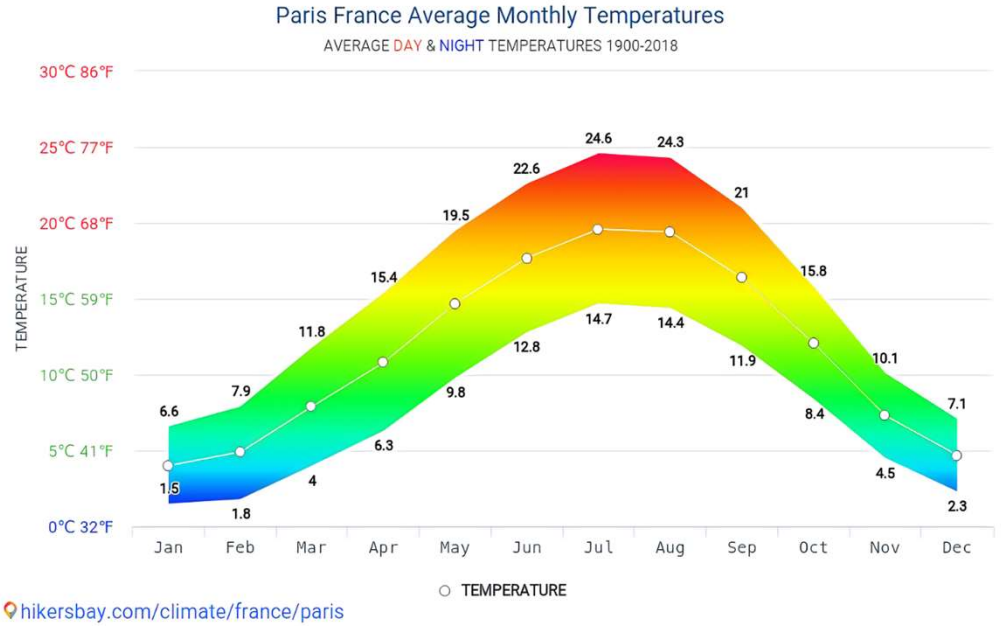


Serbia
Wheat/soybean: 1.68



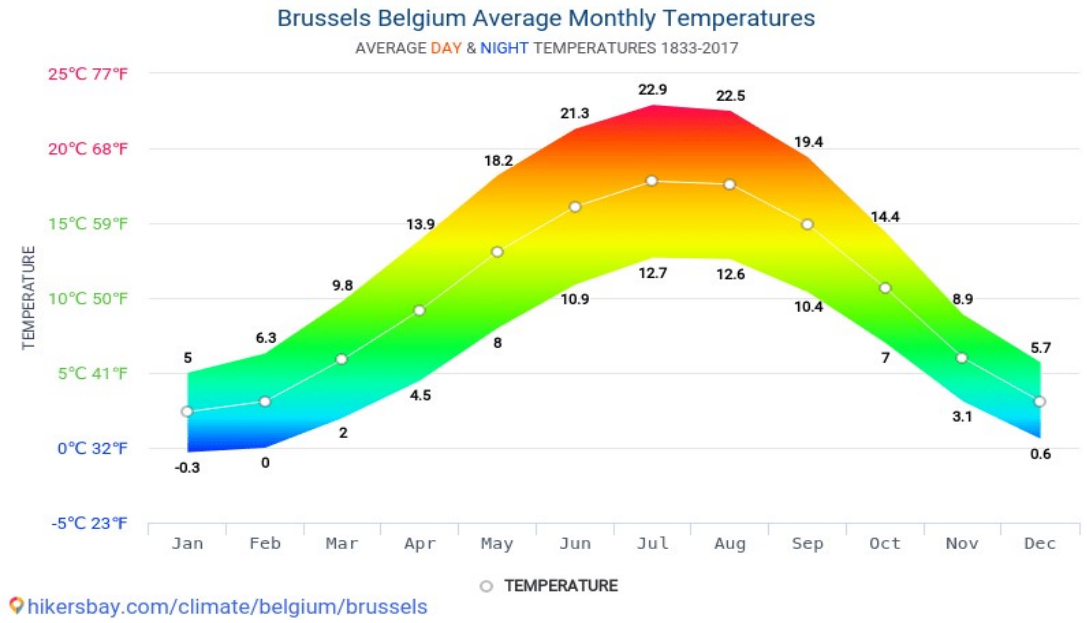
hikersbay.com/climate/serbia/belgrade

France
Wheat/soybean: 2.70

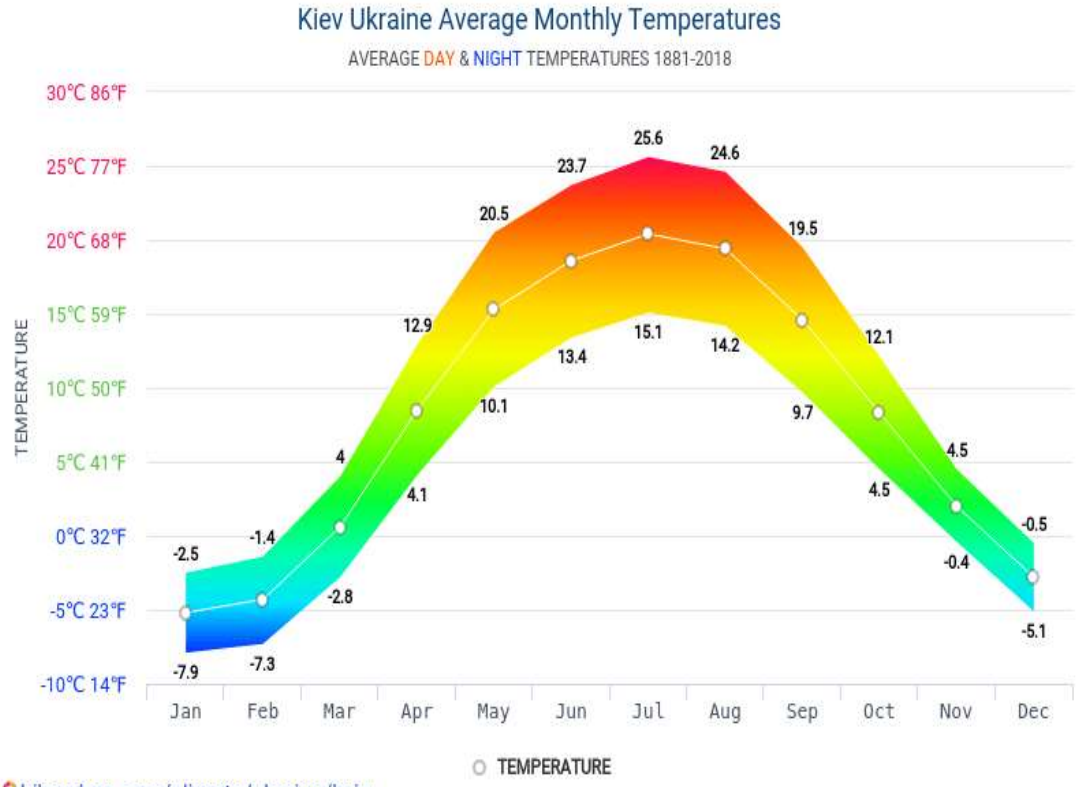


hikersbay.com/climate/france/paris

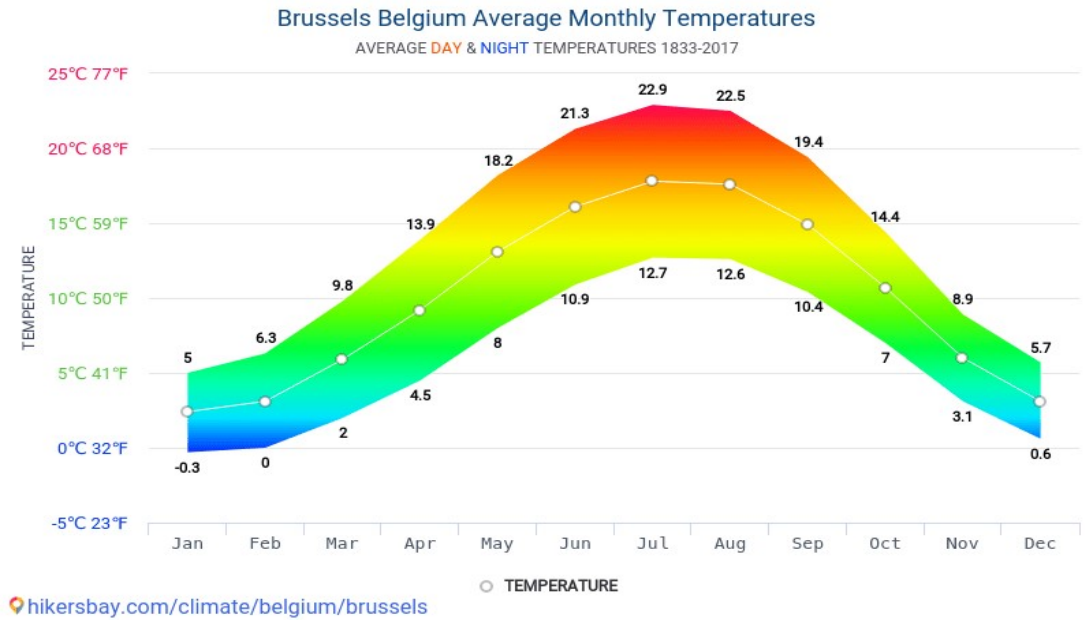
Belgium
soybean: 3.00



Ukraine
Wheat/soybean: 1.81

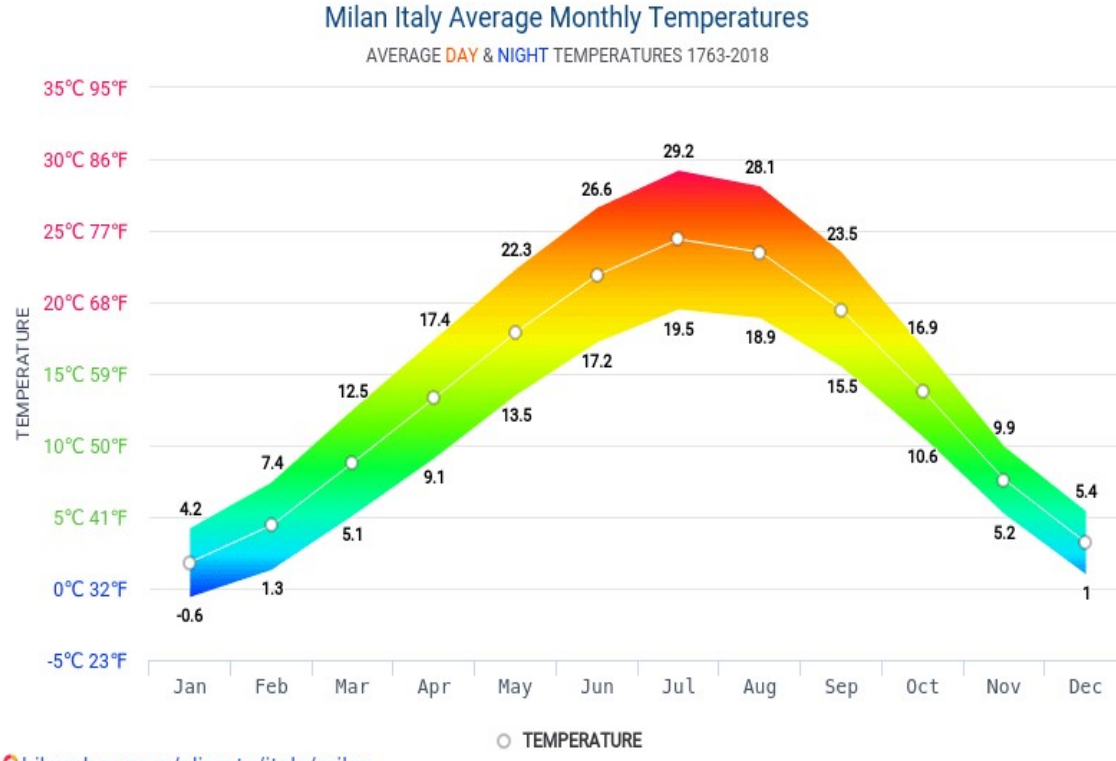


Belgium
soybean: 3.00



hikersbay.com/climate/belgium/brussels

Italy
Wheat/soybean: 1.10

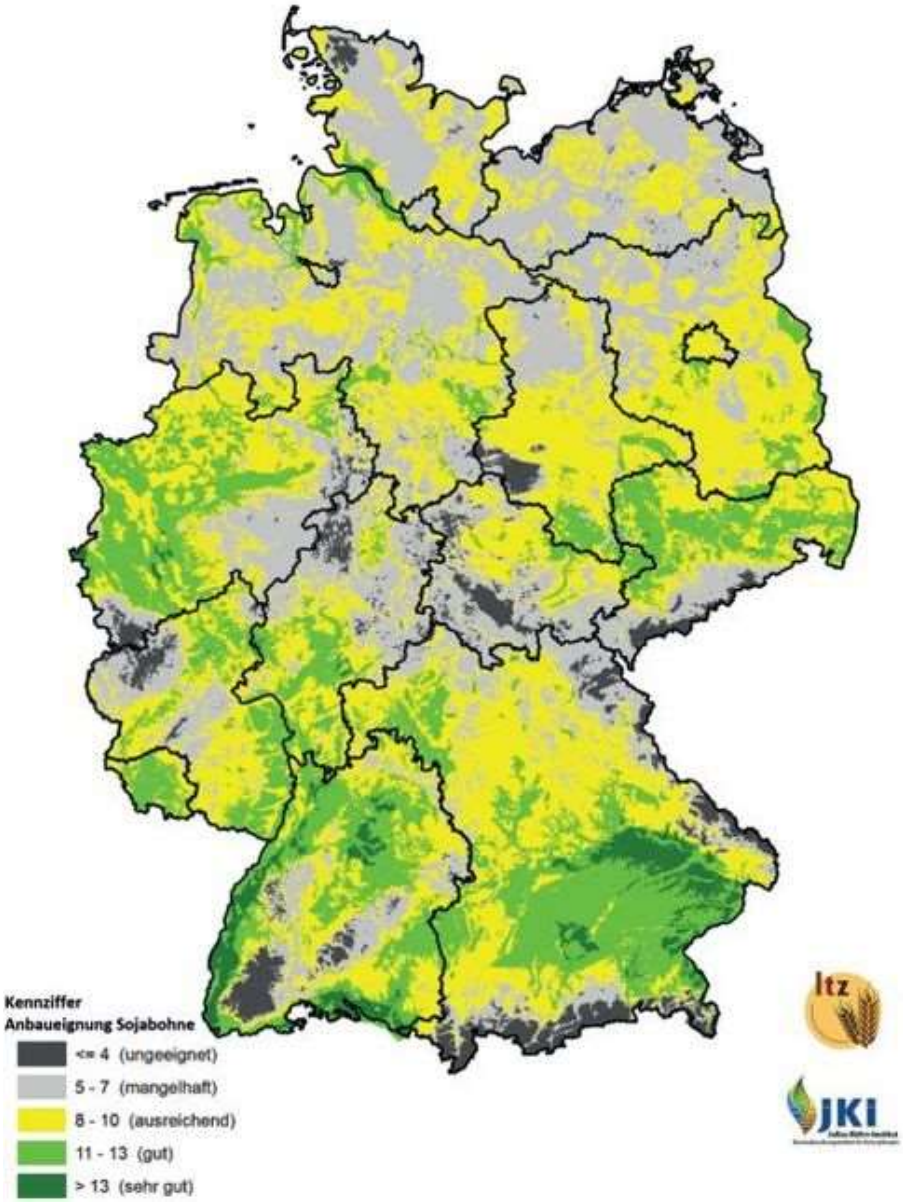


hikersbay.com/climate/italy/milan

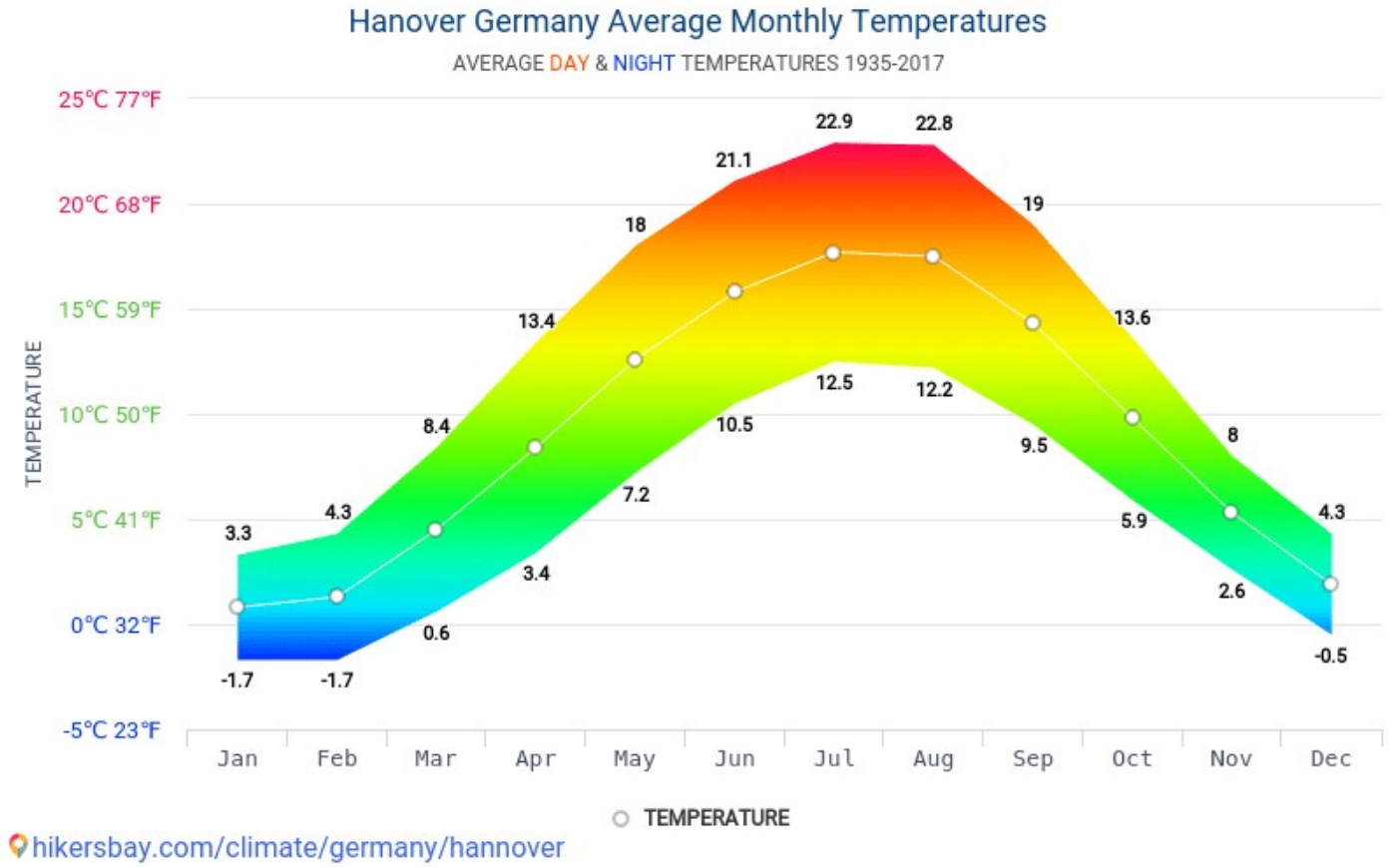
Suitability for soybean production in Germany

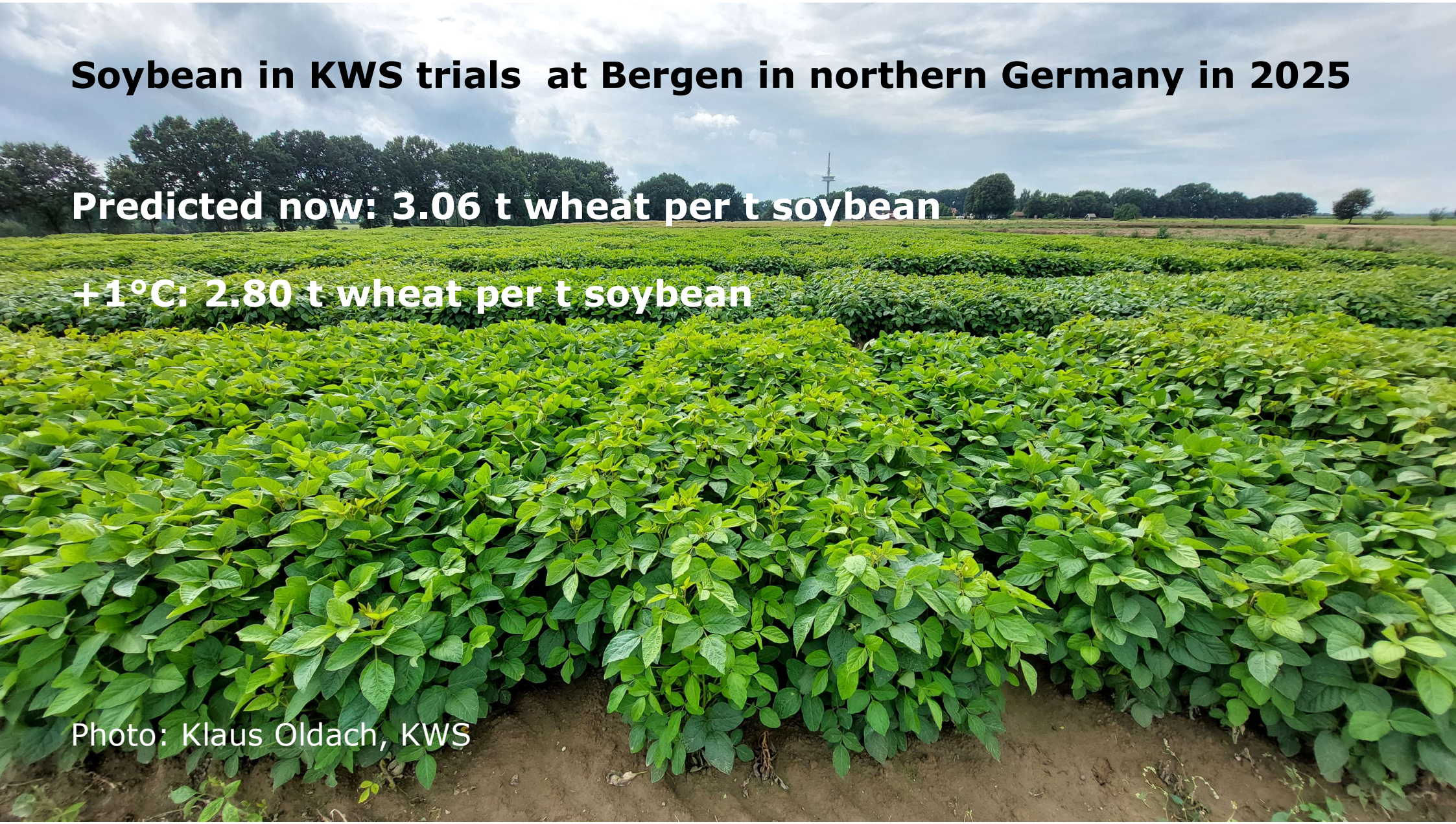
(from Roßberg and Recknagel 2017, Journal für Kulturpflanzen)

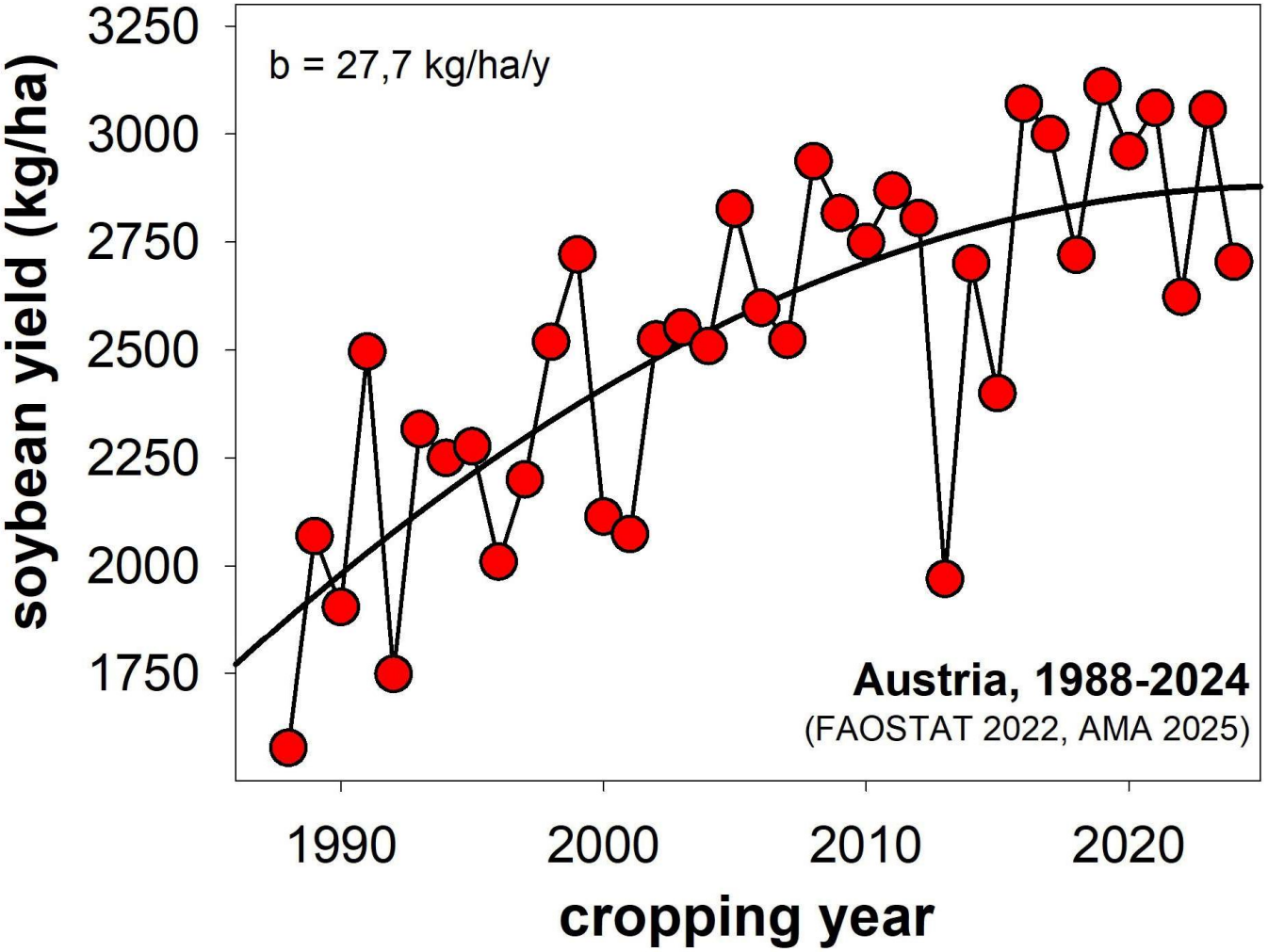
The most important factor will be the effect of warming on the performance of wheat, barley and co.



Monthly temperatures at Hannover




Soybean in KWS trials at Bergen in northern Germany in 2025
Predicted now: 3.06 t wheat per t soybean
+1°C: 2.80 t wheat per t soybean
Photo: Klaus Oldach, KWS



Soybean yield progress in Austria

(1988-2024)

Regression
over 37 years
in kg/ha per year:
b= +27.7 (Austria)


Photo: Johann Vollmann


Symptoms
of drought
Photo: Johann Vollmann


Severe drought
Photo: Johann Vollmann

Legume
Generation

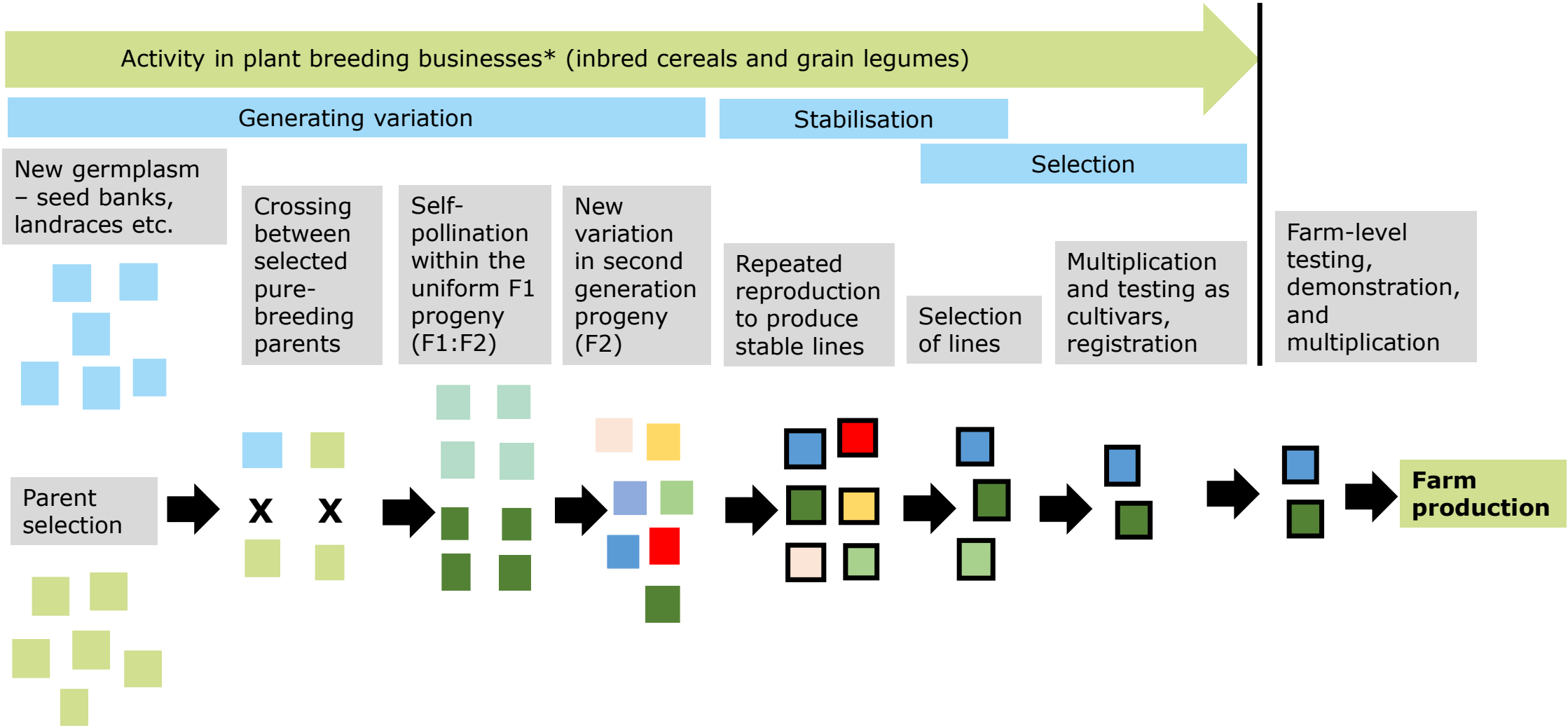
Boosting legume breeding in Europe

It all starts with a seed

Legume
Generation

An individual crop = Genetics x Environment x Management

(G x E x M)



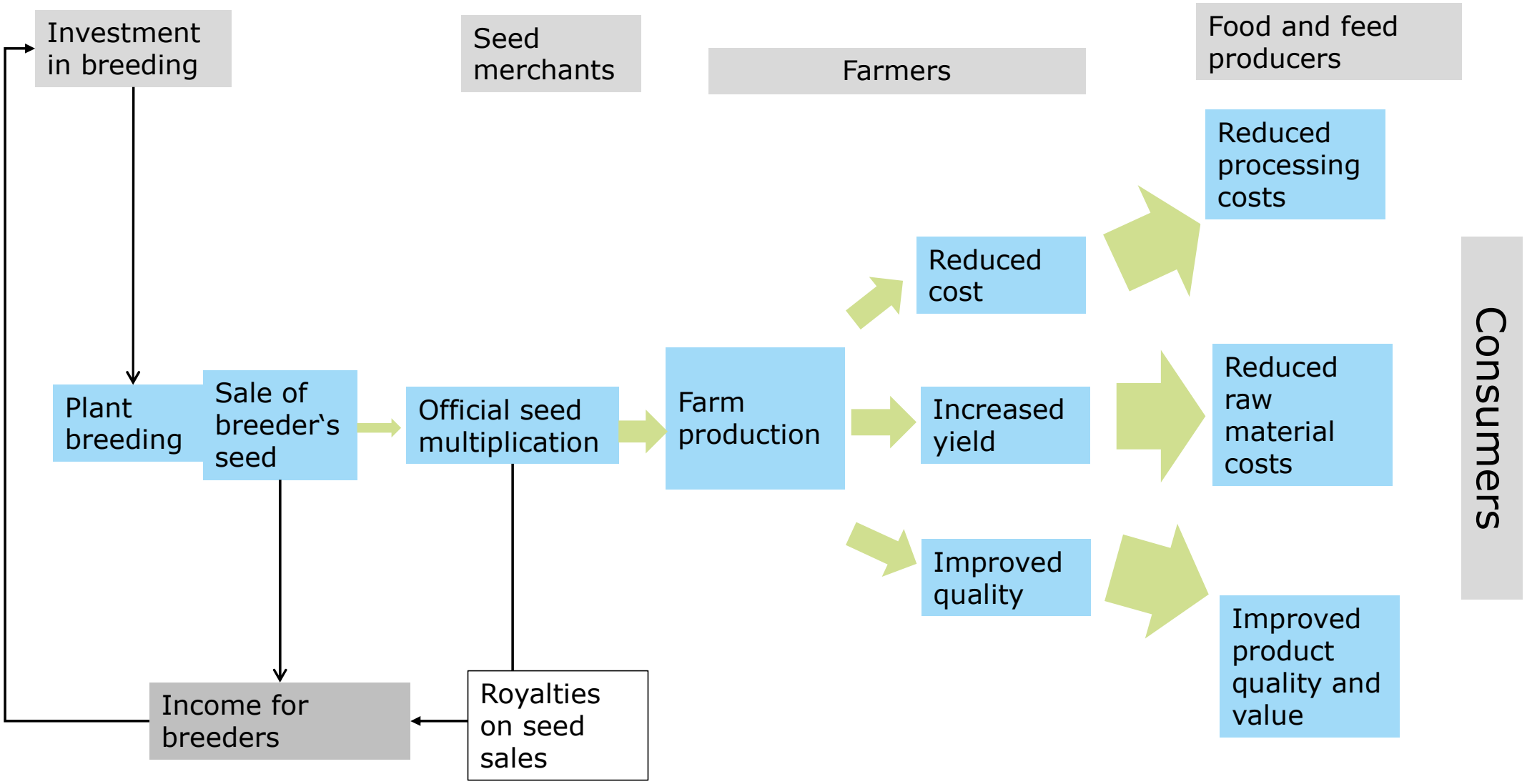
* Breeding businesses here includes cultivar testing organisations who provide cultivar data for registration. These are public organisations in most countries.

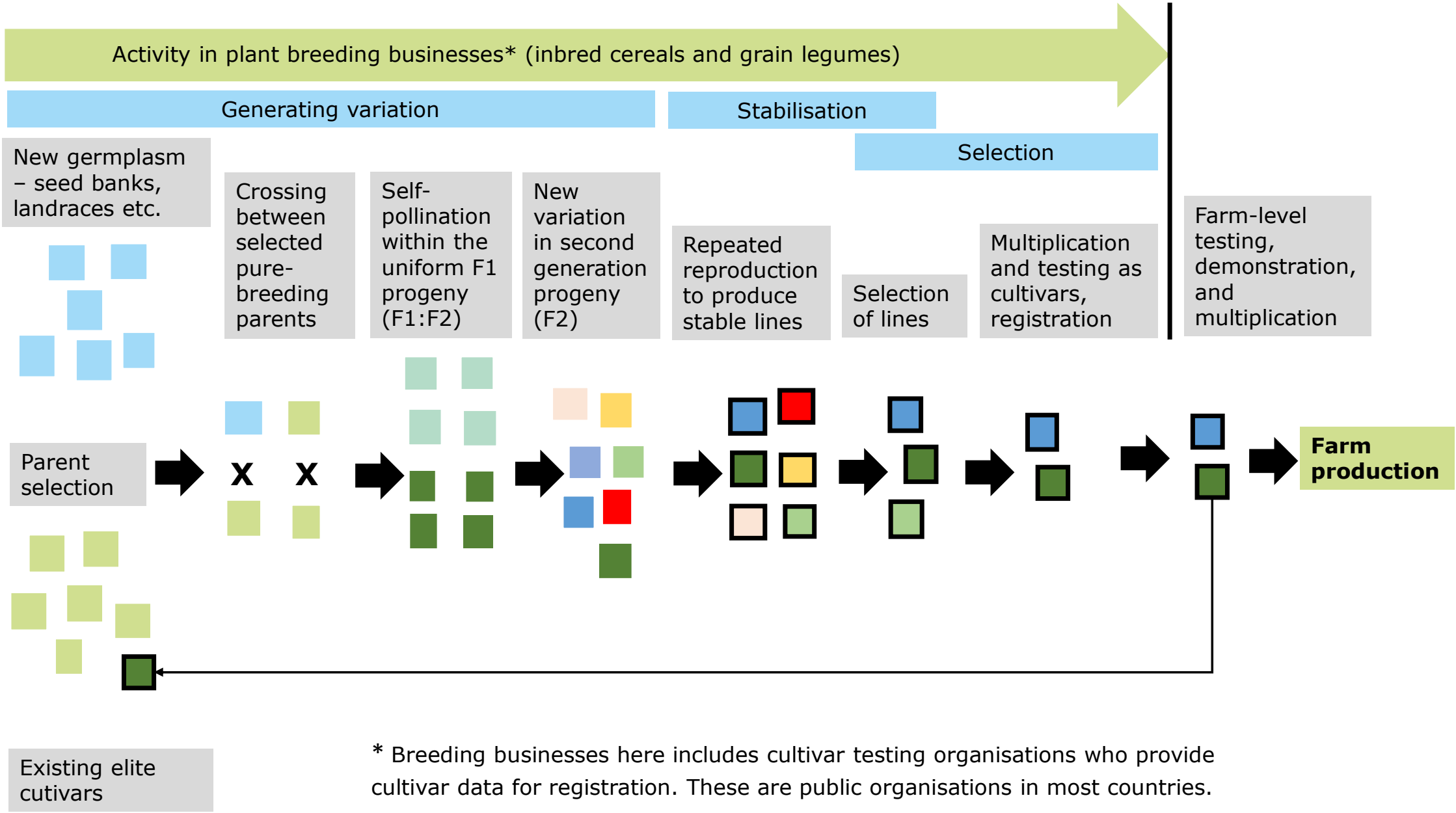
Soybean field sites

Johann Vollmann
BOKU

Legume Generation

The generation and distribution of value from plant breeding





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Breeding for climate change

How does climate change affect plants

These are annual plants: climate and weather

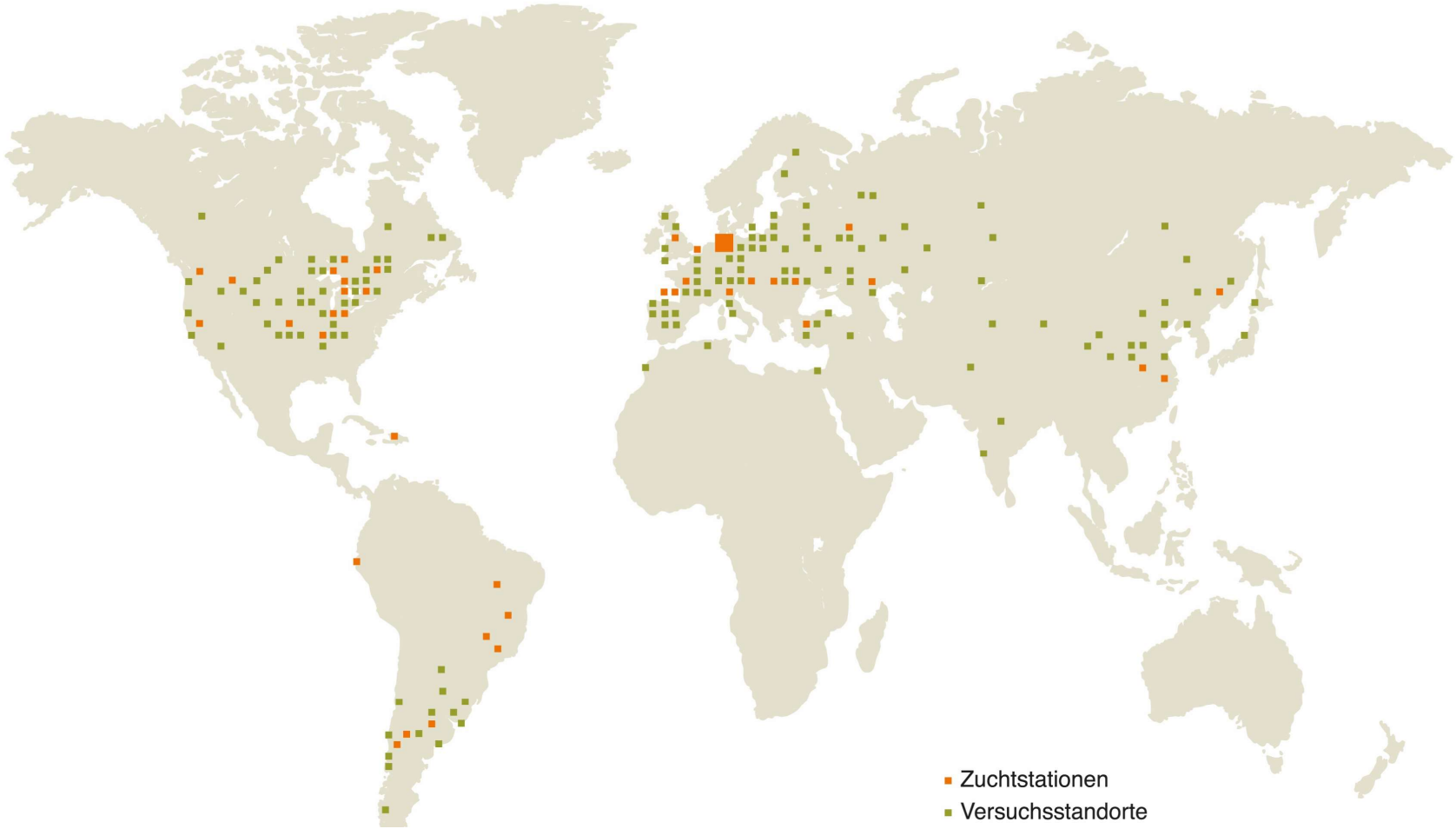
Warmer or colder?

Drier or wetter?

Plant breeding largely self-adjusts to environmental change

KWS

Züchtungs- und Vertriebsaktivitäten der KWS Gruppe in über 70 Ländern



Breeding targets (traits) for climate change

Timing of harvest – earlier or later

Insensitivity to long days

Early growth and vigour under cool conditions: lower base temperature

Tolerance of summer chilling

Tolerance and survival of heat stress

Tolerance of drought and water-logging

Breeding targets (traits) for climate change

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Early growth and vigour under cool conditions: lower base temperature

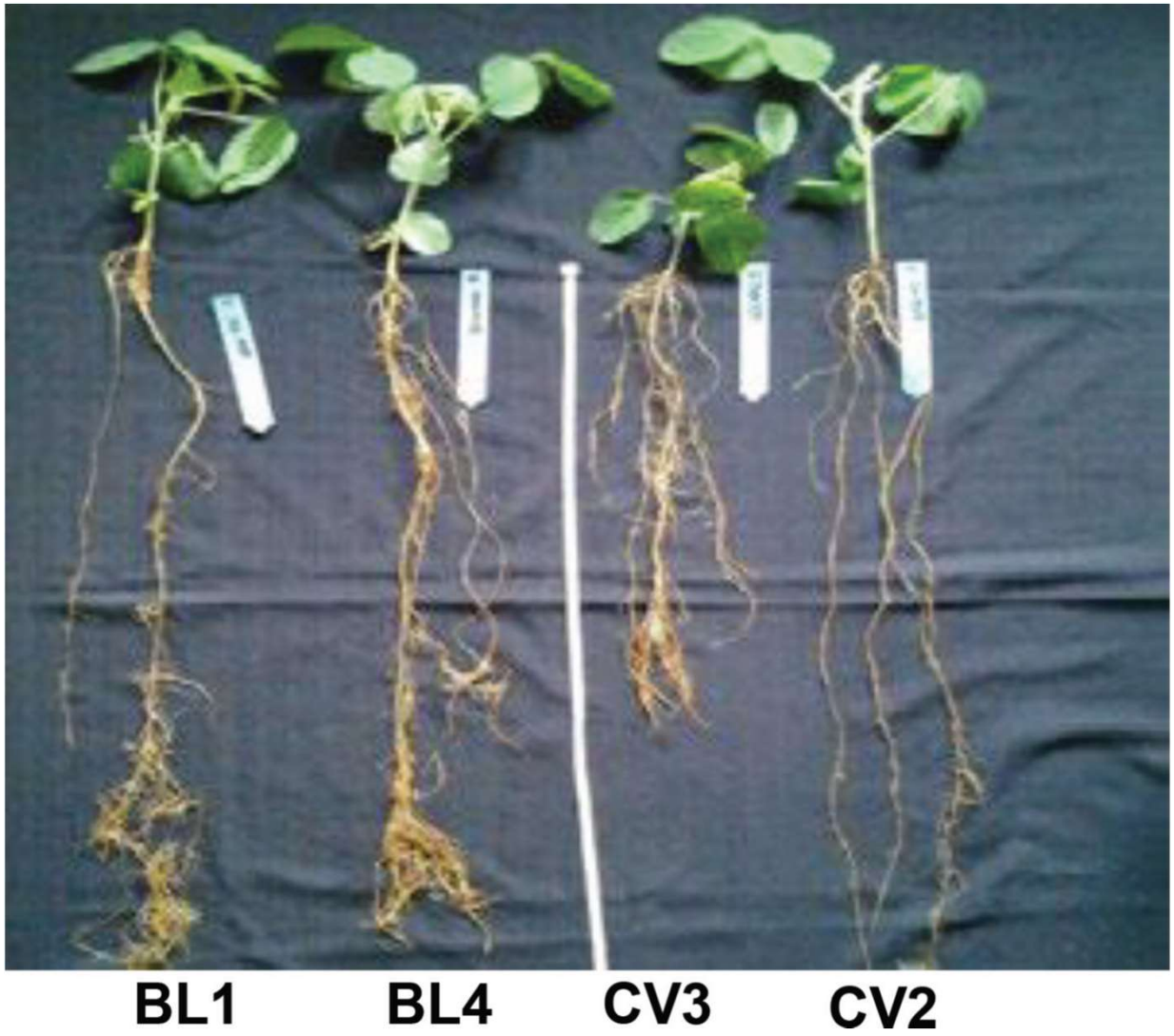
Tolerance of summer chilling

Tolerance and survival of heat stress

Tolerance of drought and water-logging

These are complex traits with very significant trade-offs between traits relevant to climate change

Root traits are likely to become more important



Mwenye, O., van Rensburg, L.
Jacoby, A., and Van der Merwe, R. 2018
Seedling shoot and root growth responses among soybean (*Glycine max*) genotypes to drought stress. In: Soybean - Biomass, yield and productivity. Ed. Kasai, M.

Euphytica 17 (1968): 385–403

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.

Zeichnungen von Hans Erni, zwei Objekte und zwei Autos im Windkanal, um 1933

Bild: ETH-Bibliothek Zürich, Bildarch

Developing and serving the Soybean Innovation Community

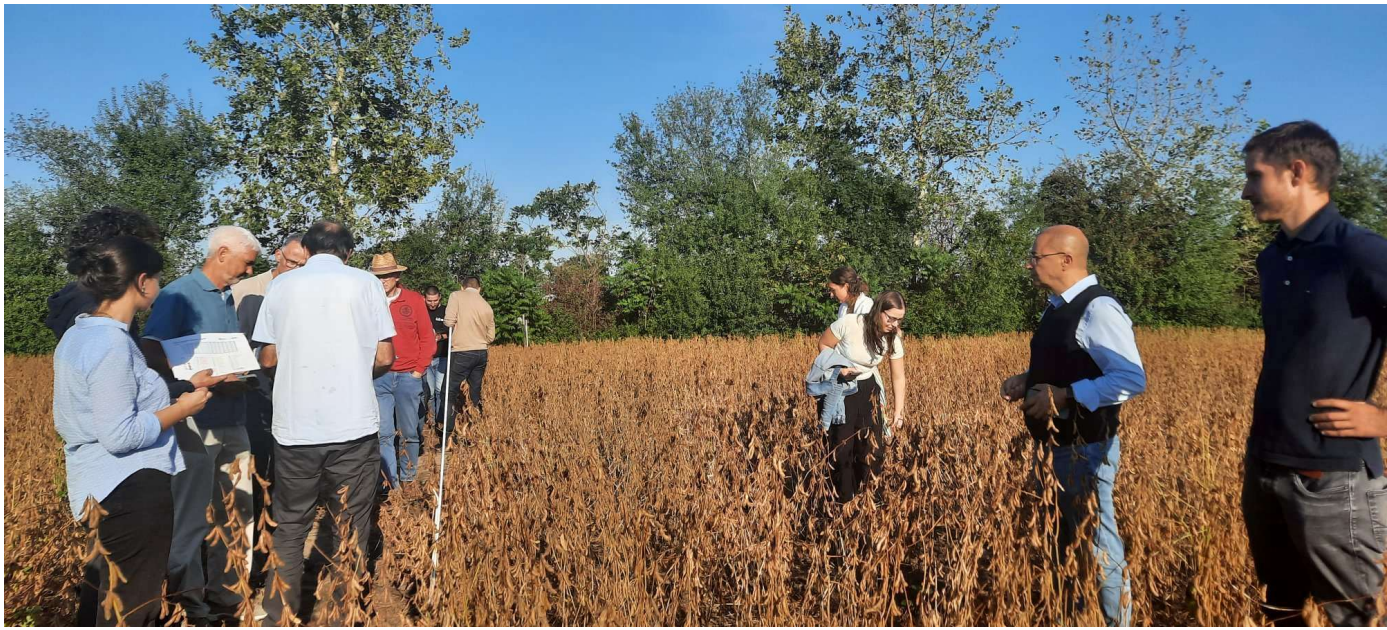


Photo credit: Jasmin Karer

Soybean IC meeting,
Tulln, Austria, SEPT 2024

Task 1.2: Breeding for yield and adaptation

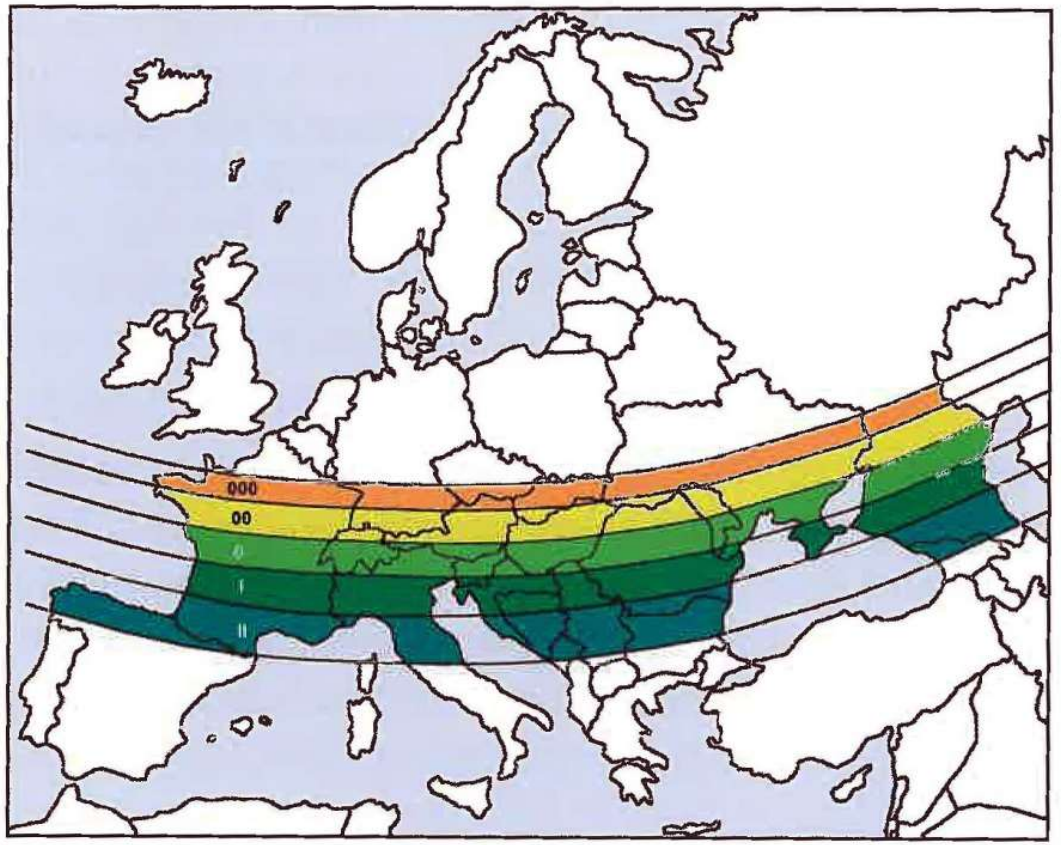
Needs

- Yield performance
- Appropriate flowering / maturity
- Drought tolerance in south and central Europe
- Cold tolerance in north and central Europe

Strategies

Yield trials in different target regions

- MG 000 and 0000: High-latitude long-day environments, northern Europe
- MG 00: Central European conditions
- MG 0-I: Cultivars for low-latitudes, southern Europe



Source: Miladinovic (2011)

Breeding for yield and adaptation

Yield trials

Y1 (MG 000/0000): n=60 genotypes

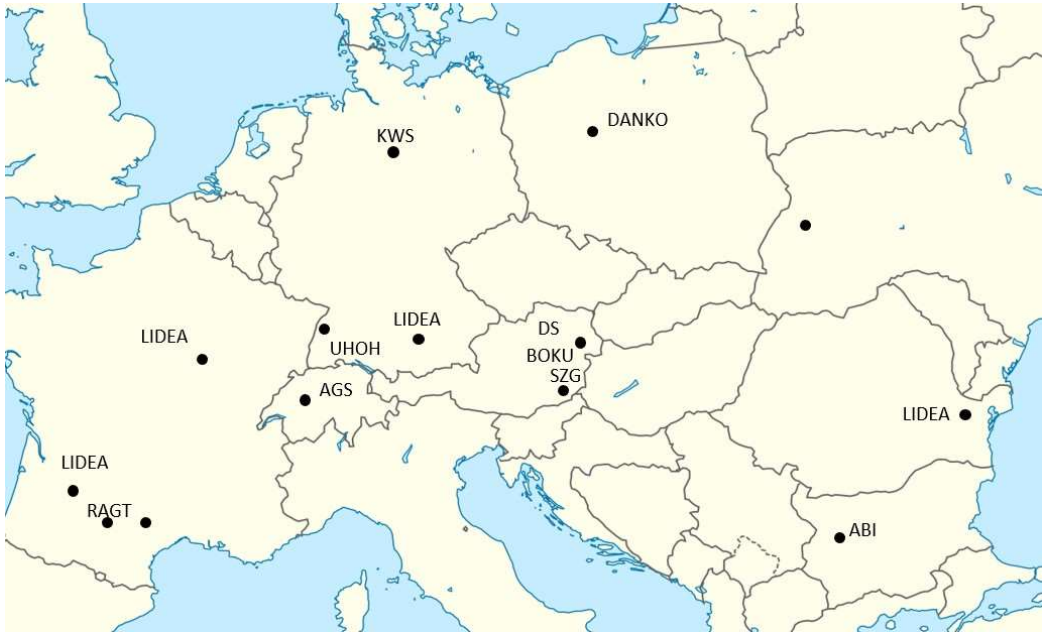
MG 00: n=45 genotypes

MG 0-I: n=30 genotypes

Locations: Covering soybean target regions in different latitudes

Measurements

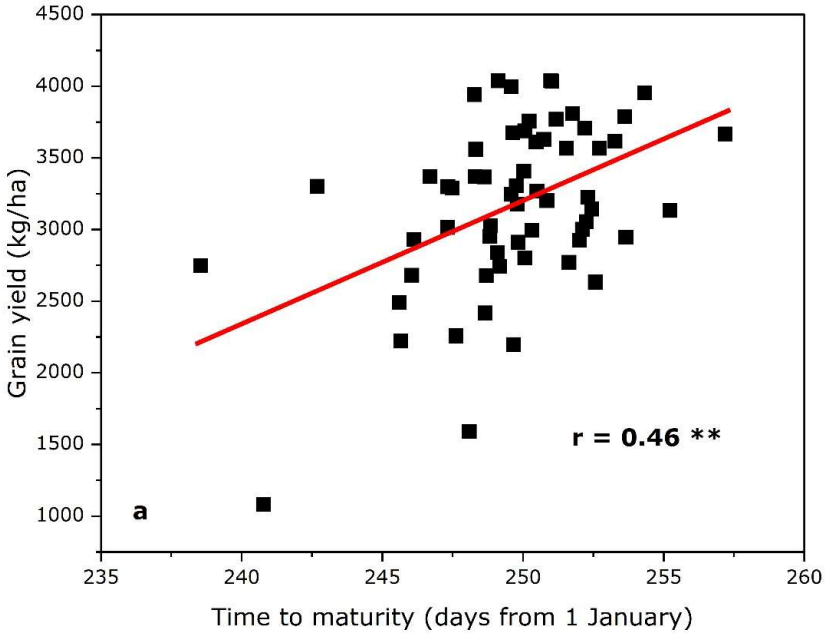
Agronomic characters, harvest quality, digital phenotyping, physiological traits, genotyping with new SNP panel etc.



Legume Generation soybean experimental sites

Breeding for yield and adaptation

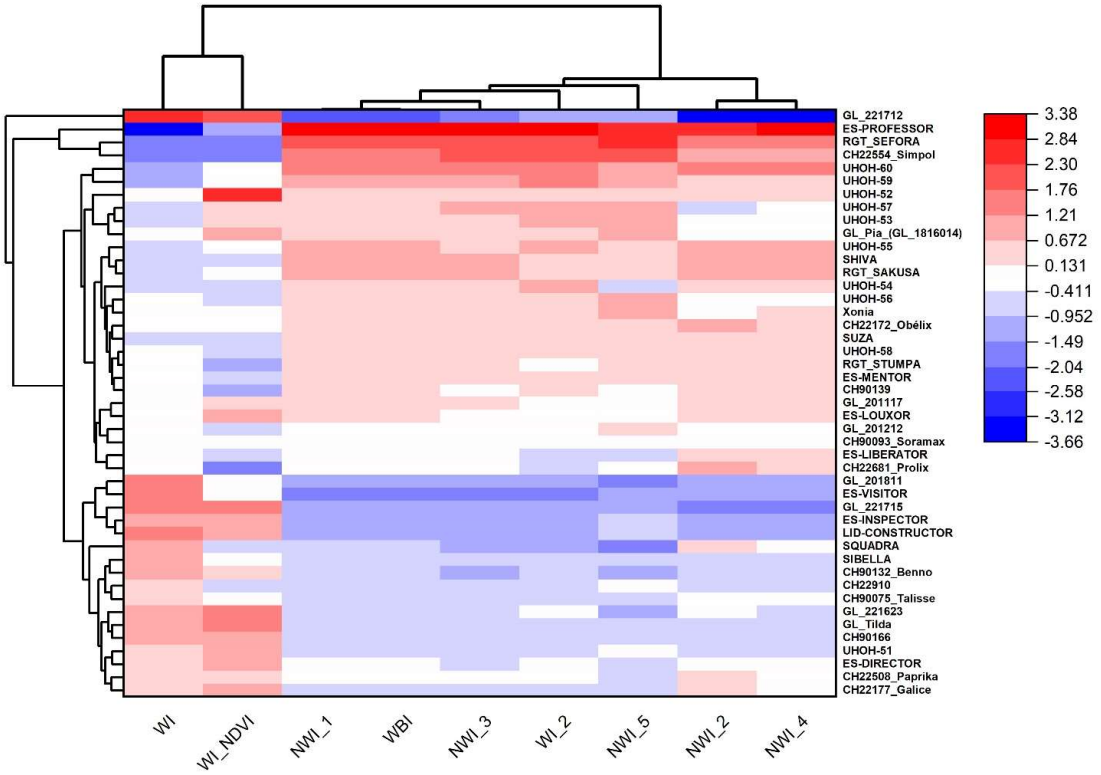
Differences in maturity between genotypes and experiments (Tulln, Austria, 2024)



Positive correlation between time to maturity and grain yield in the early maturity (MG 000) set (Y1) of genotypes (Tulln, Austria, 2024)

Breeding for yield and adaptation

Digital phenotyping: Hyperspectral reflectance is recorded in the field. Over 40 different indices can be calculated from spectral data describing biomass accumulation, water status or nitrogen metabolism (N_2-fixation)



Grouping of genotypes of the Y2 (MG 00) set according to nine water indices describing differences in water status of genotypes (Tulln, Austria, 2024)

Soybean

Photos: Donal Murphy-Bokern,

Legume Generation

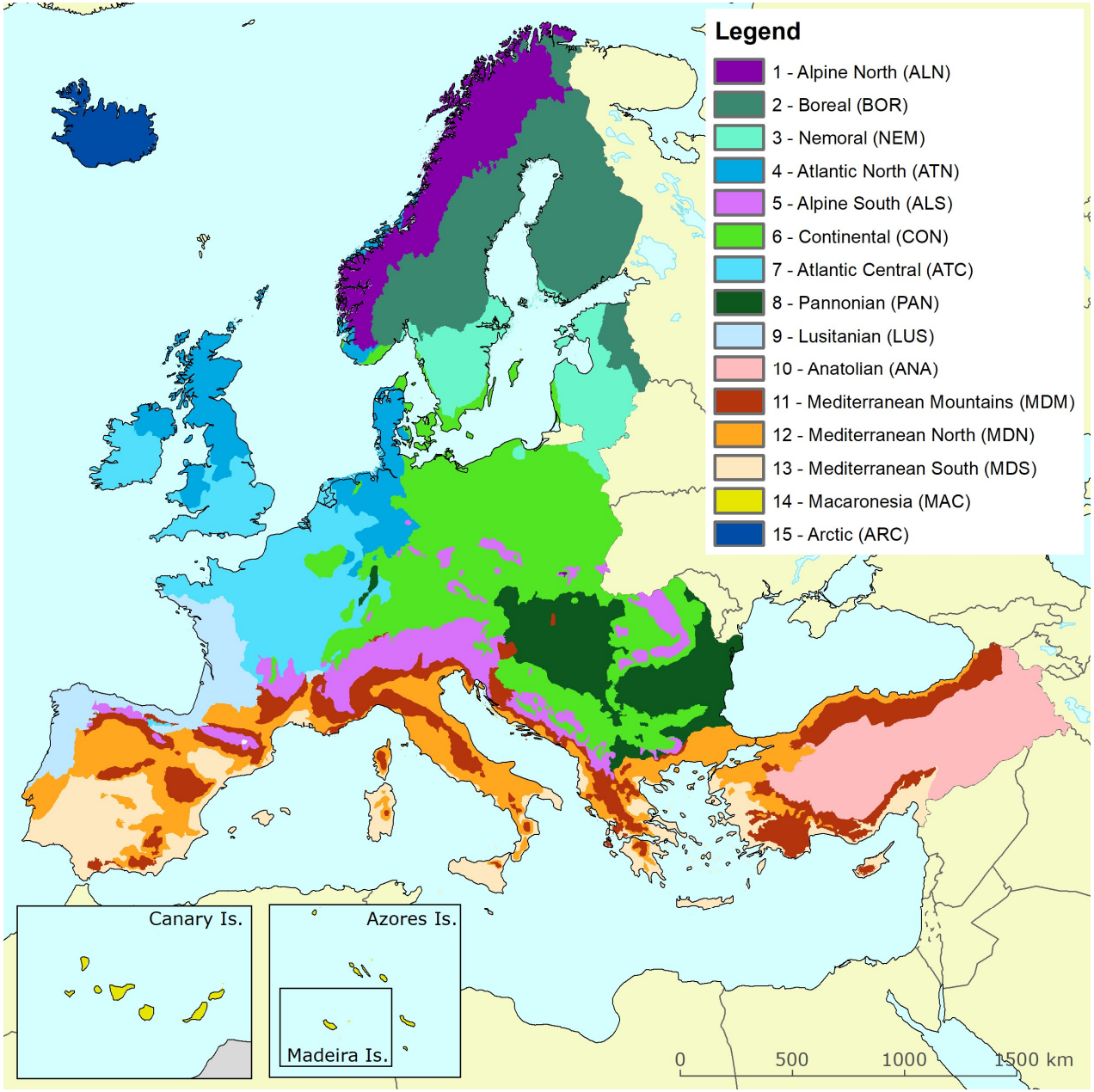
Project consortium partners

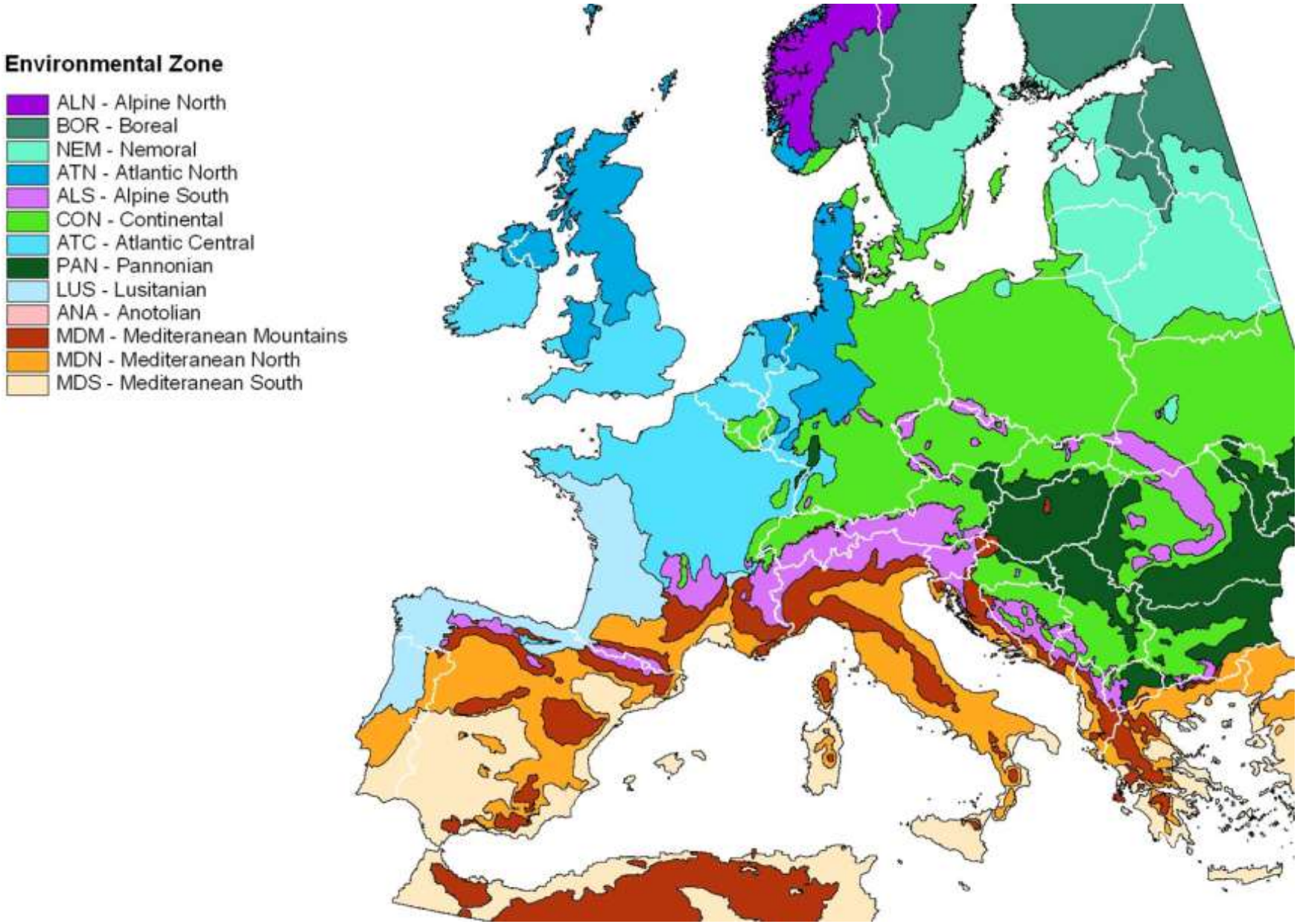
24 EU-funded partners
33 partners to the consortium agreement

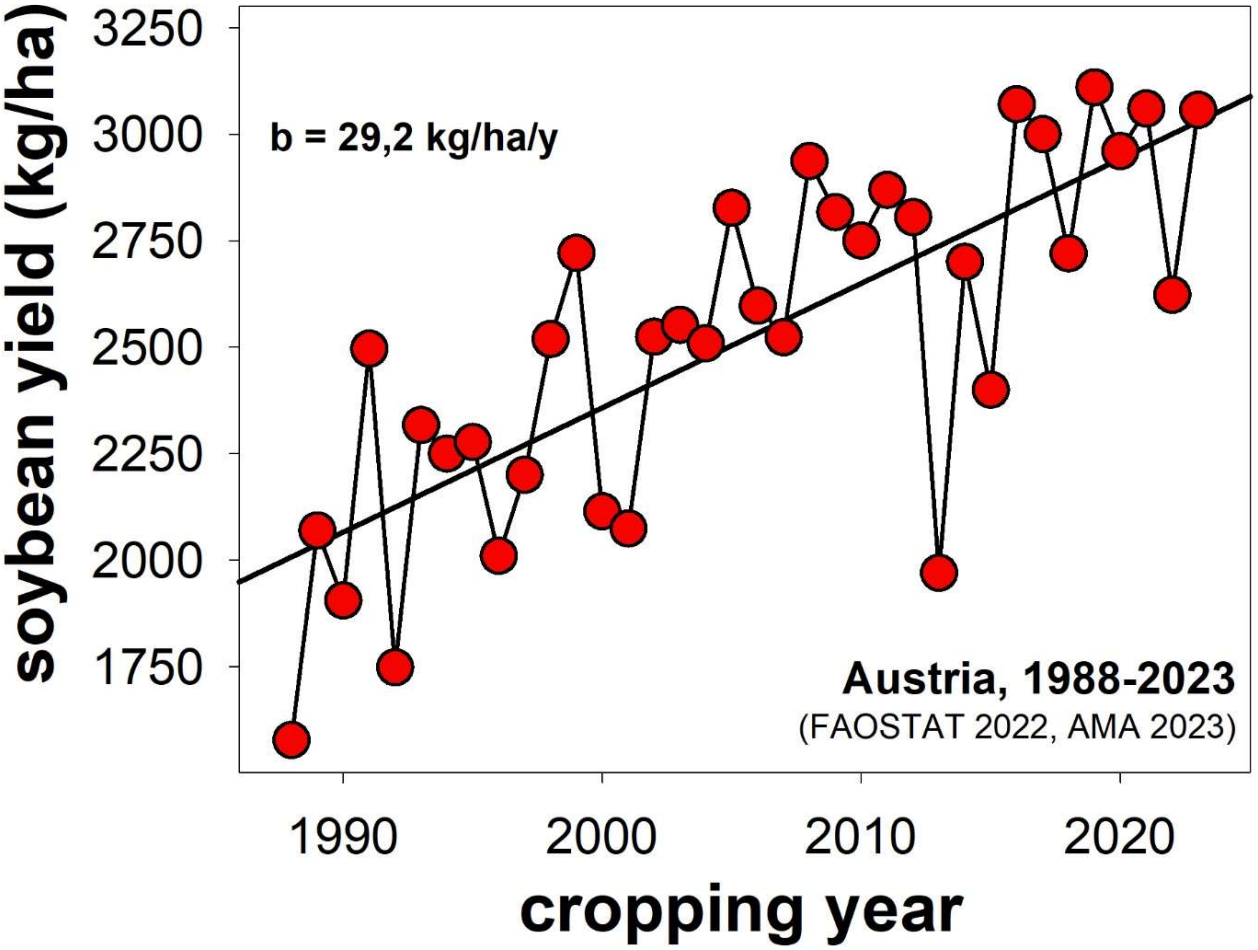
IPK LEIBNIZ INSTITUTE
Donal Murphy-Bokern
DONAU SOJA
SERIDA
UNIVERSITÀ POLITECNICA DELLE MARCHE
RAGT 2n
UNIVERSITY OF HOHENHEIM
1880 DANKO
Euroseeds Embracing Nature
John Innes Centre
IGR pan
JKI Julius Kühn-Institut
Radboud Universiteit
agresearch āta mātai, mātai whetū
Germinal
Earlham Institute
ΔΙΕΘΝΕΣ ΠΑΝΕΠΙΣΤΗΜΙΟ ΤΗΣ ΕΛΛΑΔΟΣ
ABI
VAN WAVEREN Saaten GmbH
SZG Saatzucht Gleisdorf
AARHUS UNIVERSITY
Lidea
SaatGut Keyserlingk-Institut
Agroscope
PRIFYSGOL ABERYSTWYTH UNIVERSITY
UNIVERSITÀ DEGLI STUDI DELLA BASILICATA 1982
USDA
UNIVERSITY OF OXFORD
Ideen um Pflanzen EUKUSA Ideen pflanzen
KWS
UNIVERZITA PALACKÉHO V OLOMOUCI
BOKU UNIVERSITY
LfL Bayerische Landesanstalt für Landwirtschaft

European Environmental Zones

European Environment Agency 2018




Environmental Zone
ALN - Alpine North
BOR - Boreal
NEM - Nemoral
ATN - Atlantic North
ALS - Alpine South
CON - Continental
ATC - Atlantic Central
PAN - Pannonian
LUS - Lusitanian
ANA - Anotolian
MDM - Mediteranean Mountains
MDN - Mediteranean North
MDS - Mediteranean South

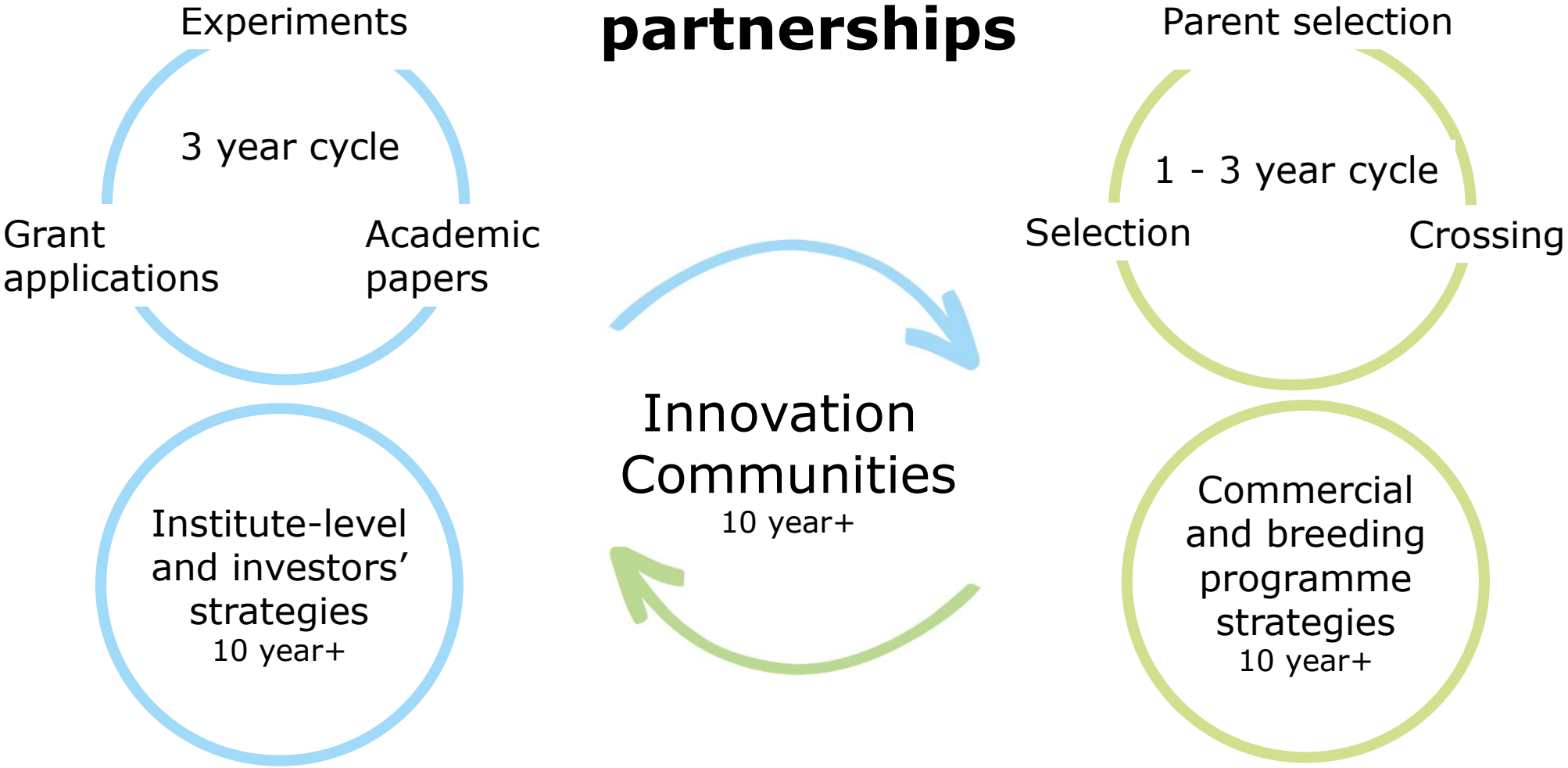


Soybean yield progress in Austria

(1988-2023)

Regression
over 36 years
in kg/ha per year:
b= +29.2 (Austria)

We need deep long-term partnerships



Conclusions – the development of soybean in a warming world

1. **Effect of competitivess between crops will be the major factor**

2. **Increased competitiveness of soybean re most grain crops**

3. **Maize and sunflower are likely to remain competitive with warming**

4. **Farming and plant breeding are largely self-adapting**

5. **But breeding of in-bred crops is subject to profound market failure: we need public investment in long-term partnerships at scale**

6. **The key is generating new variation relevant to environmental change**

7. **We need to link knowledge of how crops respond to the environment and generate yield (crop physiology) with genetics and breeding**

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OPINION

Developing legume-supported cropping systems in Europe: Have we overlooked something?

Donal Murphy-Bokern

Kroge-Ehrendorf, Lohne, Germany

Correspondence
Donal Murphy-Bokern, Kroge-Ehrendorf, 49393 Lohne, Germany.
Email: donal@murphy-bokern.com

Abstract

Why are legume crops rare in Europe even though they grow well there? This opinion paper brings together concepts from crop physiology, classical economics and sociotechnical theory to address this question. It argues for increased focus on research and innovation on crop performance. The starting point is that trade policy no longer explains the marginalisation of legumes. A more recent premise that mutually supporting social, technical and agricultural factors have combined over time to establish and maintain the current cropping systems is also incomplete. However,


BREAD

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