Pea & Bean
Yield Enhancement Network
2022 Results Meeting

Agenda

9:30	*Arrive, tea & coffee*
10:00	Summary Pea YEN Learning & Discussion
12:00	Lunch
12:45	Summary Bean YEN Learnings and Discussion
14:45	Break
15:00	Sponsor liaison meeting (inc. feedback from 2022, Vision for future YEN & how to expand Pulse YEN)
16:00	Close

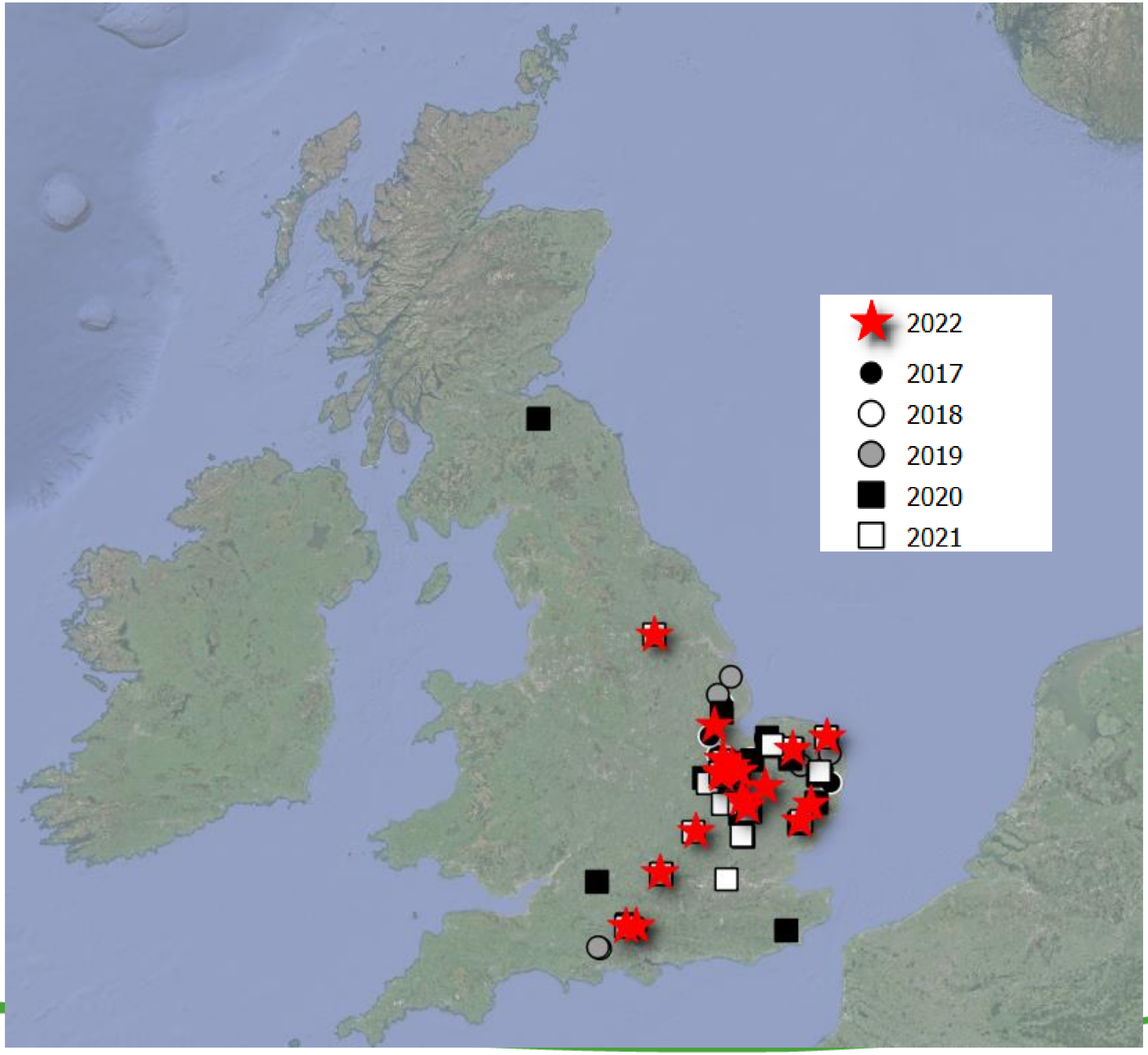
The Pea YEN wouldn’t exist without it’s sponsors:

PEA YEN the data set 2017 - 2022

Introduction

- 25 entries registered in 2022
- 17 of which were able to return yields
- 58 yields from 2019-2021 data set.
- Data from 2017 and 2018 also added in where possible
- 95 Entries with Yields

Year	Average yield
2019	4.2 t/ha
2020	3.7 t/ha
2021	4.0 t/ha
2022	3.4 t/ha



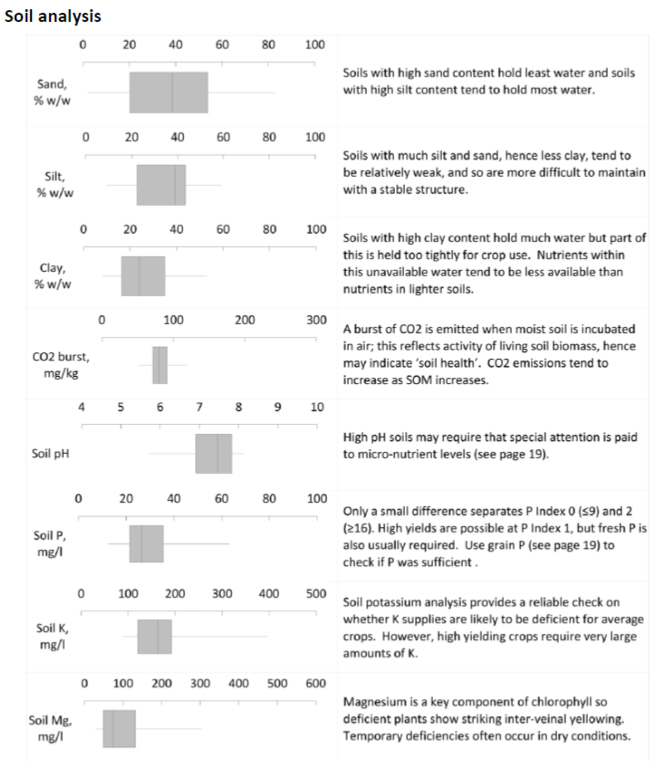
High level - preliminary analysis of Pea YEN 2017-2022 data

- **Partition analysis** - partitioned the data set into the top and bottom 25 % of yields and tested whether crop characteristics differed between the high and low yielding groups
  - Note that this cannot disentangle cause and effect (cannot say what is *driving* yield) but combined with expert judgement we should be able to develop practical messages
  - Just because a factor is not highlighted in the analysis does not mean it is unimportant.
  - Most data is from 2019-2022

High level - preliminary analysis of Pea YEN 2017-2022 data

- **REML**
  - more sophisticated analysis that allows ‘effect sizes’ to be applied, including on categorical data. This helps explain the average variation of an average yield, but it should be remembered that many factors will be influencing yield.
  - Note that this cannot disentangle cause and effect (cannot say what is *driving* yield) but combined with expert judgement we should be able to develop practical messages
  - A straight line is fit to give the REML effect size above the average, but in reality, effects will level off eventually
  - Just because a factor is not highlighted in the analysis does not mean it is unimportant.

Site and soil factors



	Index 2 mg/L	Bottom 25% yield entrants (2.3 t/ha)	Top 25% yield entrants (5.0 t/ha)	REML significance	REML effect
Latitude		52.6	52.2	NS	
Yield potential (t/ha)		7.5	7.5	NS	
OM % (LOI)		6.4	9.1	NS	
Clay content (%)		25.0	20.2	-	
Silt content (%)		31.0	52.1	<0.001	0.03 t/ha per silt %
pH		7.6	7.6	NS	
Soil P (mg/l)	16-25	24	28	NS	
Soil K (mg/l)*	121-180	201	172	NS	
Soil Mg (mg/l)*	51-100	97	105	NS	

*2021 data not included

Categorical data

	No data points	REML significance	REML effect/notes
Variety type	93	<0.01	Marrowfats generally lower yielding than large blues and maples but not whites
Previous crop	91	NS	Majority of crops after cereals
Manure history	92	0.025	Fields with no history of or known use of manures lowest
Cultivation strategy	92	0.012	Deep non inversion, plough based, unknown, min til, direct drill then other in order of highest to lowest. *Interpret with caution as could be driven by farm factor.*

Foot rot risk assessments

	No data points	REML significance	REML effect
Foot rot risk category	61	NS	
Didymella Index	41	0.071	-3.8 t/ha per index unit
Fusarium Index	42	NS	
Aphanomyces Index	42	NS	

Leaf tissue Nutrition

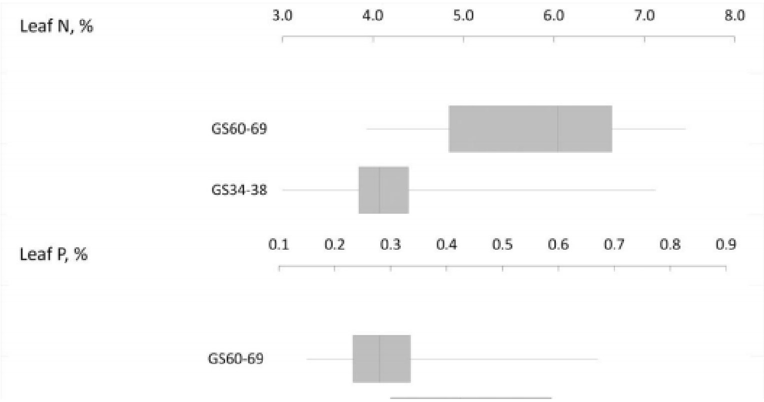
RESOURCES AND THEIR CAPTURE

Nutrient capture

Leaf tissue testing was carried out by Lancrop Laboratories. Whilst some crops were tested pre-flowering or at pod set, not enough data for these growth stages was collected to create benchmarks. Therefor only the data for flowering GS60- 69 is shown below.

Nutrient symbols are as follows:

N	Nitrogen	Fe	Iron
P	Phosphorus	Mn	Manganese
K	Potassium	Zn	Zinc
Mg	Magnesium	Cu	Copper
Ca	Calcium	B	Boron
S	Sulphur	Mo	Molybdenum
Na	Sodium		



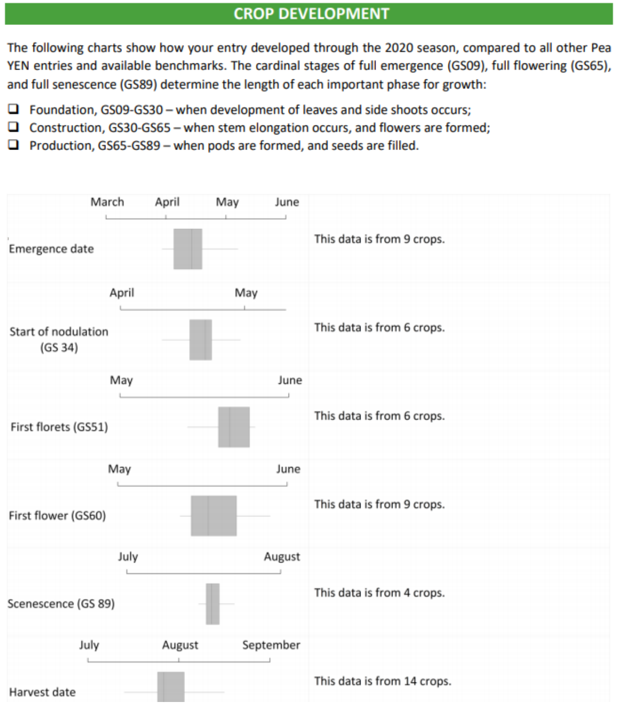
GS 60- 69	Bottom 25% yield (2.3 t/ha)	Top 25% yield (5.0 t/ha)	REML significance
N %	5.22	4.71	NS
P %	0.45	0.37	NS
K %	1.86	1.93	NS
Mg mg/kg	16.1	12.1	NS
Cu mg/kg	14.2	20.1	NS

2017 & 2018 data not included

Leaf tissue Nutrition cont.

GS 60- 69	Bottom 25% yield (2.3 t/ha)	Top 25% yield (5.0 t/ha)	REML significance
Mn mg/kg	39.6	33.5	NS
Mo mg/kg	22.6	15.2	NS
Zn mg/kg	54.7	57.4	NS

Crop development

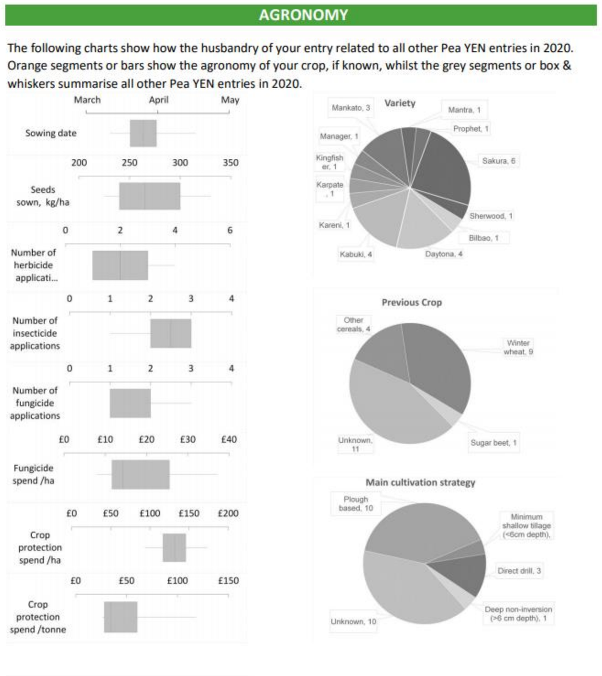

CROP DEVELOPMENT

The following charts show how your entry developed through the 2020 season, compared to all other Pea YEN entries and available benchmarks. The cardinal stages of full emergence (GS09), full flowering (GS65), and full senescence (GS89) determine the length of each important phase for growth:

- Foundation, GS09-GS30 – when development of leaves and side shoots occurs;
- Construction, GS30-GS65 – when stem elongation occurs, and flowers are formed;
- Production, GS65-GS89 – when pods are formed, and seeds are filled.

	Bottom 50% yield entrants (2.3 t/ha)	Top 50% yield entrants (5.0 t/ha)	No of data points	REML significance	REML effect
Sow date	03/04	29/03	71	0.068	-0.021 t/ha per day after the YEN average
GS10 - emergence	-	-	33	NS	
GS34 – nodulation	12/05	05/05	27	NS	
GS60 – First flower	21/06	06/06	38	NS	
GS89 - senescence	24/07	18/07	32	NS	
Harvest	08/08	05/08	58	NS	
Season length (days)	127	128	56	NS	

Crop management associations with yield



	Bottom 25% yield entrants (2.3 t/ha)	Top 25% yield entrants (5.0 t/ha)	No of data points	REML significance	REML effect
Fert P_2O_5 applied (kg/ha)	31.3	22.0	48	NS	
Fert K_2O applied	37.2	34.5	49	NS	
Fert SO_3 applied	3.4	19.1	45	NS	
Num herbicide apps	1.7	2.5	57	0.015	0.47 t/ha per app
Num insecticide apps	1.7	2.1	56	NS	
Num fungicide apps	1.3	1.6	57	0.096	0.47t/ha per app

Yield components

	Marrowfats		Marrowfats			All combining types		
	Bottom 25% yield (2.2 t/ha)	Top 25% yield (4.6 t/ha)	No of data points	REML significance	REML effect	No of data points	REML significance	REML effect
Plant Count (direct measure)	81	79	15	NS		73	NS	
Number of shoots / plant	1.06	1.03	15	NS		70	NS	
Seeds/m^2	1182	2061	25	<0.001	Unable to calculate	73	<0.001	0.002 t/ha per seedm^2
Plant height (cm)	66.8	94.1	17	<0.001	Unable to calculate	50	<0.001	
Pods per shoot			31	NS		83	0.093	0.07 t/ha per pod/shoot
Peas per pod			31	NS		83	NS	

Yield components cont.

Pea Type	Marrowfats		Marrowfats			All combining types		
	Bottom 25% yield (2.2 t/ha)	Top 25% yield (4.6 t/ha)	No of data points	REML significance	REML effect	No of data points	REML significance	REML effect
TSW (85%)	363	382	25	0.01	Unable to calculate	73	NS	
Total DM per plant (g)	13.3	16.4	24	0.022	Unable to calculate	69	0.085	0.05 t/ha per g DW per plant
Pea DM per shoot	6.4	7.7	24	0.006	Unable to calculate	69	0.015	0.12 t/ha per g DW per shoot
HI	0.48	0.48	24	NS		69	0.006	0.05 t/ha per HI % point
Biomass t/ha	3.7	9.1	24	<0.001	Unable to calculate	69	<0.001	0.31 t/ha per t/ha biomass

Yield components – All other types

	All others		All other types			All combining types		
	Bottom 25% yield (2.1 t/ha)	Top 25% yield (6.5 t/ha)	No of data points	REML significance	REML effect	No of data points	REML significance	REML effect
Plant Count (direct measure)	68	89	24	NS		39	NS	
Number of shoots / plant	1.02	1.06	45	NS		70	NS	
Seeds/m^2	2860	3299	48	<0.001	0.002 t/ha per seed/m^2	73	<0.001	0.002 t/ha per seed/m^2
Plant height (cm)	65	80	33	0.003	0.03 t/ha per cm	50	<0.001	
Pods per shoot	8.8	9.7	52	NS		83	0.093	0.07 t/ha per pod/shoot
Peas per pod	3.9	3.0	52	NS		83	NS	

Yield components cont.

Pea Type	All others		All other types			All combining types		
	Bottom 25% yield (2.1 t/ha)	Top 25% yield (6.5 t/ha)	No of data points	REML significance	REML effect	No of data points	REML significance	REML effect
TSW (85%)	241	270	48	0.014	0.01152	73	NS	
Total DM per plant (g)	13.6	14.1	45	NS		69	0.085	0.05 t/ha per g DW per plant
Pea DM per shoot	7.0	7.5	45	0.05	0.1109	69	0.015	0.12 t/ha per g DW per shoot
HI	0.51	0.57	45	0.034	4.708	69	0.006	0.05 t/ha per HI % point
Biomass t/ha	6.7	9.4	45	<0.001	0.2338	69	<0.001	0.31 t/ha per t/ha biomass

Seed nutrient analysis

CROP NUTRITION POST MORTEM

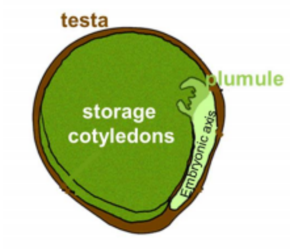


Diagram showing the structure of a pea seed; the cotyledons contain most N, K, S, Cu & Zn, whilst the testa contains most Fe, Mn, P, Ca, Mg and Na.

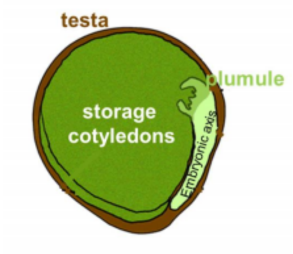
- The YEN has trail-blazed use of grain analysis not only to enable accurate estimates of P and K removals from fields, but also to provide a general post-mortem on each crop's nutrition.
- Lancrop analysed 12 nutrients in grain samples from the Pea YEN in 2020.
- Mineral nutrients in seed can usefully be taken to reflect the nutritional history and status of the crop throughout its life. Any individual nutrient level can be related both to all other nutrients in the sample, and all other YEN samples, hence indicating which nutrients are most likely to have been limiting.
- From the following box & whisker charts, you should be able to identify the nutrient(s) most likely to have limited your crop by comparing with the mid-level in all the other YEN samples.
- No comments are offered on specific nutrients this season but, as the Pea YEN accumulates data over future seasons, we will be able to improve interpretation of seed nutrient analyses and suggest critical thresholds.

Pea Type	All others		Marrowfats	
	Bottom 25% yield (2.1 t/ha)	Top 25% yield (6.5 t/ha)	Bottom 25% yield (2.2 t/ha)	Top 25% yield (4.6 t/ha)
N %	4.41	4.54	4.42	4.28
P %	0.37	0.41	0.46	0.34
K %	1.68	1.43	1.85	1.56
Mg %	0.16	0.16	0.17	0.16
Mn mg/kg	85.8	16.8	15.2	22.0
Zn mg/kg	37.1	37.7	42.8	37.7

YEN

Seed quality analysis

CROP NUTRITION POST MORTEM



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	No data points	REML significance	REML effect/notes
Staining	83	NS	
Admixture	85	0.007	-0.27 t/ha yield associated with each % point of Admixture above the average
Waste	87	<0.001	-0.08 t/ha yield associated with each % point of Waste above the average

Summary – Site, Soil and nutrition

- Some association between yield and location, although most of the data is tightly centralised around the east of England
- Yields not limited by yield potential
- Silty soils tend to see higher yields – suggesting water retention is important
- Most growers within target range for soil pH and soil nutrient indices. No association with fert applications, but note only bagged fert applied within season accounted for

Summary – Establishment & Agronomy

- Higher yields associated with earlier sowing (-0.021 t/ha per day delay)
- Generally, marrowfats are lower yielding
- Fields with manure history associated with higher yields
- Cultivation strategy impacts yields.
  - Deep non inversion > plough based > unknown > min till > direct drill
- Higher yields associated with herbicide and fungicide use but not insecticide use (*remember to not assume cause and effect!*)
- Negative associations of waste and admixture with yield - *indicating issues with conditions at harvest?*

Summary – Yield Components

- Across all variety types, higher yields positively associated with:
  - pods/shoot, seeds/m^2
  - Plant height, individual shoot biomass, crop biomass and Harvest Index

- In addition, when split out into variety types reveals
  - TSW (seed filling) important within variety types
  - Higher plant population associated with increased yields in non-marrowfats
    - *Note that most marrowfat entries above economic optimum plant popn*

- High yields coming from large well podded plants
  - Maximise light capture and avoid stress through flowering to increase sink size

- Seed filling important for seed size
  - Avoid stress during seed fill and maximise canopy duration

YEN

Bean YEN –the data set 2019 - 2022

The Bean YEN wouldn’t exist without it’s sponsors:

ADAS

BASF We create chemistry

nrm part of Cawood

PGRO

Lancrop Laboratories

Agrii

Elsoms The Seed Specialists

senova

DE SANGOSSE GROUP

LSPB COMBINING EXCELLENCE

DTN

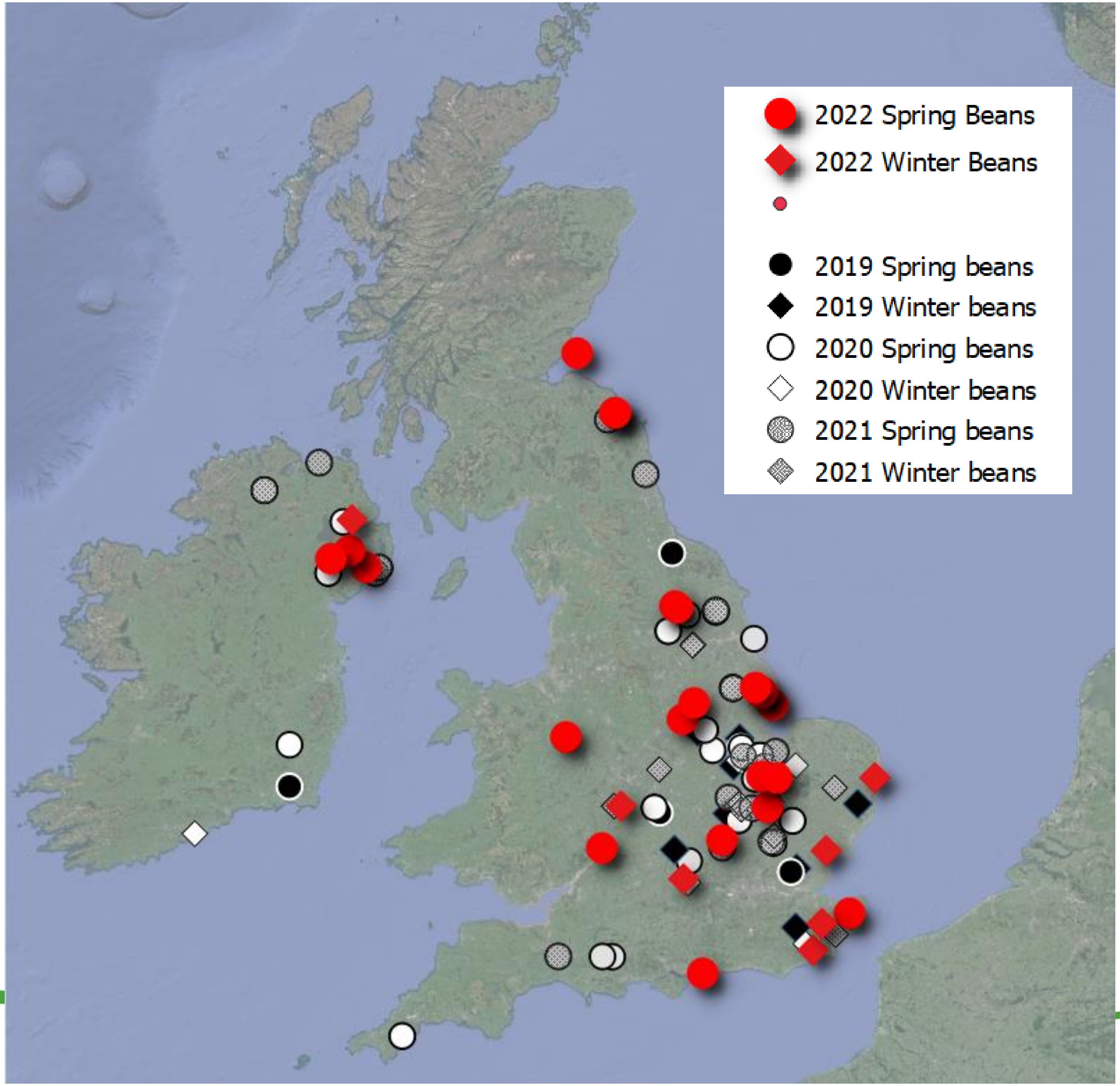
YEN

- 39 entries registered by close 2022.
- 32 returned yields
- Last analysis was 74 yields

- 106 yields from 2019-2022

- Wide spread of data

Year	Average yield
2019	5.5 t/ha
2020	4.2 t/ha
2021	5.1 t/ha
2022	4.8 t/ha



YEN

High level - preliminary analysis of Bean YEN 2019-22 data

- **Partition analysis** - partitioned the data set into the top and bottom 25 % of yields and tested whether crop characteristics differed between the high and low yielding groups
  - Note that this cannot disentangle cause and effect (cannot say what is *driving* yield) but combined with expert judgement we should be able to develop practical messages
  - Just because a factor is not highlighted in the analysis does not mean it is unimportant.
  - Most data is from 2019-2022

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- **REML**
  - more sophisticated analysis that allows ‘effect sizes’ to be applied, including on categorical data. This helps explain the average variation of an average yield, but it should be remembered that many factors will be influencing yield.
  - Note that this cannot disentangle cause and effect (cannot say what is *driving* yield) but combined with expert judgement we should be able to develop practical messages
  - A straight line is fit to give the REML effect size above the average, but in reality, effects will level off eventually
  - Just because a factor is not highlighted in the analysis does not mean it is unimportant.

Site and soil factors

	Bottom 25% yield entrants (3.1 t/ha)	Top 25% yield entrants (6.3 t/ha)	No data points	REML significance	REML effect
Yield potential (t/ha)	10.6	11.6	98	0.06	0.17 t/ha per YP t/ha
SOM % (LOI)	5.8	6.0	71	NS	
Clay content (%)	25.0	23.3	64	NS	
Silt content (%)	39.4	52.2	64	<0.001	+0.02 t/ha per silt %
pH	7.3	7.2	72	NS	
Mean Temp in Jun & Jul	16.6	15.8			

YEN

Categorical data

	No data points	REML significance	REML effect/notes
Variety type	106	NS	No significant difference between winter and spring crops
Previous crop	100	NS	Data set includes “unknowns”
Manure history	103	NS	
Cultivation strategy	106	NS	

Categorical data

	Spring			Winter			All		
	No data points	REML significance	REML effect	No data points	REML significance	REML effect/notes	No data points	REML significance	REML effect
Drill row width	64	NS		22	0.088	0.07 t/ha per cm above average	88	NS	
Seed rate (reported as kg/ha)	44	0.011	-0.008 t/ha per kg/ha seed above average	17	NS		63	0.006	-0.006 t/ha per kg/ha seed above average
Seed rate (reported as seeds/m^2)	46	NS		20	NS		66	NS	

Nutrition

*2021 data not included

	Index 2 mg/L	Bottom 25% yield entrants (3.1 t/ha)	Top 25% yield entrants (6.3 t/ha)	No data points	REML Significance	REML effect
Soil P (mg/l)	16-25	33	25	72	NS	trend for indices
Soil K (mg/l)*	121-180	272	198	55	NS	
Soil Mg (mg/l)*	51-100	179	145	55	NS	
Fert P_2O_5 applied		22	16	70	NS	
Fert K_2O applied		26	24	72	NS	
Fert SO_3 applied		4.7	9.0	69	NS	
Grain P %		0.48	0.47	96	NS	
Grain K%		1.15	1.19	96	P=0.034	+0.28 t/ha per 0.1%

Crop development – spring beans

Bean Type	Bottom 25% yield (3.1 t/ha)	Top 25% yield (6.2 t/ha)	No data points	REML significance	REML effect
Sow date	20/03	26/02	62	0.006	-0.03 t/ha per day after the YEN average
GS10 – emergence	20/04	01/04	38	NS	
GS34 – nodulation	21/05	06/05	37	NS	
GS60 – First flower	14/06	13/06	42	NS	
Senescence	14/08	26/08	39	0.033	+0.03 t/ha per day after the YEN average
Harvest	10/09	14/09	49	NS	
Sowing-GS34 (days)	57	71	-		
Season length (days)	173	205	49	0.01	+0.02 t/ha per day above YEN average

YEN

Crop management associations with yield

	Bottom 25% yield entrants (3.1 t/ha)	Top 25% yield entrants (6.3 t/ha)	No data points	REML sig	REML Effect
Num fungicide apps	1.1	1.2	74	0.089	+0.3 t/ha per app
Num herbicide apps	1.7	1.6	75	Ns	
Num insecticide apps	0.9	1.1	75	Ns	

Harvest losses

	Bottom 25% yield entrants (3.1 t/ha)	Top 25% yield entrants (6.3 t/ha)	No data points	REML sig	REML Effect
Average number of beans lost/m^2	41	35	45	NS	
Average estimate yield losses (t/ha)	0.26	0.27	45	NS	

Bruchid damage to seed

Bean Type	Spring Beans		Winter Beans		REML	
	Bottom 25% yield (3.1 t/ha)	Top 25% yield (6.2 t/ha)	Bottom 25% yield (3.6 t/ha)	Top 25% yield (6.5 t/ha)		
Bruchid beetle damage %	24.7	9.3	26.8	10.6	***	-0.03 t / %

Damage highly significantly associated with temperature in May

No association at all with insecticide applications

Yield components – spring sown

Bean Type	Bottom 25% yield (3.1 t/ha)	Top 25% yield (6.2 t/ha)	No data points	REML	REML effect size
Actual plant count	40	44	22	NS	
Shoots per plant	1.0	1.1	64	NS	
Pods / shoot	12.1	17.1	63	<0.001	0.13 t/ha per extra pod per shoot above average
Seeds /pod	2.4	2.8	64	0.004	0.91 t/ha per extra seed per pod above average
Seeds/m^2	589	1000	63	P<0.001	0.005 t/ha per seed m^{-2} above average
Seed weight mg	536	632	63	0.003	0.005 t/ha per mg per seed above average

Yield components spring sown cont.

Bean Type	Bottom 25% yield (3.1 t/ha)	Top 25% yield (6.2 t/ha)	No data points	REML	REML effect size
Plant height (cm)	97	115	63	<0.001	0.02 t/ha per cm
Total DM per plant (g)	24.9	41.8	64	P<0.001	0.05 t/ha per g
Total DM per shoot	23.8	37.7	64	P<0.001	0.06 t/ha per g
Bean DM per shoot	24.9	41.8	64	P<0.001	0.09 t/ha per g
Harvest Index	0.56	0.63	64	P=0.002	0.08 t/ha per %
Biomass	4.7	8.4	64	<0.001	0.7 t/ha per t/ha

Yield components - winter

Bean Type	Bottom 25% yield (3.1 t/ha)	Top 25% yield (6.2 t/ha)	No data points	REML	REML effect size
Actual plant count	-	-	-	-	
Shoots per plant	1.9	1.4	23	0.034	-1.04 t/ha associated with each extra shoot above the YEN average
Shoots/m^2 (yield derived)	31	33	23	NS	
Pods / shoot	8.9	10.9	23	NS	
Seeds /pod	2.6	3.2	23	0.05	1.2 t/ha per extra seed per pod above average
Seeds/m^2	523	897	23	P<0.001	0.007 t/ha per seed m^{-2} above average
Seed weight mg	660	730	23	0.016	0.007 t/ha per mg per seed above average

Yield components winter cont.

Bean Type	Bottom 25% yield (3.1 t/ha)	Top 25% yield (6.2 t/ha)	No data points	REML	REML effect size
Plant height (cm)	95	124	23	0.003	0.04 t/ha per cm
Total DM per plant (g)	55.0	53.0	23	NS	
Total DM per shoot	27.6	37.3	23	0.021	0.06 t/ha per g
Bean DM per shoot	14.1	20.4	23	0.017	0.1 t/ha per g
Harvest Index	0.49	0.55	23	0.023	0.12 t/ha per %
Biomass	6.0	10.2	23	<0.001	0.62 t/ha per t

Summary – Site, Soil and nutrition

- Association of measured yields with potential yield
- Hot summers generally poorer for yields
- Siltier soils tend to see higher yields - indicating that water retention is important
- Most growers within target range for soil pH and soil nutrient indices
- No association with fertiliser applications, although more S was applied to high yielding crops
  - … note only bagged fert applied within season analysed
- K in seed positively associated with yield

Summary – Crop development & Agronomy

- Spring beans: Higher yields associated with earlier sowing, later senescence and longer season
- Winter beans: low sample size
- No yield difference between winter and spring varieties
- High yields associated with lower seed rate and wider rows (winter beans)
- Trend for REML association with fungicide use (0.3 t/ha per application), but not with insecticide use
  - *remember to not assume cause and effect*
- Negative association between yield and Bruchid Beetle damage
  … but data shows not controlled by insecticide use
  … related to May temperatures
- Minimising harvest losses no longer significantly associated – were most crops prone to shedding this year (average 0.25 t/ha)?

Summary – Yield Components

- In spring beans higher yields positively associated with:
  - Pods/shoot, seeds/pod and seeds/m^2, but not plants per m^2 or shoots per plant
  - Bean seed size (TSW)
  - Plant height, individual plant and shoot biomass, crop biomass and Harvest Index

- Similar in winter beans
  - but negative association with shoots per plant and no effect of pods/shoot

- High yields coming from large well podded plants with several seeds per pod and low numbers of large stems per plant
  - Maximise light capture and avoid stress through flowering to increase sink size

- Seed filling important for seed size
  - Avoid stress during seed fill and maximise canopy duration

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RESEARCH ARTICLE

The Bean YEN: Understanding bean yield variation on UK farms

Charlotte White, Thomas Wilkinson, Daniel Kindred, Steve Belcher, Becky Howard, Roger Vickers, Roger Sylvester-Bradley

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