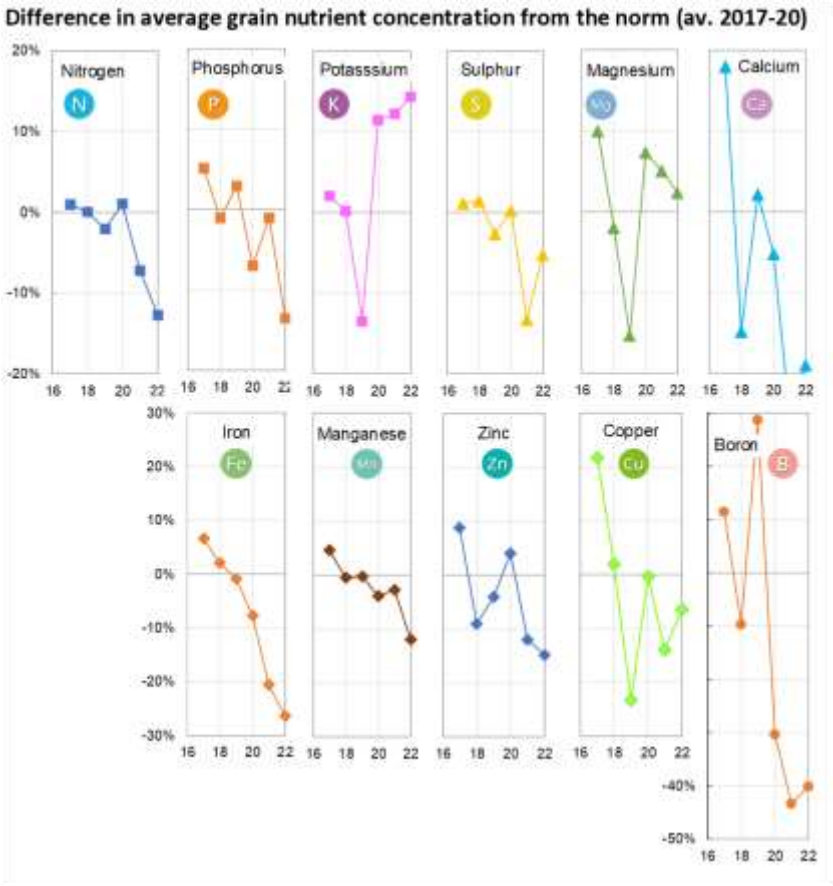
Crop Nutrition Season Review for 2022

By ADAS's Crop Physiology Team, April 2023

1.Nutrient Harvests shared across the UK

After harvest 2022, YEN Nutrition has reported on 745 crops from 115 farms: 531 of wheat, 127 of barley, 19 oats, 61 oilseed rape, 25 beans and a few others including, linseed, triticale, and rye. This is more than in 2021 and, with field data provided by entrants, is helping to improve our understanding of how soils, crops and management affect crop nutrient status year by year.

We have analysed these data along with data from crop YENs to build a picture of crop nutrient performance for the recent season.



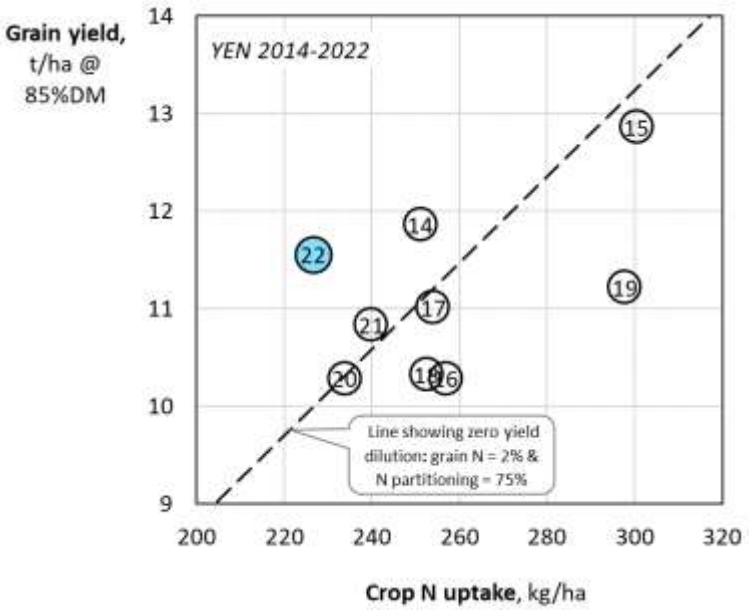
Low grain nutrients in 2022

After six years of analysing grain nutrients in Cereal YEN, we can see how levels have varied over seasons (the charts are for YEN wheat crops).

Of macro-nutrients, potassium (K) and calcium (Ca) have varied most strikingly. Nitrogen (N) and sulphur (S) have been low in the two recent seasons, whilst phosphorus (P) and most of the micro-nutrients show longer term decreases. K was high again in 2022, but average potash offtakes were varied (range 2.1 to 6.6 kg/t K_2O) and less on average (4.7 kg/t K_2O) than is assumed in RB209 (5.5 kg/t K_2O).

This review addresses the following nutritional issues using YEN datasets for 2022, and previous seasons.

2.'Nutrient drought' AND Yield Dilution



Likely explanations for low nutrient concentrations in 2022 are (i) so called 'nutrient drought' through spring and early summer, when prolonged topsoil dryness inhibited nutrient capture and/or (ii) the relatively high yields, enabled by good capture of subsoil water, diluted the nutrients captured by the crop, after they were redistributed to the grain.

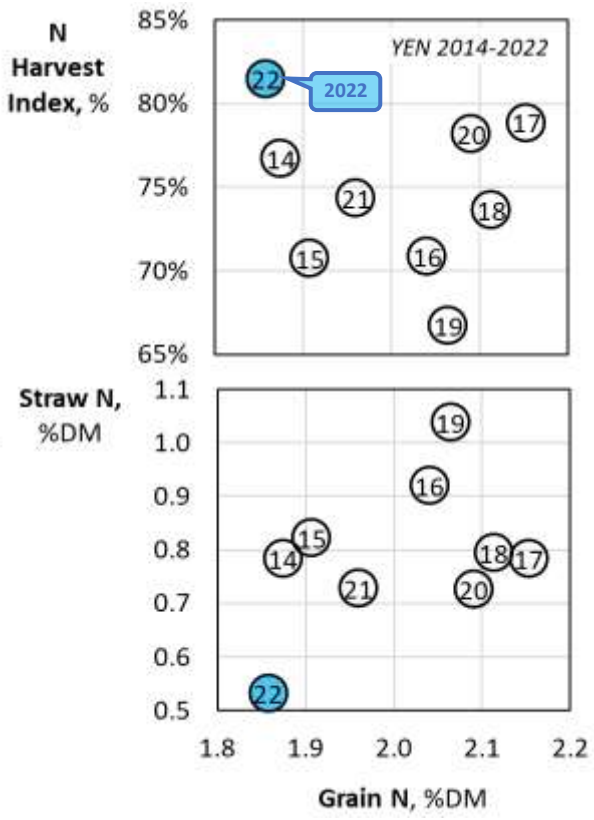
We have only recently analysed straw for all nutrients, but we started straw analysis for N in 2014 so know full N capture by YEN wheat crops since then. Average N capture in 2022 was less than in any previous year of YEN, yet yields were third highest (after 2014 & 2015). We therefore conclude that grain N (& protein) levels were low for both reasons (i) & (ii); other nutrients were probably affected similarly.

3.2022: Signs of Lost Yield

Nutrients are used first by green canopies for photosynthesis; then nutrients needed for seedling establishment (for which all seeds have evolved) are redistributed to the grain. (Post-anthesis nutrient capture is not well-researched but when measured, appears to be small). Hence premature nutrient redistribution can cause premature canopy death and reduced yield.

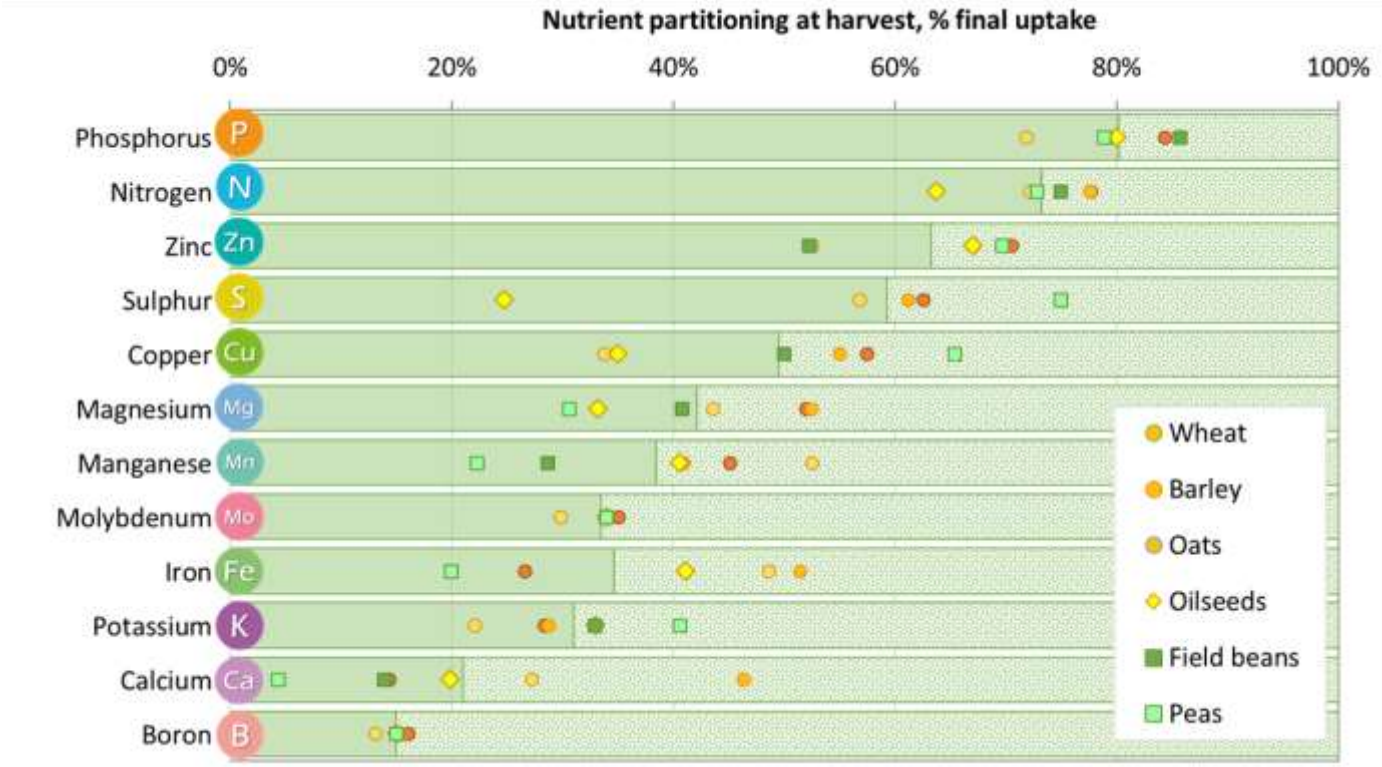
Average redistribution of N to grain at harvest was greater in 2022 (81%) than any previous year (average 75%) and straw N was much less (0.53%) than in any previous year (average 0.8%). Partitioning of other nutrients was also high in 2022 e.g. 92% for P (see below). So it seems likely that canopy size and persistence in 2022 were both reduced due to small uptake of nutrients.

So, even though grain yields in 2022 were good, they were probably less than if normal nutrient capture had been achieved.



4.In the end, grains hold most of most nutrients

Global evidence for the exact final partitioning of nutrients between photosynthetic crop canopies and their developing seeds is incomplete and uncertain for the grain crops grown most in the UK. So up until now, YEN Nutrition has relied on evidence from the global feed industry which, to inform feed formulation, publishes nutrient levels that are normally found in grains and crop residues used in feeds. This global feed data underlies the partitioning diagram used in YEN Nutrition reports (below).

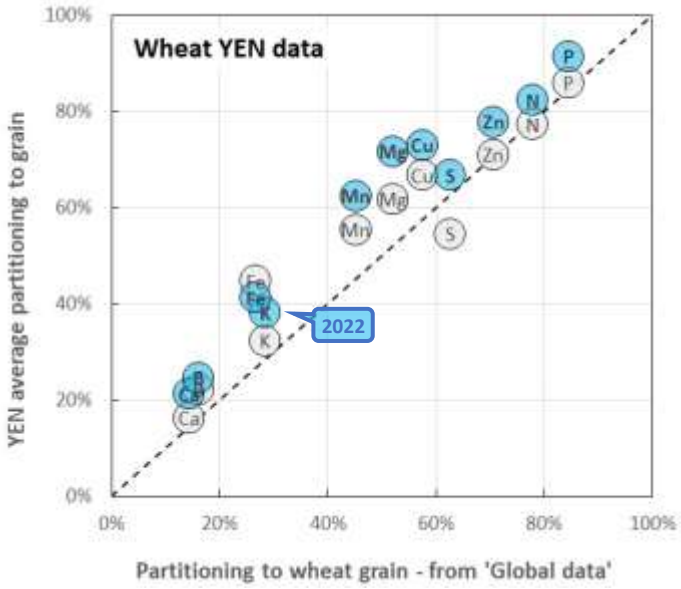


These are the partitioning values we use in YEN reports to estimate total capture of each nutrient by each crop for which samples are analysed.

To check these values, in 2020 we analysed ~30 samples of wheat straw from YEN for all nutrients, and in 2022 we analysed samples of wheat, barley & oat straw.

Overall the proportions of nutrients held in grain were larger in YEN than the global data suggest, especially Mg, Fe, Mn and Cu. Partitioning in the nutrient-droughted season of 2022 was 10% greater than in 2020. However, total uptake of N (and maybe all nutrients) was also low in 2020 compared to the norm (see previous page).

Ca, B, K and Fe (and probably Mo) were the nutrients of which most remains in the straw. YEN data show the other seven nutrients to be mostly partitioned to the grain by harvest.



Based on these data, and further straw analyses that we are able to make in future seasons, we will improve our estimates of nutrient partitioning, hence total nutrient capture reported to YEN entrants.

5.Nutrient 'norms' by crop type in 2022

We are learning ever more about normal nutrient levels in all crops. Averages for the major UK grain crops are in the next table from 2022. Grain P in wheat was less than in other cereals this year. Sulphur levels were quite satisfactory for most crops, especially oilseed rape. Once again manganese levels were much greater in wheat than barley, but the reverse was true for iron and molybdenum. Over 90% of barley Mn levels were less than the critical value of 20 mg/kg so we need to test whether barley is generally deficient in Mn, or whether the

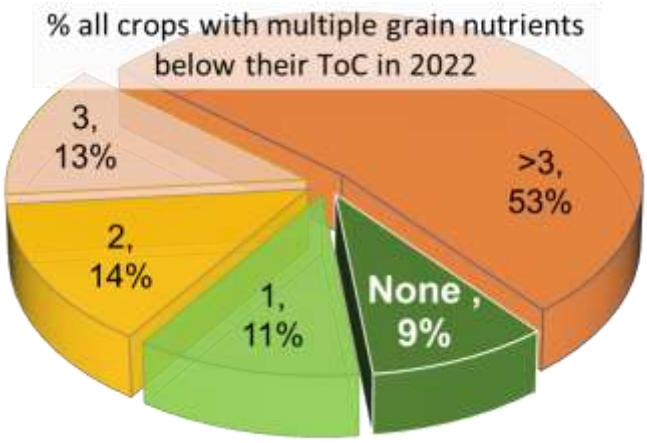
critical value differs from other cereals. Beans have a much greater N:S ratio than other crops, begging the question of whether beans would generally have benefited from increased sulphur supplies. Note that grain K differs between wheat and barley; this needs to be taken into account when applying potash to crops. Especially since RB209 recommends that both should be treated the same. We are discussing with AHDB whether RB209 values can be updated.

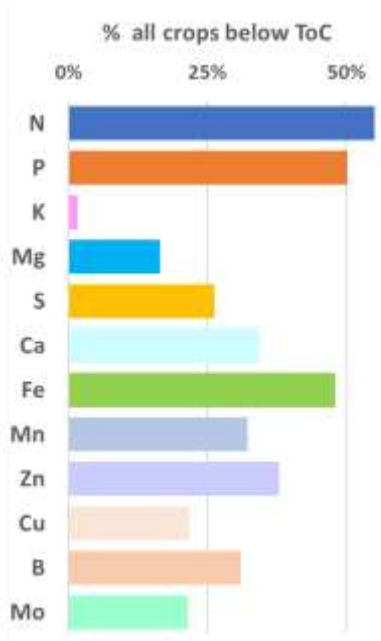
Table showing average grain nutrient levels by crop type of samples analysed in YEN Nutrition 2022. Differences need to be about twice the SED to be considered 95% certain.

	No.	N	P	K	S	Mg	Ca	Fe	Mn	Zn	Cu	B	Mo
	data	% DM						mg/kg DM					
Wheat	513	1.87	0.27	0.46	0.13	0.091	0.042	34	26	22	3.8	0.90	0.47
Bread	170	1.98	0.27	0.45	0.13	0.098	0.043	37	27	22	3.9	0.92	0.50
Feed	337	1.81	0.26	0.47	0.12	0.087	0.041	33	26	21	3.8	0.88	0.44
Barley	127	1.78	0.30	0.58	0.13	0.109	0.055	55	14	27	4.9	0.97	0.83
Feed	77	1.82	0.31	0.58	0.13	0.055	0.110	57	15	26	4.9	0.97	0.81
Malting	50	1.73	0.29	0.59	0.13	0.056	0.107	53	13	28	5.0	0.97	0.85
Oats	19	1.87	0.32	0.50	0.16	0.109	0.093	81	45	26	5.5	1.39	4.99
OSR	61	2.95	0.62	0.75	0.41	0.267	0.476	72	38	37	3.6	11.08	0.47
Beans	25	4.68	0.43	1.28	0.18	0.118	0.115	63	14	44	14.7	10.26	2.57
SED		0.059	0.011	0.014	0.006	0.004	0.004	2.7	1.9	1.4	0.28	0.134	0.182

6.Multiple low levels again

Because critical values are not known for all nutrients or in all crops, we currently use 'ToCs' ('thresholds of concern' which are the low quartiles[1] from entries of this crop type in all YENs over five years from 2016 to 2020). ToCs and known critical values agree well (for the 8 values known for cereals). P shows the biggest difference; its ToC is 0.27%, whilst 0.32% is thought critical, so most crops appear P deficient (see below).





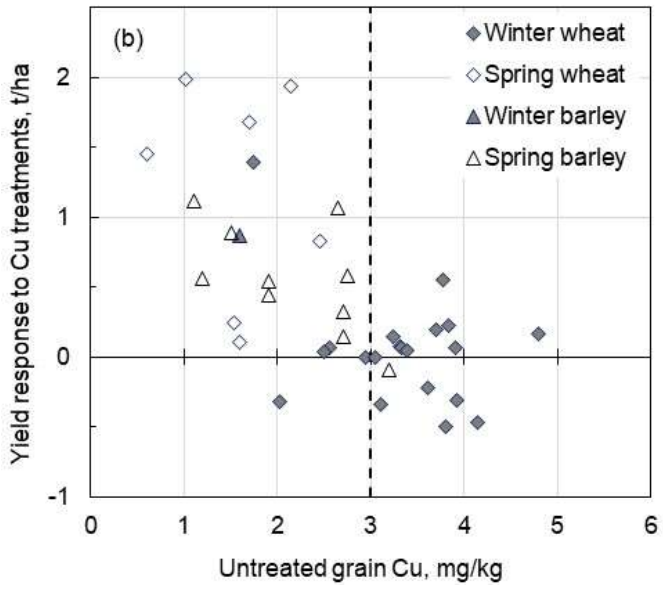
Using ToCs gives a comprehensive picture of likely deficiencies across all nutrients and all crops. This year only 9% of crops had no nutrients below their ToC, and 66% of crops had more than two nutrients below their ToC.

Nitrogen and phosphorus were the major nutrients most commonly showing low values. Potassium was rarely below its ToC. Iron was the micro nutrient most commonly below its ToC. Interestingly although iron deficiencies in plants are visually quite distinctive (as white interveinal chlorosis) this deficiency is rarely observed in field crops.

So overall, it appears that crop yields in 2022 were most commonly limited by shortages of N & P.

[1] The low quartile is the value that divides the top three quarters of values from the bottom quarter of values.

7.Critical copper in grain



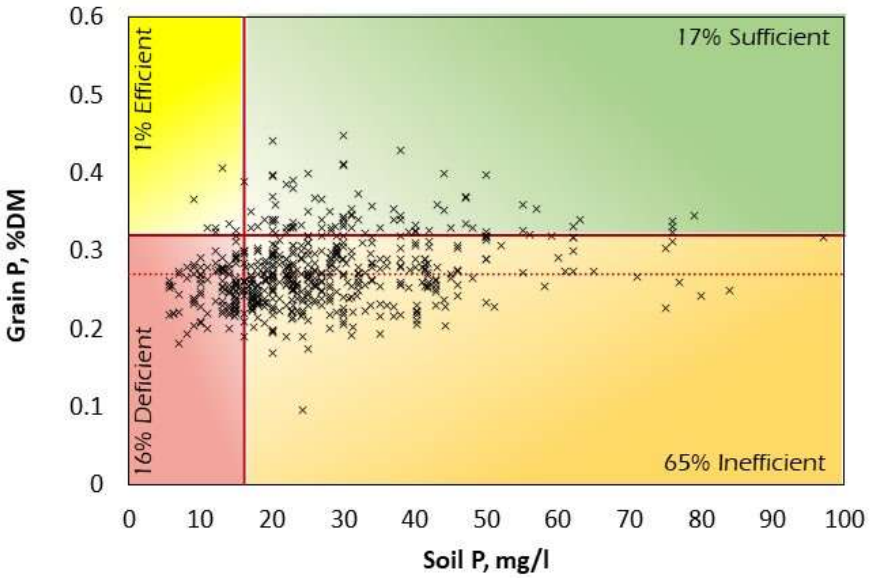
We are trying to collate evidence for critical values of all nutrients in all grains. In 2022 we updated evidence for copper in wheat and barley. Until now, we have assumed that 2.5 mg/kg was the best value to regard as critical, but further evidence now indicates that 3 mg/kg Cu should be regarded as critical for both these cereal species.

Further details are given in our 40 page paper prepared for the International Fertiliser Society; see below.

8.Big Phosphorus capture challenge

Cereal grain P levels in 2022 varied from 0.16% to 0.46%, i.e., from 3.4 to 9.7 kg/t P_2O_5. Standard assumptions in RB209 are usually too high, at 6.5 kg/t for wheat and 8 kg/t for other cereals.

Only ~18% of fields had grain P at or exceeding the critical value of 0.32%, indicating that ~80% of crops captured too little P. We have seen consistently inadequate P capture since 2017 but 80% of crops being affected is worse than ever; it was ~55% last year.



Soil P levels of Index 2 or more (>16 mg/l) slightly increased the chances of grain P being adequate but the relationship between grain P and soil P was weak. The prevalence of inefficient P capture by crops this year clearly emphasises the importance of improving P capture, rather than improving P supply. Only 30% of crops received P_2O_5 applications (mainly, but not exclusively, those at P Index 1 or 2); these crops did not have significantly greater grain P. We are keen to work with anyone interested in testing means of increasing P capture, whether by focussing on topsoil root densities, mycorrhizal associations, foliar P or whatever.

9.Nutrient Harvests: essential yardstick to transform nutrition

Only in recent years have we realised the importance of measuring the nutrients that are harvested field-by-field. A paper spelling out the case for this approach is now published by the International Fertiliser Society, available (with free abstract) here. This paper shows how grain analysis and benchmarking pays for itself just

by enabling P & K to be applied accurately, instead of using standard assumptions. Additionally, harvest analyses can detect the nutrient deficiencies that are most common on each farm. Average benefits of £3,500 per field were estimated if inaccuracies in N & P nutrition could be corrected.

10. Announcing: NUTRI-CHECK NET

Funded under Horizon Europe, ADAS has formed a consortium with nine other organisations across nine European countries to launch a new project called NUTRI-CHECK NET. Over the next three years this project aims to "maximise site-specific precision in managing the nutrition of European arable crops". It will do this by forming three Crop Nutrition Clubs in the UK and 26 such Clubs across Europe. The network will collate the ways that farmers across Europe find it easiest, and most telling, to monitor and manage the nutrition of arable crops, and will disseminate these through to December 2025. Further project details can be found via FarmPEP here.

11. Acknowledgements and Contact:

As ever, we must highlight that YENs and their findings would not exist without their sponsors. Whilst YEN Nutrition is mainly supported by entrants' fees, logos of sponsors who have been particularly concerned with supporting the findings in this report are shown below.

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