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Investigation into the specific weight differences between wheat varieties tested in the HGCA Recommended List and commercially-grown crops from 2007–2012

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1. Abstract

Wheat quality suffered greatly during the 2011/2012 season and many growers failed to achieve the required specifications for their end-user requirements. This resulted in growers becoming financially penalised and the UK export market struggling to compete globally. This study compared quality information from HGCA Recommended List trials and from commercial grain samples taken between 2007 and 2012. The aims were to integrate variety quality data collected from these two sources in order to investigate quality differences between varieties tested in the RL and those crops grown commercially and to identify factors which may account for variable specific weight measurements between seasons. Specific objectives included:

1. To examine Recommended List (RL) and Cereal Quality Survey specific weight quality data within region and year to assess the quality potential that can be achieved.
2. To identify factors which may have influenced the fluctuation in specific weight quality in each region and year.

Analysis of both the commercial crop and those grown in an RL trial situation indicates that specific weight is variable between seasons and 2012 was an incredibly poor season in both the RL and the commercial crops, only achieving 71.9kg/hl and 69.6kg/hl respectively. Regional and seasonal differences were mirrored in the two sets of information and 2011 achieved the highest specific weights and 2012 the lowest in both sets of data. This suggests the RL data can be used to help the industry understand fluctuations in quality. The RL data does use higher inputs to manage disease and the drop in quality in 2012 was lower than that observed in commercial data, suggesting high fungicide inputs may have mitigated the loss in quality to a certain degree, but the major factor was the weather. Close investigation of the varieties shows later-maturing varieties tend to have higher yields but lower specific weights than early-maturing varieties. This pattern is seen over the last five years and not just in the poor quality year of 2012. Although yield is an important driver in the selection of new varieties, choosing early-maturing varieties to grow alongside later but potentially higher yielding varieties for a specific end use may mitigate losses in quality from specific weight which may be associated with high rainfall and low sunshine in the grain filling periods in June and July.

2. Introduction

Flour is the largest single market for quality wheat in the UK, with around 6 million tonnes of wheat used for this product each year, and the quality of acceptable wheat for specific end-uses is tightly controlled. Each batch of wheat grain is analysed for the quality specifications required by the millers' customers for each grist or blend, and this is dependent on qualities including moisture content, protein content, Hagberg Falling Number and specific weight. Lower premiums or rejections will occur if the grains do not meet the correct specifications. The quality characteristic of specific weight, defined as the weight of grain which can be packed into a fixed volume, and measured in kilograms per hectolitre (kg/hl) is relevant to all users, as it has a direct impact on the economics of grain transport and this characteristic will be focussed on in this study.

Wheat varieties on the HGCA Recommended List are currently classed for suitable end uses using four categories as defined by the National Association of British and Irish Millers (nabim). Group 1 and 2 varieties are primarily used for bread making, and command high qualities in order to be accepted and currently they must achieve a specific weight of 76 kg/hl to be accepted for these premium flours. Group 3 contains softer varieties for biscuit and cake flours, requiring slightly lower quality specifications of 74 kg/hl. The group 4 varieties are grown mainly as feed wheats, and specific weight requirements are even lower at 72 kg/hl (Table 1). Additionally, the UK will usually export approximately 2.5 million tonnes of wheat per year, accounting for 17% of the UK wheat crop. Varieties suitable for the overseas market are classified as ukp and uks, and are also expected to achieve certain quality specifications (Table 1).

Table 1. Minimum standards of specific weight required for end use categories

	nabim Group 1	**nabim Group 2**	**nabim Group 3**	**Group 4**	**uks**	**ukp**
End use	Bread	Bread	Biscuit/cake	Feed	Export – biscuit/cake	Export – bread
Specific weight threshold	76 kg/hl	76 kg/hl	74 kg/hl	72 kg/hl	75 kg/hl	76 kg/hl

Wheat grain quality was poor in 2012, with many growers failing to achieve their agreed contractual quality requirements – in some cases buyers of full specification milling wheat were accepting grain of 70kg/hl. In these instances, charges for failing to meet the required standards ranged from £1–£2/kg/hl. Feed wheat buyers with a contractual specification of 72kg/hl were charging penalties in a similar range, up to 68kg/hl. Below this level, charges increased to £2.50/kg/hl (Farmers Weekly Online).

An understanding of factors which may influence specific weight will be valuable to the industry, to not only prevent growers becoming financially penalised for failing to achieve the correct quality specifications, but to also drive export of UK wheat in order to prevent over supply of the domestic market and prevent depression of UK prices relative to world prices. Due to the poor quality of 2012, the UK became a net importer of wheat.

HGCA collects two major sources of annual quality data, the HGCA Recommended List (RL) and the Cereal Quality Survey. The HGCA Recommended List evaluates varieties under optimal conditions throughout the UK, assessing the potential traits which can be achieved. Grain quality is tested and scores for protein content, Hagberg Falling Number, specific weight, 1,000 grain weight and Chopin alveograph readings are presented within the RL tables for growers to make variety selections based in this information. The Cereal Quality Survey (CQS) is conducted annually as an authoritative assessment of wheat and barley quality in Great Britain. Quality data (moisture content, protein content, Hagberg Falling Number and specific weight) is collected from cereal laboratories across Great Britain, and the results are disseminated to the industry.

2.1. Aims

This study aims to integrate variety quality data collected from these two sources in order to investigate quality differences between varieties tested in the RL and those crops grown commercially and to identify factors which may account for variable specific weight measurements between seasons.

Specific objectives include:

1. To examine of Recommended List and Cereal Quality Survey specific weight quality data within region and year to assess the quality potential which can be achieved.
2. To identify factors which may have influenced the fluctuation in specific weight quality in each region and year.

The key deliverable will be to identify recommendations for short-term improvements to crop management practice that could enable growers to achieve more consistent quality in their crops.

3. Materials and methods

3.1. Datasets

Comprehensive data relating to national and regional quality trends for specific weight in wheat were defined using data from the HGCA Recommended List and Cereal Quality Survey. Quality data collected in each of these surveys include specific weight, Hagberg Falling Number and protein content. Full protocols and methodologies are available at http://www.hgca.com/content.output/1245/1245/Markets/Survey%20Results/Cereal%20Quality%20Survey%20Methodology.mspx and http://www.hgca.com/content.output/6568/6568/Varieties/Varieties/Recommended%20Lists%20protocols.mspx. These data were used to calculate specific weight averages.

Climatic data and UK regions were collected from the UK met office, and can be obtained at http://www.metoffice.gov.uk/climate/uk/datasets/#. These data were used to describe the climatic range across years.

Ripening, yield and variety data was obtained from the HGCA 2013/14 Recommended List, and can be obtained at http://www.hgca.com/cms_publications.output/2/2/Publications/On-farm%20information/HGCA%20Recommended%20Lists%202013-14%20for%20cereals%20and%20oilseeds.mspx?fn=show&pubcon=9230. These data were used to calculate average yield and specific weight of varieties over a six year period.

4. Results

4.1. Objective 1: The examination of Recommended List and Cereal Quality Survey specific weight quality data within region and year to assess the potential which can be achieved

The overall trend of specific weight from 1994 to 2012 is shown in Figure 1. Specific weight quality data recorded in the RL trials has revealed a high degree of variation year-on-year, ranging from 79.6 kg/hl in 1995 to 71.9 kg/hl in 2012. During 1994 to 2011, the average specific weight reached the nabim Group 3 specification threshold consistently, and the 76kg/hl Group 1&2 threshold was reached in 12 of the 19 years. 2012 is a clear anomaly, with average specific weights failing to even reach the 72kg/hl specification required for feed wheat. Interestingly, 2011 was a high year for this quality characteristic, with the average reaching 78.4 kg/hl and the following year recording the lowest specific weight averages within the 19 years. These data suggest the season effects can compromise the quality of the grain, since there would not have been a major change in variety choice within two years.

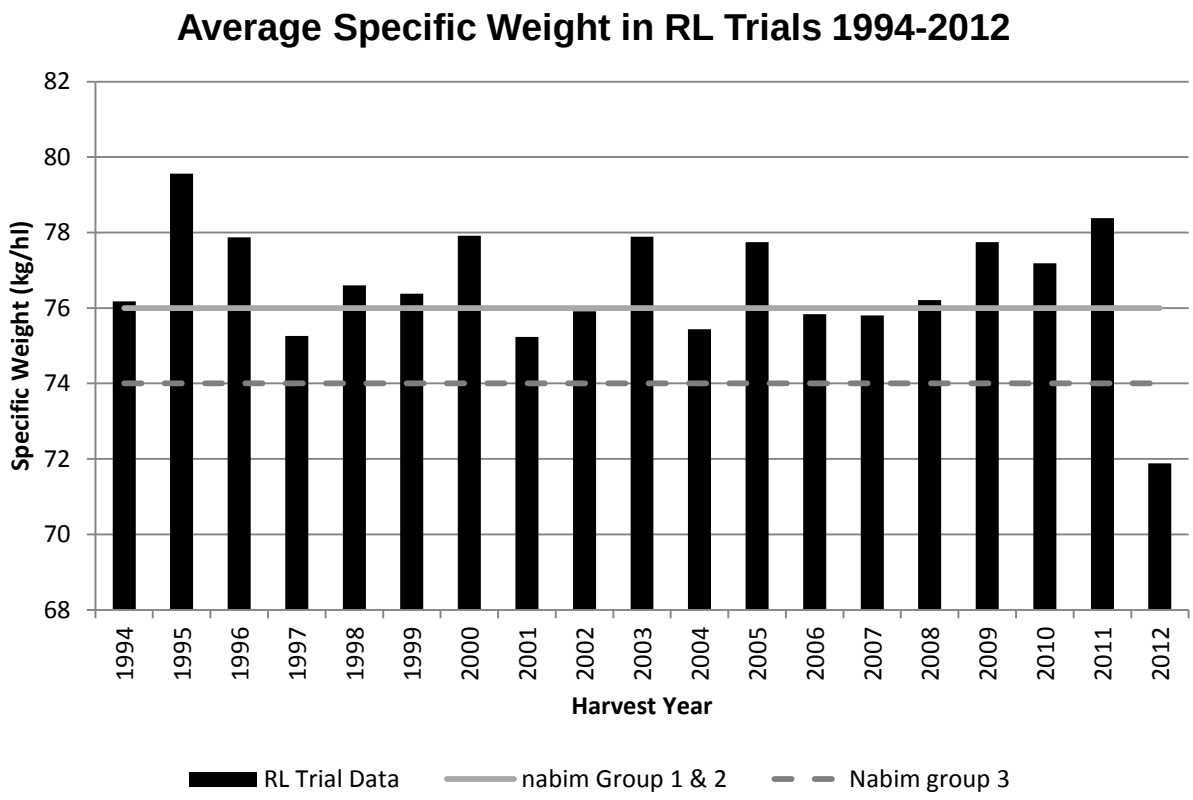

Figure 1. Average specific weight recorded in RL trials from 1994–2012

The CQS data represents crops grown in a commercial situation, and interestingly a similar trend in specific weight quality to those crops grown in an RL trial situation is observed. The overall specific weight trend from 2007 to 2011 increased year-on-year, in both commercial and RL crops (Figure 2). The quality peaked during 2011 in both datasets, reaching 78.8 kg/hl in commercial crops, and 78.4 kg/hl in RL trial samples. In the majority of cases, RL trials performed better than the commercial crops, although both followed closely within 1% from the years 2007 to 2011.

In 2012, the wheat specific weight dropped significantly in both RL and commercial crops, reaching 71.9 kg/hl in RL samples, and only 69.6 kg/hl in the commercial samples. This 3% difference is three times larger than the average between the previous five years. These data show specific weight is highly unstable across seasons and fluctuates in both commercial and RL situations.

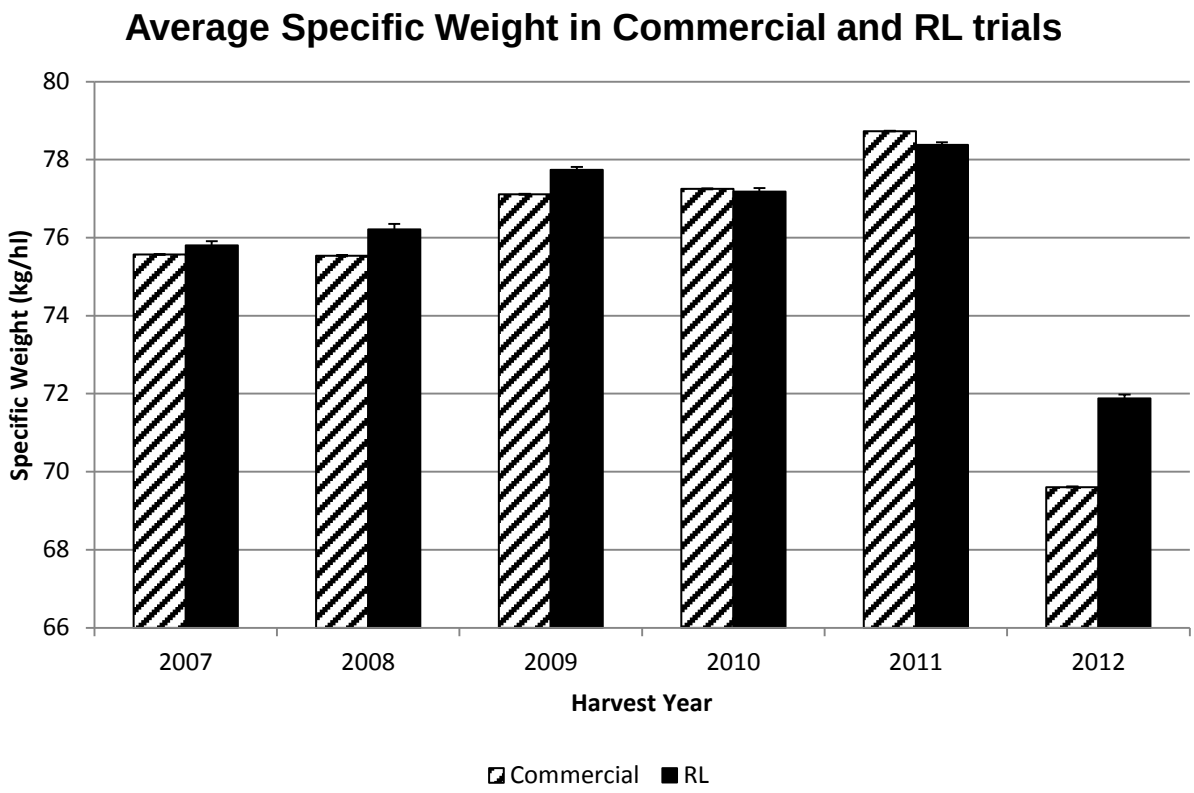

Figure 2. Average specific weight recorded in RL trials and the CQS commercial crops from 2007–2012.

Regional comparisons of quality differences were explored between the commercial and RL trials and it was observed that specific weight in both the commercial and trial situations varies over region. In the commercial crops, the lowest specific weights were recorded in the south west UK (SW) and Scotland (Scot) (73.7 kg/hl and 74.0 kg/hl, respectively), with the greatest specific weight recorded in the south east UK (SE) and midlands (M) (Figure 3). The RL data follows the same pattern, with lower specific weights recorded in the south west and Scotland, whereas higher specific weights are recorded in the midlands. The mirroring of the data from the commercial and RL crops across the regions suggests regional influences in grain quality. Again, overall, the RL samples achieved higher grain quality than those crops grown in commercial trials, achieving a 2% benefit on average.

Regional specific weight also displays a high variation each year, compounding the suggestion that there is a large year effect on quality. In each region, the highest specific weight over the six-year period was recorded in 2011, and the lowest quality in the following year, 2012 (Figure 4). The midlands achieved the highest specific weight in 2011, of 79.6 kg/hl, yet fell to one of the lowest specific weights in 2012, only reaching 68.1 kg/hl. Regions which achieve a consistantly low specific weight, such as Scotland, did not experience such a dramatic reduction in quality, with the difference in specific weight from 2011 to 2012 only being 8%, compared with the 17% drop in the midlands.

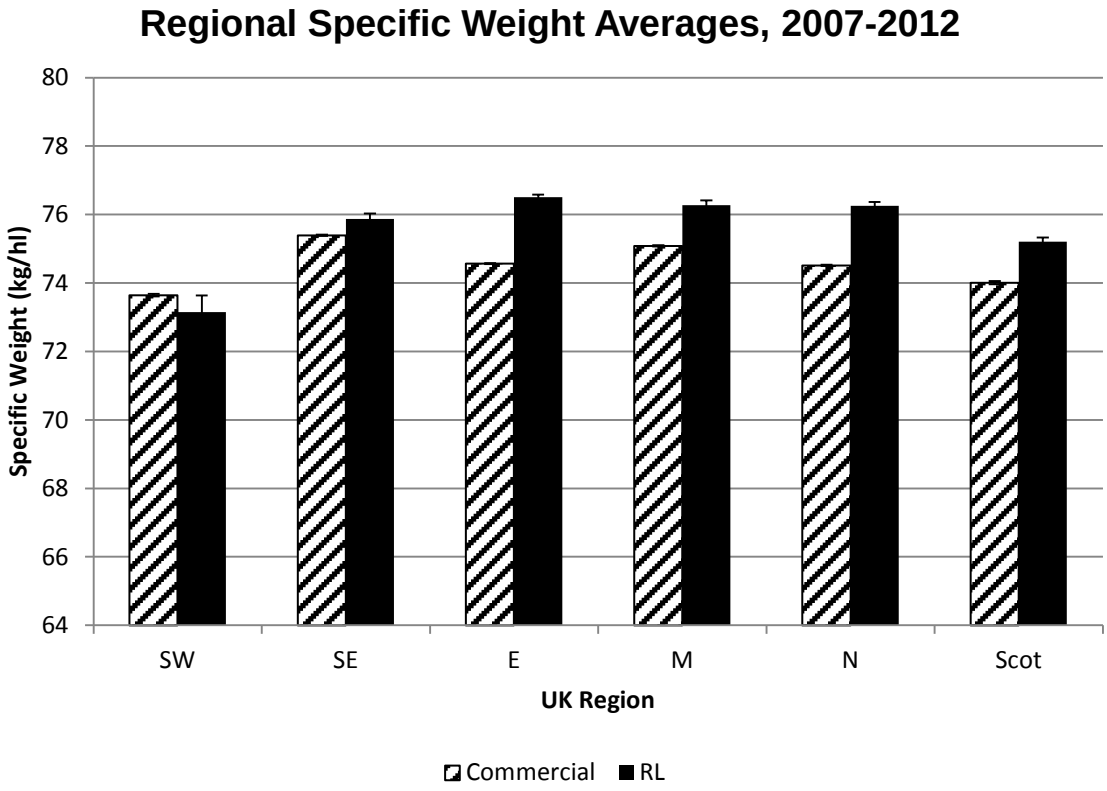

Figure 3. Regional specific weight averages in both RL and CQS commercial crops from 2007–2012

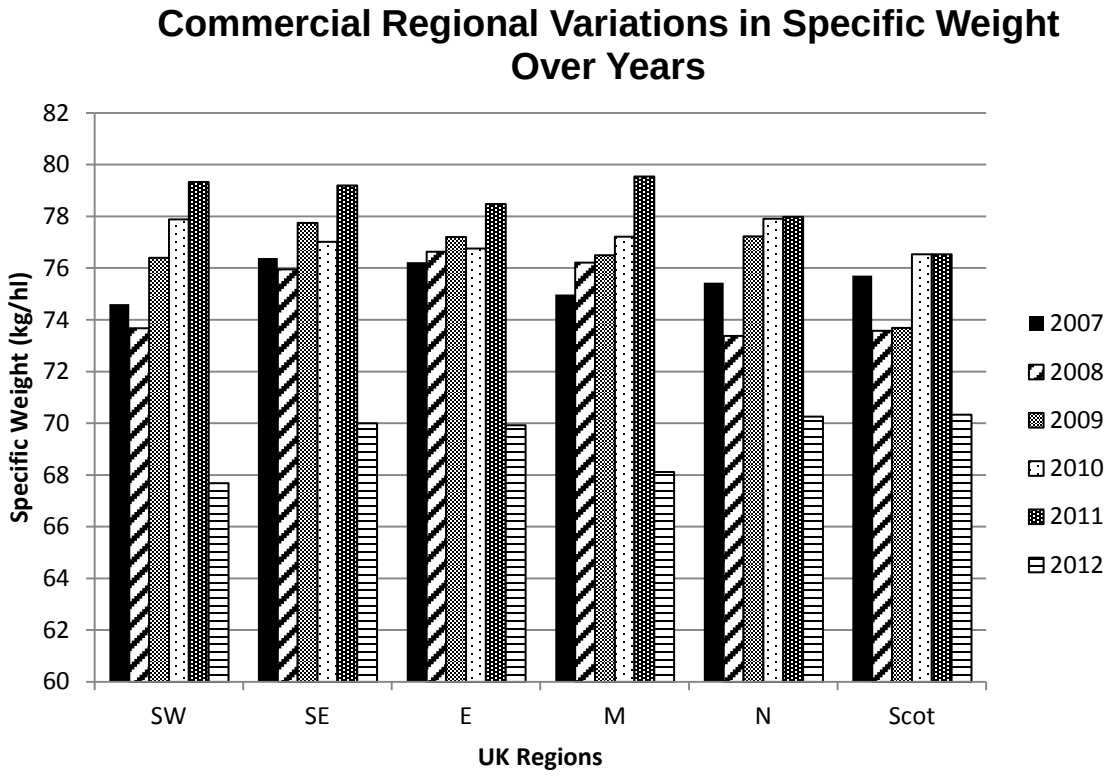

Figure 4. CQS commercial regional specific weight averages between 2007 and 2012

Integration of the RL and commercial data has identified an intriguing mirroring of both datasets. This is shown in both the over years and over region analysis (Figures 2 and 3). The over years analysis, showing just an average 1% difference in specific weight during the years 2007-2011, suggests consistency between commercial and RL datasets within each year. This consistency is also observed between commercial and RL crops grown within the same region (Figure 4). In the majority of instances, the crops grown to RL protocol achieve higher specific weight than those crops grown on commercial farms. The RL protocol treats crops with a robust fungicide application – much higher than those in a commercial situation – reducing the disease pressure, and so any differences which may be observed between the two datasets may be due to higher disease pressure in the commercial crops.

In 2012, quality in both the commercial and RL crops dropped dramatically, 12% in commercial and 8% in RL crops (Figure 3). The season was likely to have a contributory effect on this, with an enhanced disease pressure due to a wet season. Since the dramatic drop was observed in the RL crops too, it is unlikely that disease can contribute solely to the reduction of quality seen in 2012, as the RL crops eliminate disease pressure. Indeed an increased disease pressure may account for the increased difference between the RL and commercial crops during this season, but it will not account for the large difference observed between 2011 and 2012.

4.2. Objective 2: Identify factors which may have influenced the fluctuation in specific weight quality in each region and year

The large variations of specific weight quality between years suggest a climate effect which could be attributed to the different seasons. The climates of 2008 and 2012 were studied in depth, due to the different specific weights and annual yields.

2008 achieved the highest yields in the six year period which was studied, whereas 2012 achieved the lowest, at a difference of 3.2 t/ha. However, the difference in specific weights did not correlate with that of the yields – although the highest yields were achieved in 2008, the highest specific weight was not; 2011 achieved the highest specific weight, 78.8 kg/hl in commercial crops, yet yields were lower averaging 9.9 t/ha (Figure 5). These differences recorded in each year have been attributed to climatic differences in these seasons, however, the met office data shows a similar total UK rainfall during these years, 1,127 mm in 2008, and 1,230 mm in 2012 (Figure 6). However, the monthly recordings during these years differ significantly (Figure 7).

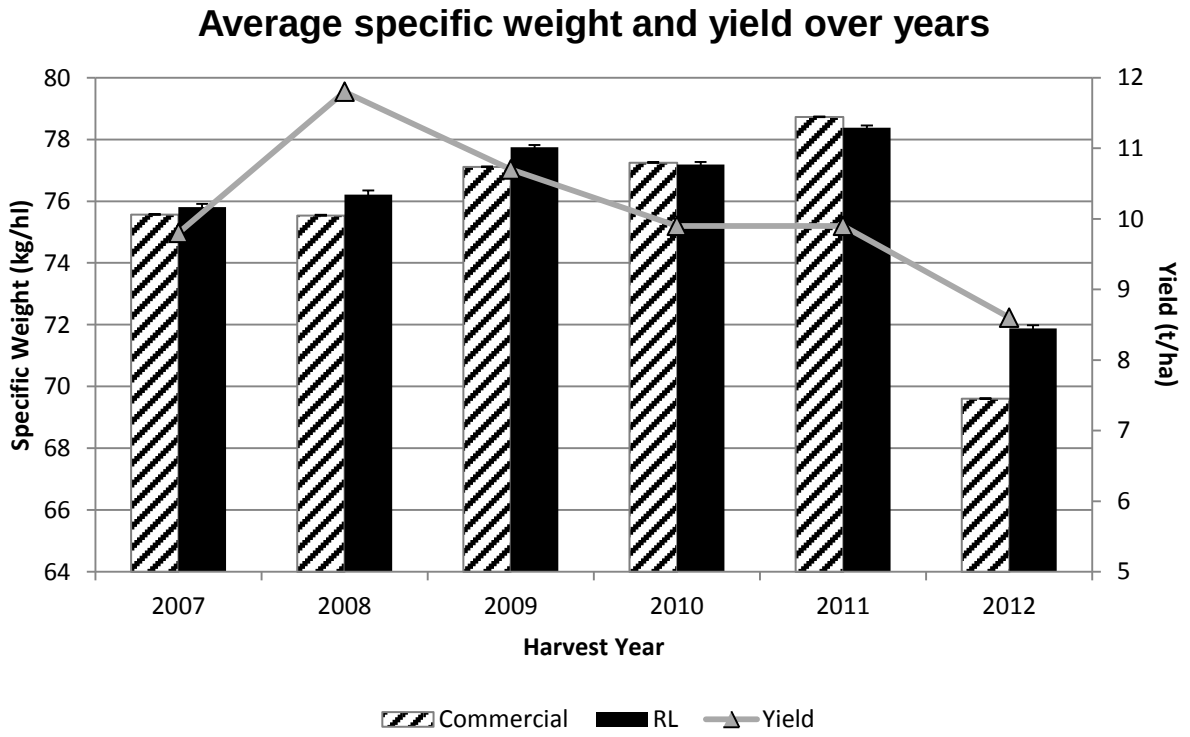

Figure 5. Average specific weight in RL and CQS commercial crops and corresponding average yields from 2007–2012

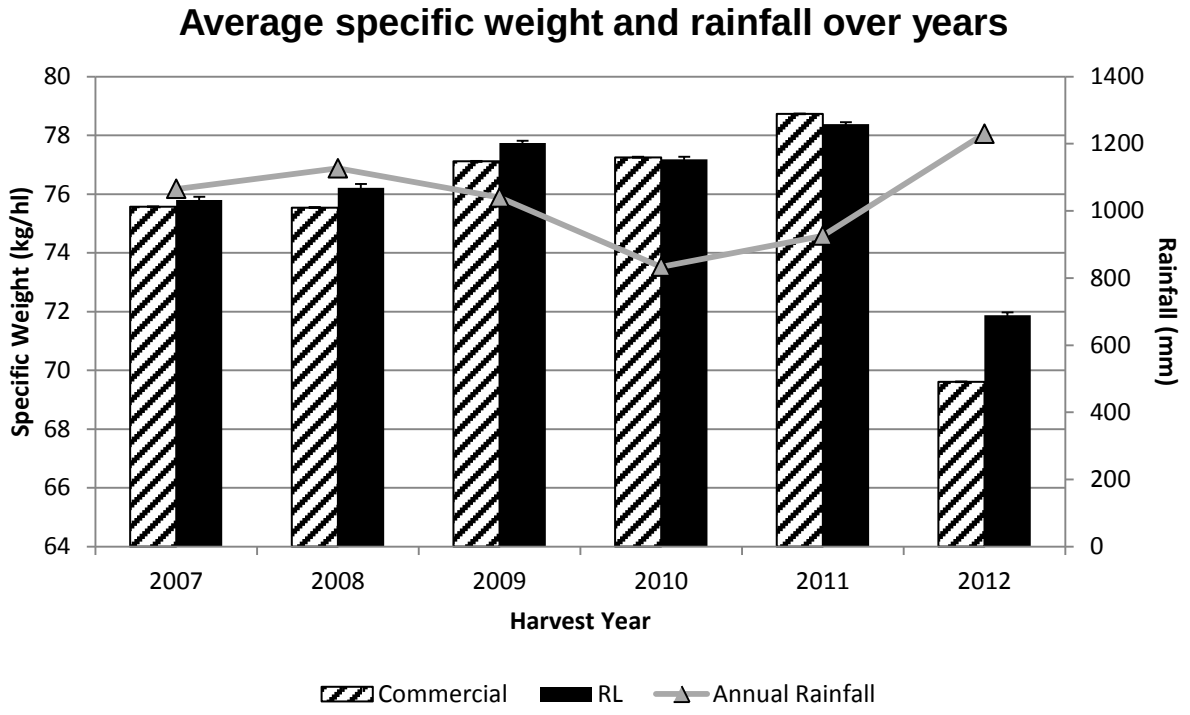

Figure 6. Average specific weight in RL and CQS commercial crops and corresponding UK total rainfall from 2007–2012

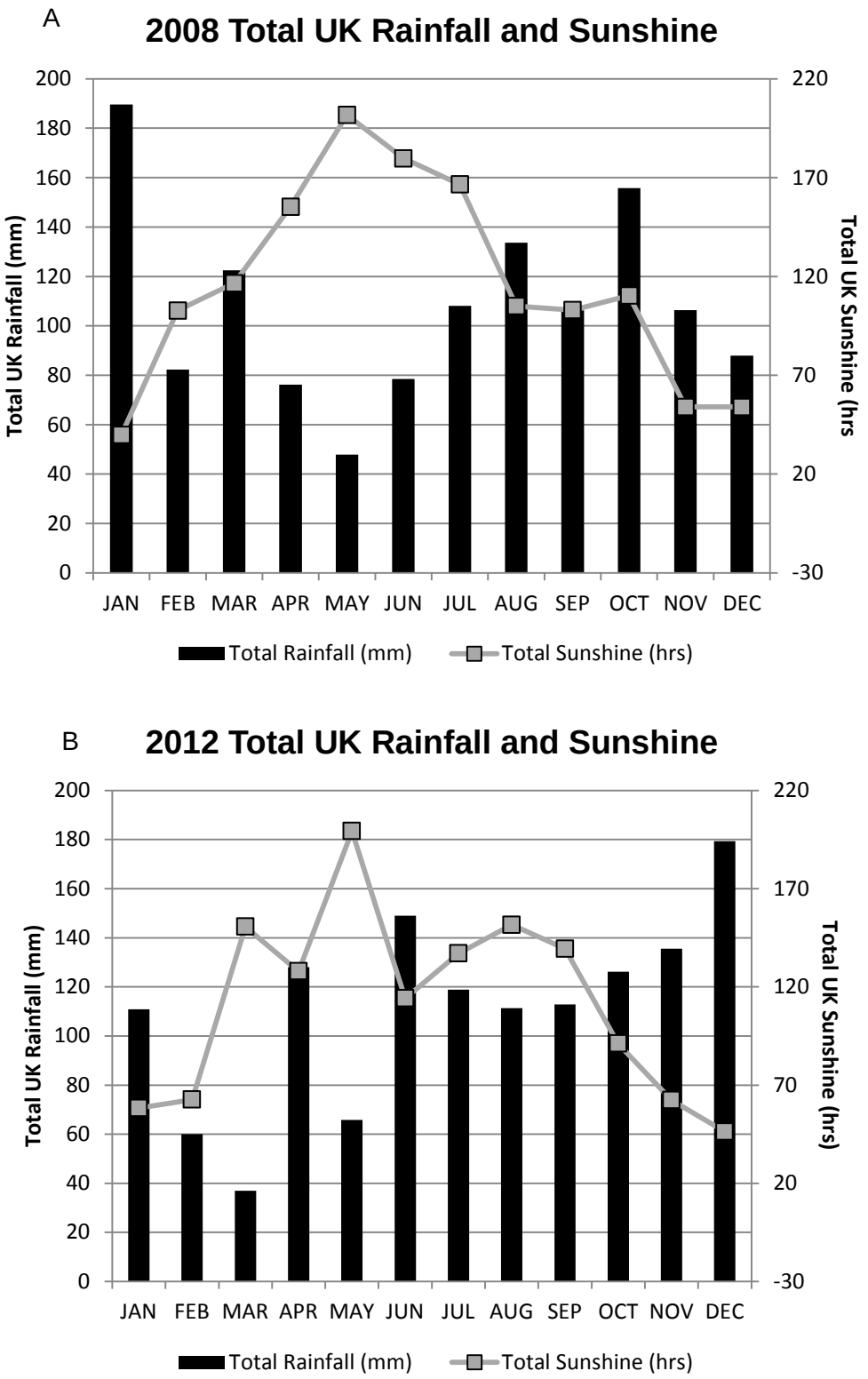

Figure 7. (A) 2008 UK monthly total rainfall and total sunshine hours. (B) 2012 UK monthly total rainfall and total sunshine hours.

In 2008, the majority of the rainfall occurred during January and the late summer and autumn – 53% of rainfall fell during these periods. High sunshine hours were observed during the spring and early summer months of April–July (Figure 7A).

In 2012, the majority of the rainfall occurred in the latter 6 months of the year, in June (149 mm) and Dec (179 mm). The sunshine hours fluctuated greatly during the late spring/early summer months (March to July), remaining stable at around 140 hours during the autumn, and decreasing over the winter months (Figure 7B).

The differences in climate between these two years is striking, particularly during the spring and early summer months, where high sunshine hours, reaching 202 hours, and low rainfall were seen in 2008, yet the opposite is observed in 2012.

Varietal traits were explored for relationships with specific weight. In the RL, varieties are classed by time to ripen, expressed as days earlier or later than a standard variety. The standard variety used in the 2013/14 RL was Solstice, and varieties have been classed as those -2 and -1 days to ripening as 'early', 0 days to ripening being 'timely', +1 and +2 days to ripening as 'late', and +3 and +4 days to ripening as 'very late'.

Early ripening varieties in both the commercial and RL crops produced the highest specific weight qualities, of 75.9 kg/hl in commercial crops, and 77.6 kg/hl in the RL crops over the past five years (Figure 8). A decreasing trend in specific weight is observed in varieties which are later ripening. This is observed in both the commercial and RL crops, with a decrease of 5% and 8% between the early and very late ripening varieties in the commercial and RL crops, respectively.

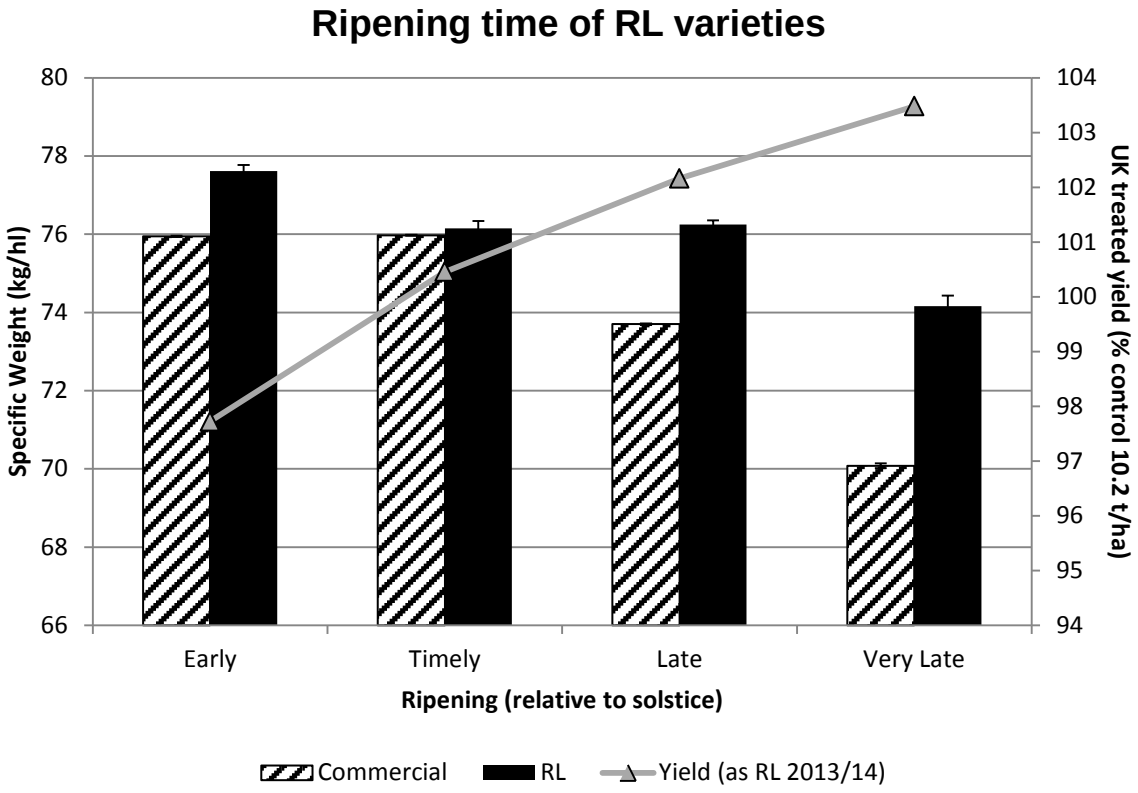

Figure 8. Ripening time of varieties in the 2013/14 RL

Intriguingly, the average yield of these ripening groups (as defined by the 2013/14 RL) increases, from 9.9 t/ha in the early ripening varieties, to 10.6 t/ha in the very late ripening varieties.

RL trials are conducted to the same protocol each year – a protocol which allows crops to be grown in optimal conditions therefore providing data on varieties' potential qualities. The long term RL specific weight datasets show a large degree of variation year on year of crops grown under RL trial conditions (Figure 1). The consistency of the protocol used suggests that there is likely to be a season effect causing the high variations each year. These variations suggest that climate maybe influential in defining the quality of the wheat, and the climates analysed in this study (2008 and 2012) indicate high variations of rainfall and sunshine hours, which can occur over a single season. Indeed, these are the two main aspects of climate which can influence specific weight. Higher solar radiation during the grain growth is necessary to enable adequate photosynthesis, providing carbohydrate for grain filling, which will contribute to a higher specific weight (Kettlewell *et. al*). Conversely, rainfall can reduce specific weight, as continued wetting and drying of grain during ripening can reduce the packing efficiency of the grain. 2008 and 2012 recorded similar UK annual rainfall, 1,295mm and 1,173mm respectively, yet specific weight recordings differed dramatically – 2008 achieved 76.2 kg/hl, whereas 2012 only achieved 71.9 kg/hl in RL trials. However, as identified in figure 7, the periods in which these weather conditions occur vary greatly. In 2008, optimal conditions for grain growth and filling are present during June and July, contributing to high specific weight achieved in this year. Conversely, in 2012, a wet and dark June would have restricted grain filling, coupled with a wet and dark April which will have reduced grain number and grain quality. These factors suggest that climate is a large influence on seasonal variations in specific weight quality.

5. Discussion

The data presented in this study gives strong indications that the specific weight can be highly influenced by numerous factors, including season, region, ripening time of variety and climate.

High variations observed over seasons suggest climate may have a large influence on the specific weight quality achieved, since RL trials are performed to the same protocol each year. The specific weight also varies between regions, yet the variation is consistent in both the RL and the commercial data. Since there will be climatic variations between each region, this further compounds the suggestion that climatic conditions will affect specific weight.

There is close mirroring of the commercial and RL data in the over years analysis, as well as the over regions analysis. This suggests that the RL is a good representation of the commercial situation. Although there is a close mirroring between the quality of crops grown in a commercial

situation, and those grown in the RL trials, the latter often achieves a higher specific weight. This is due to the robust fungicide protocol used in the RL, reducing the disease pressure. However, the large drop in quality in 2012 cannot be accounted for by disease, since the RL crops also dropped dramatically in quality.

It can be seen that growers were limited in their options for maintaining high specific weights in 2012, as even when disease was completely controlled as in the RL trials, quality still dropped dramatically – additional fungicide applications by growers would have been unlikely to improve the quality achieved in that season. The reduction in quality during 2012 can more likely be attributed to the climatic conditions – low sunlight and high rainfall were recorded during the grain filling months of June and July, reducing the rate of photosynthesis and also causing a high rate of wetting and drying to the grain – all factors which will contribute to a low specific weight.

This analysis has identified areas where growers can take action to maintain the optimum specific weight in the season which occurs. The ripening time of the varieties influences specific weight, and it has been observed that earlier ripening varieties achieve much higher specific weights than the varieties which are much later to mature. However, this does not come without costs, and it is also the later ripening varieties which achieve a much higher yield. Growers should therefore consider using a range of maturities within their crops to achieve both the yield and qualities required for their end market.

6. References

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