Desk study to evaluate contributory causes of the current 'yield plateau' in wheat and oilseed rape

Media Executive Summary

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Since the mid-1990s, increases in UK wheat yields on-farm have stalled, while oilseed rape farm yields have fluctuated wildly since the 1980s with yields now little different to those of thirty years ago. This is despite genetic yield gain continuing to deliver progress at more than 0.5% per year for winter wheat and 2% for oilseed rape.

The aims of this study were to identify agronomic factors that may be constraining wheat or oilseed rape yield improvement, assess the scope and opportunities for raising national yields through agronomy and highlight knowledge gaps or barriers to be addressed.

National yield trends were analysed in relation to cropped area, genetic improvement, weather patterns, economic influences, crop nutrition and protection, plus other aspects of agronomy.

Farm-specific data were evaluated to investigate the effects of changes or differences in agronomic practice and research evidence examined to quantify their likely impact on yield.

Climate and weather patterns were implicated in yield trends in both oilseed rape and winter wheat. Recommended List trials show more rapid yield improvement in wheat in the West and North than East with almost no improvement on light soils suggesting a possible impact of spring or summer droughts.

In contrast, yield in oilseed rape responds positively to increasing sunshine hours and negatively to increasing rainfall in spring, likely resulting from enhanced pollination and increased crop photosynthesis giving improved seed-set. Recent warm dry springs, combined with cold dry winters, which reduce some pests and diseases, are implicated in improved oilseed rape yields in the last few years.

Past and future increase in atmospheric CO_2 concentration should favour increased yield, with potential increase in yield of up to about 6% between 1980 and 2011 for winter wheat.

Commodity prices showed a limited influence on wheat yield but there was a strong relationship between oilseed rape price and yield from 1984 onwards.

Nitrogen and trace elements

Evidence that sub-optimal N use may be limiting both winter wheat and oilseed rape yields was apparent in the data. The optimum N dose for modern wheat varieties has risen by about 20kg N/ha per tonne of yield improvement over varieties grown in the 1980s but N use has been static.

Grain %N values based on HGCA Cereal Quality Survey data also indicate that N use on wheat crops may be suboptimal. The average amount of fertiliser N applied to oilseed rape has fallen from a peak about 270kg N/ha in 1983 to a current level of 180-190kg N/ha. It is uncertain if the N requirement of modern varieties has risen with yield potential, but some data hints that current amounts of spring N applied to oilseed rape are suboptimal.

Although there is a logic to increasing N use on winter wheat and oilseed rape, economic and environmental constraints mean the answer must be to focus on N use efficiency. Plant breeding, fertiliser technology and agronomy must all play a role to maximise N delivery and uptake by the crop.

There is also strong evidence that insufficient use of S fertiliser has limited yields in both winter wheat and oilseed rape in the past. The deficit in S use was reduced by the early 2000s for both crops but it is likely that some winter wheat crops at medium or high risk of S deficiency are still not receiving sufficient S and while it is recommended that all oilseed rape crops now receive S but only 60-70% of crops are currently treated and rates may be suboptimal.

Applications of phosphate (P) and potash (K) fertilisers to winter wheat and oilseed rape have fallen since the mid-1990s but the proportion of fields tested with soil indices below critical is not rising and there is no evidence that suboptimal P and K are limiting yields, although this situation may change as many farms are currently running P and K deficits. Although independent data is lacking, there is no evidence to suggest that widespread trace element deficiencies are limiting yield in either winter wheat or oilseed rape.

Pests, weeds and disease

While pest and disease management remains a challenge, there is little indication of rising pest or disease incidence since the mid-1990s. Both winter wheat and oilseed rape have seen increasing trends in fungicide use as crop prices have recovered from lows in the 1990s and early 2000s.

The incidence of some nematode species may be increasing but the implications of this for yield are uncertain. Yield impacts of emerging diseases such as verticillium wilt and clubroot in oilseed rape are also unknown as is the effect of Turnip Yellows Virus (TuYV), although there is no evidence of a trend in the annual occurrence of aphids causing TuYV.

Weed management has become increasingly difficult in many key wheat producing areas, with control of black-grass particularly challenging for some farmers. The direct impact on yield may have been minimal but, on some farms, overall crop management strategies are now heavily influenced by the need to maximise black-grass control, which may restrict options for increasing yield.

Soils and rotations

The drive to reduce costs and perceived environmental benefits have driven a move from plough to reduced tillage since the 1990s and there is some evidence that this may have a small yield penalty, more especially so in oilseed rape, although the longer-term impact of reduced tillage on yield under UK conditions is uncertain.

Increased machinery wheel loads, inducing high stresses in deep soil horizons irrespective of the tyres or tracks used, can have a significant negative impact on yields. There are no data to quantify the incidence and severity of deep compaction in the UK but some damage from large machinery seems inevitable, perhaps compounded by failure to maintain drainage systems in some cases. The continued long-term decline in soil organic matter content of arable soils is likely to compound negative impacts of changes to tillage and there is a need to better understand soil quality and how it can be improved in arable systems.

Changes in rotations have had contrasting impacts on winter wheat and oilseed rape yields. The proportion of second or subsequent wheat crops declined from 50% in the 1980s to 30% in the 1990s which was probably responsible for some of the rapid improvement in winter wheat yields seen at that time. More recently, changes in rotations are likely to have had minimal impact on winter wheat yields, although the increase in the number of wheat

crops sown before 1 October from less than 20% in the 1980s to nearly 40% since the late 1990s is likely to have had a small positive impact on yields.

There has also been consistent yield improvement in early-sown Recommended List crops, with late-sown crops having higher seasonal variation and no increase. Further use of early sowing, particularly on light land prone to spring drought may offer further scope to increase yields.

Changes to rotations resulting in a decrease in the proportion of oilseed rape crops sown after a break of four or more years, with a rise in crops sown after a break of two or three years over recent years is likely to have had a negative impact.

Yield loss estimates of 3%, 6% and 12% for oilseed rape crops with a break of three years, two years or one year respectively have been reported when compared to a four year break and further erosion of the break between oilseed rape crops is likely to limit potential for increasing national oilseed rape yields.

Although plant breeding has continued to deliver a steady increase in yield potential, uptake of newer higher yielding varieties on farm has not always followed. In oilseed rape in particular, uptake of new high yielding varieties has been poor, with growers selecting varieties that were easier to manage and harvest ahead of highest yield varieties, although since 2004 this trend has been reversed to some degree. More information is needed to help farmers match varieties to specific farm situations, to demonstrate how varieties that offer a step forward in yield can be grown and managed profitability on-farm.

Farm management practice

Consultation with stakeholders repeatedly identified on-farm attention to detail being key to high and increasing yields. Farm Business Survey (FBS) data revealed contrasting fortunes between farms growing winter wheat, with some maintaining a steady increase in yields, mirroring the increase in genetic potential, while others experience years of yield stagnation or even decline.

Since the late 1980s, the gap between the top and bottom 25% of farms in the FBS, based on winter wheat yield, has risen from 3.0t/ha to 4.5t/ha in 2009. The fact that these farms in the top yield quartile are also achieving the highest wheat gross margins is indicative of effective farm management and not merely out and out striving for yield. The difference between the top and bottom quartile farms for oilseed rape has not increased but

top-yielding farms have highest gross margin, which, as with wheat, suggests effective farm management is vital.

Effective knowledge transfer is key to improving on-farm management, this may be through grower groups that seek out and share knowledge, on-farm team knowledge transfer, investment in training or more use of agronomists or specialist advisors. Precision farming techniques are also likely to be important in delivering better targeting of agronomy, while improving the outputs from labour and machinery.

Changes to agronomy to increase yields have to be weighed against potential environmental costs. Management decisions have multiple impacts, some negative, some positive, the balance of which will require careful consideration. The broad contribution of crop management decisions to changes in greenhouse gas (GHG) emissions is reasonably well understood but less is known about small changes likely to be involved in individual crop management decisions.

Legislation

Environmental legislation is likely to present considerable obstacles to increasing yields. For instance the Water Framework Directive, Drinking Water Directive and Sustainable Use Directive have implications for pesticide use in significant areas of the UK.

Withdrawal of pesticides not only reduces opportunities to control pests, weeds or diseases but places extra pressure on those that remain available, increasing the likelihood of resistance build-up and loss of control of pests, weeds or disease. An integration of chemical and cultural control measures combined with continued development of crop resistance to pests and diseases through breeding is needed to maintain and improve crop yields.

No single factor has had a dominant influence on yield trends. Changes to agronomy have had a number of mainly small effects, with growers aiming to maximise profit not yield. To restore rising yields in the face of warmer conditions, economic or environmental pressures and evolving weed, pest or disease threats, a more holistic approach to agronomy is needed.

Specific recommendations

Short-term

- Recommended List outputs should be supplemented by additional information to help inform variety selection for specific situations
- Better tools and information to aid forecasting, monitoring and management of growth and lodging risk
- Collation of research relevant to early-sown wheat crops in a suitable format for growers
- Make available updated advice on areas in which crops are at medium or high risk of S deficiency
- Regular soil testing to ensure effective targeting of P and K fertilisers
- Maximise awareness of the practical implications of pesticide resistance and managing or mitigating risk
- Consider the implications of timing of operations and inputs for yield improvement

Medium-term

- Improved farm benchmarking of yield data
- Help and advice for growers to 'health check' their cropping systems, including the impacts of rotation, cultivation and soil management strategies
- Making precision farming more accessible and practical for small or medium-sized farms
- Studies on how agronomy can impact on or improve fertiliser efficiency
- Evaluation of the contribution of pollination and seed set to oilseed rape yield
- Evaluation of the short and long-term yield implications of the move from ploughing to non-inversion cultivation
- Addressing the knowledge gap regarding the state and health of UK soils, with respect to soil compaction and varying soil organic matter levels
- Evaluation of nematode incidence in wheat and oilseed rape

Long-term

- Better collection of data about on-farm practice to enable better monitoring of changes in farm practice
- Breeding and selection of varieties suited to changing environmental conditions in the UK