**Historic England (formerly English Heritage) & NTSGA Project 6220 Thatch supply research (2DS.201)**

## Executive Summary

WP1 has been completed and funding is now sought to proceed to WP2.

The growing trials have been successfully completed using a range of old and modern varieties of wheat and different growing regimes.

The results provide very useful information into how each one performs and answers some of the myths that have been built up about the performance of locally grown straw and its suitability for thatching.

Facsimile roofs have been thatched using each of the straw varieties and once these have been sited and erected, longer term testing can begin to assess their performance on the roof.

The research method established by this project can now be applied to other areas of England where different types and methods of thatching are deployed.

**Background**

This research was designed to answer claims that English-grown straw thatching does not last and is outperformed by imported water reed. In the last few decades many contentious claims and myths have been voiced over this issue, with the result that a great deal of important historic thatch and distinctive local traditions have been lost.

English Heritage's commissioned historical research in the 1990s showed unequivocally that English thatching traditions were based on locally grown straw and that distinctive methods and detailing developed in each region in response to building type and design, materials used and climate. This tradition prevailed for centuries, even in areas where local water reed was also used.

In the last few decades there has been great pressure from some thatchers and importers to replace straw thatch with imported water reed. Not only does this radically change the appearance of the building and streetscene, it often results in the total stripping of centuries of historic layers of thatch which provides a unique historical and archaeobotanical record.

There are many reasons for this situation. Most importantly it is claimed that the modern varieties of straw do not perform particularly well, partly due to: too much Nitrogen being used, a failure to withstand inclement weather and premature decay on the roof. This research is being carried out by a number of traditional straw thatching growers in East Anglia to provide empirical information to try and answer these assertions.

Five different varieties of wheat straw have been grown and harvested. Now that the Conservation Varieties Act of 2009 allows the marketing of old varieties, some of these are being tested alongside the two most popular modern ones. Different growing regimes have been fully recorded including the use of varying amounts of Nitrogen. Weather data, ground conditions etc have also been logged, as have observations and tests carried out on each variety.

The resulting straw has been harvested and facsimile long straw roofs produced which are to be erected on land belonging to one of the growers. Regular monitoring and testing will take place over several years (suggested 20 years) as part of WP2.

**Headline findings for WP1 long straw production and its thatching are as follows:**

- Certain older lines offered specific points of difference to those that are in wide-scale production to merit their registration as conservation varieties to broaden the choice of materials available to growers of long strawed wheats for thatching. Squareheads Master 13/4, Yeoman and New Harvester are in the process of being registered to enable the legitimate sale of seed.

- The growing trials have established that consistent good quality thatching straw using the older taller wheat varieties can be achieved when matching the suitability of variety, land type, residual land fertility and growing husbandry employed.

- The project also indicated that the newer wheat varieties (Maris Widgeon and Maris Huntsman) required still more attention to detail using further timed chemical inputs to produce a healthy standing height and achieve usable quality thatching straw.

- The same attention to detail is also needed to cut the good crop within the window of opportunity, and to have the threshing and handling machinery set up correctly to avoid the least damage (crushing/breakage) as possible to the straw with grain cleanly threshed out.

- The taller older varieties can give farmers a better financial return with a greater tonnage quantity of high value thatching straw per hectare than more modern shorter wheat varieties.

- High fertility through increased quantities of artificial nitrogen top dressing can damage a growing crop indirectly in conjunction with increased disease and storms beating down the crops early, leading to further fungal weakening of the lodged stems that becomes evident with mechanical damage when threshing takes place. (see 2.6)

- On normal well-thatched roofs the low residual content of nitrogenous compounds within <u>all</u> straw is mostly inaccessible to brown rot fungi that populates the outer 2-

3cm surface of thatch. This inaccessibility of nitrogenous compounds is likely to be the reason why thatch works so well as a roof covering as it limits the progress of brown rot fungal decay. (see 5.1) High nitrogen applications to the crop during the growing season have very little effect on final quantities of residual nitrogen left in the harvested straw. (see 2.5)
*Monitoring of the WP2 Long Straw thatched roofs will indicate whether this science is true.*

- Although rare, advanced 'premature degradation' of thatch has been a major concern to both the thatching industry and conservation bodies alike, the reasons for this failure of thatch has been mainly levelled at growers and producers of both thatching straw and water reed by suggesting that the material supplied is too high in nitrogen, contaminated (non-specific), poor quality (non-specific) or stored badly. Apart from the 'high nitrogen' content of thatch material it is possible that the other factors could play a possible contributory part in faster establishment of decay, however little is said of the part that thatchers, design and aspect can also play in this story of decay! It is clear that poor and abnormal thatch retains moisture deeper into the thatch coat of all types of thatch; this constant moisture is a major contributory factor to establishment of aggressive specific fungal decay deeper into the thatch, that is missing from the 2-3cm surface thatch. (read more 5.2)

  *Moisture and temperature monitoring etc of the WP2 Long Straw thatched roofs will indicate where possible problems may occur and perhaps the possible advantages of long straw thatch has over other types of thatch. Growers and thatchers of long straw have long observed that this type of thatch is far less likely to suffer from white/soft rot 'premature degradation'.*

- Long Straw thatchers with experience ask that the long straw they purchase and use is not unduly mechanically damaged and is of good useable length. (see 2.3)

## Review and conclusions report 2015

## Summary of the two year thatching straw crop growing trials, WP1

Five winter wheat's were trialled; New Harvester; Yeoman; Squareheads Master 13/4; Maris Widgeon and Maris Huntsman on three different husbandry schemes of low input nitrogen (35 units); high input nitrogen (70 units) and residual (following a legume crop).

No spring wheat's were used in this pilot trial, so the report cannot make any recommendations about its suitability of growing this crop for thatching straw.

A comparator using a modern wheat/rye hybrid called Triticale was drilled alongside the wheat's on the first year but failed to germinate with no time left late in the year to re-drill ., This was a disappointment as many combed wheat reed growers from other parts of the country do grow this crop for thatching. It was decided there would be no point growing it for the 2014 harvest as we couldn't compare without the 2013 harvest.

The wheat lines were cut with reaper binders when the stem nodes were still green, stooked in the fields for around 2 weeks so that the straw dried and the grain ripened. The sheaves were counted and then thrashed in separate machines to keep the seed separate and pure, the threshed straw lines of 2013 were then prepared as yealms to thatch the already built roof frames ready for long term monitoring of the five wheat varieties, three husbandries and three long straw thatching specification lines on north and south elevation aspects, WP2.

# 1 Plant establishment for harvest 2013 and 2014

Plant establishment was average to poor during the autumn of 2012 and the following autumn of 2013 due to prolonged periods of wet weather that made cultivations difficult and sowing late, however most of the trial plots lines tillered well to produce good crops with exception of the residual treatment lines drilled in the very late autumn of 2013.

Yeoman, 13/4 and New Harvester did better for tillers and cover than the more modern Maris Huntsman and Maris Widgeon varieties.

**Conclusion:** Older wheat's tend to be more resilient to initial poor growing conditions and tiller out better when the growing conditions improve during the spring.

# 2 Crop/straw quality comparisons of harvest 2013 and 2014

## 2.1 Standing quality

All the lines on the low, high and residual husbandry stood well during the 2013 harvest with no wheat's that lodged, this partly due to no serious storms in the lead up to harvest and that the lines were between 10% and 20% down on stem number density per given area than one would expect had the plant establishment been normal the previous autumn.

Harvest 2014 storms saw some lodging under high inputs of New Harvester (40%) and Yeoman (45%) and Maris Widgeon (60%), with only a little lodging under low inputs of New Harvester (15%) and Maris Widgeon (15%), none of the other low/high input lines suffered lodging.

The residual husbandry sowings were a failure, very sparse crops, apart from the New Harvester, which was drilled prior to the other lines before a prolonged period of wet weather. New Harvester produced a good standing crop.

## 2.2 Height of lines

Comparison heights can be made on the low/high input husbandries between the two harvests, all wheat lines were shorter in height in 2013 compared with 2014, this was partly to do with the weather differences (very dry 2013 spring) and the poorer establishment of the 2013 harvest lines in the autumn of 2012.
From the tallest to the shortest varieties for both years came out much the same: New Harvester; 13/4 Squareheads; Yeoman; Maris Widgeon and Maris Huntsman came out the shortest.

Plant heights from the Laurel Farm 2013 harvest.

| **Variety** | **Top of head** | **Top of head** | **Bottom of head** | **Bottom of head** |
|---|---|---|---|---|
| **Yeoman** | Low input 115cm | High input 120cm | Low input 106cm | High input 110cm |
| **13/4** | Low input 111cm | High input 119cm | Low input 102cm | High input 112cm |
| **Maris Widgeon** | Low input 98cm | High input 109cm | Low input 89cm | High input 100cm |
| **New Harvester** | Low input 114cm | High input 126cm | Low input 106cm | High input 119cm |
| **Maris Huntsman** | Low input 87cm | High input 96cm | Low input 80cm | High input 88cm |

All 2013 high input husbandry lines were an average of 8cm taller than the low input lines, this same height difference showed up with the New Harvester; 13/4 and Yeoman for the 2014 harvest. The 2014 Maris Widgeon lines were considerably taller compared to 2013 with an average of 5cm height difference between the low/high inputs in 2014. The Maris Huntsman high input lines of both years and the 2013 low input line were virtually the same at 96-98cm, the 2013 low input line was only 87cm tall.

**Conclusion**: The modern wheat's, Maris Huntsman in particular did not grow much taller with the 70 units top dressing Nitrogen application compared to the 35 units application and only grow to their designed height, to achieve better height for Maris Huntsman top dressings of Nitrogen really need to be bumped up.
It's interesting to note that a long-standing Maris Huntsman grower disclosed that he would normally put applications of between 120 to 140 units on the Maris Huntsman to get reasonable plant height, this would only be helped by good spring growing conditions opposed to a cold dry spring.

The older wheat lines tend to attain good height for thatching even on low input and less than favourable spring growing conditions.

**2.3 Threshed quality and colour of straw**

It was noted that the 2013 wheat lines for use with the WP2 facsimile roof frames differed in colour; this could have been partly to do with different fields but also the nitrogen available to the lines. The residual straw lines were a blond colour, with the low input straw being more yellow and the high input straw being slightly more yellow still. This colour difference did not appear to affect the quality of straw threshed, all lines threshed out well without crushed breakage and fraying of the stems. Note: The field where the low and high input lines were grown is old meadow land from 25 years ago and has always produced a more yellow straw than long established arable fields.

Long straw thatchers look for relatively mechanically undamaged straw of good clean usable length with little or no grain content as a sign of quality, there are several other indicators that help them decide such as suppleness, colour and smell.
Good quality straw handles better in the yealm preparation; less waste, less yealms required to cover a roof and fewer fixings required on the roof.
The longer the cut straw (90 to 130cm) the better its suitability for thicker specification coats of thatch (30 to 45cm), with intended thinner coats of sparred thatch between 20 and 30cm thick, the thatcher may prefer shorter cut straw of between 75 and 90cm.
Note. Cut straw is usually around 10cm shorter than the standing crops, (10cm stubble).

**Conclusion:** Nitrogen inputs and availability to the lines did not adversely affect the end threshed product, this would not have been the case had any of the lines lodged early through the combination of early storms, high fertility and possible increase in plant disease weakening the base of the plants as laid buckled crops become structurally weakened at ground level by early decay prior to the correct harvesting time.

All lines in both years were cut at the correct time with the nodes green and the grain at the cheesy texture stage, and stooked in the field for around 2 weeks. Had any of the lines been cut late at an advanced ripened stage we would have expected the threshed wheat's straw to have shown far more mechanical crushed breakage of the stems and a resulting poorer quality thatching straw.

Above: Mechanically damaged long straw trussed bolt, yealm and waste.

Above: Relatively undamaged threshed long straw, trussed bolt, yealm and sample of bolt. Very little waste!

Above: Comparison of the two long straw yealms ready for thatching.

**2.4 Harvested straw yields 2013-2014**

The total number of calibrated binder cut sheaves (yield) for each variety across the set of three husbandry regimes varied from 141 for Maris Huntsman to 195 for Squareheads Master 13/4. The average yield across all the lines in each treatment showed an increase from 38.4 under the low regime to 62.8 under the high with the residual coming in at 76. It must be remembered however that the residual plots were grown on another field 8 miles away on somewhat heavier land.

If we consider just the low and high regimes that were grown on the same site then it is clear that all lines responded with a positive increase under the high regime. The highest yield under the low regime came from New Harvester (48) and the lowest from Maris Huntsman (26) while under the high regime the highest yield came from Squareheads Master 13/4 while the lowest yield again came from Maris Huntsman (37).

Converting the performances to relative increases in yield of sheaves from the low to the high indicates the ability of a line to respond to the different regimes. Across all lines the relative increase from the low to the high regime was 63.5% with marked differences between the different lines. Maris Widgeon showed the highest relative increase (94.4%) compared to just 25% for New Harvester. The low figure for New Harvester is due to its high performance under the low regime so its capacity to increase under a more fertile regime is smaller.

Numbers of sheaves carted from each treatment plot, 2013 harvest

| | Low input | High input | Residual | Total across all treatments |
|---|---|---|---|---|
| **Yeoman** | 40 | 72 | 74 | 186 |
| **13/4** | 42 | 75 | 78 | 195 |
| **Maris Widgeon** | 36 | 70 | 70* | 176 |
| **Maris Huntsman** | 26 | 37 | 78 | 141 |
| **New Harvester** | 48 | 60 | 80 | 188 |

*Maris Widgeon under residual treatment had a markedly lower seed count than the other varieties (recorded 06/03/13)

The number of harvested sheaves of the two modern varieties, Maris Widgeon and Maris Maris Huntsman, were lower compared to the older lines under the low input regime. While Maris Widgeon responded better under the high input regime, Maris Huntsman remained low in comparison to all the others with a relative increase in yield of 42.3% which was also low.

Delving further, the yield of sheaves is a product of the number of plants and the number of tillers of a particular line. There is a degree of compensation between these two elements and it has already been stated under point 1 that Yeoman and New Harvester did well for tillering than the two modern varieties Maris Widgeon and Maris Huntsman. Maris Huntsman was observed to be particularly low at tillering on the Laurel Farm High and low regime plots while not as bad on the residual plot on Hulver Farm which demonstrates the complex dynamics between variety and environment and the closer attention that needs to be given to plant density and tiller number in any future trial.

These two varieties can be split further in that Maris Widgeon is one of the last of the long strawed wheat varieties to be released while Maris Huntsman is an early product of the shorter strawed wheats which have a lower tendency to tiller and so are better suited to growing at higher planting densities. This might be behind the poorer performance of Maris Huntsman in particular on the lighter land of Laurel Farm.

Although the stem quantities averaged out to be similar on each husbandry scheme, it was clear that the tallest varieties such as New Harvester and 13/4 were up to 30% taller than say Maris Huntsman which meant a greater volume and weight of saleable straw.

Thatchers using longer stemmed wheat straw cover more ground with less yealms and fixings quicker without compromising the quality of their workmanship.

**2.5 Residual Nitrogen content of threshed straw**

Content of nitrogenous compounds can vary in harvested straw, but studies show that percentage content is very low and is only marginally increased even when very high inputs and fertility are present for the growing crops.

Conventional combined wheat straw harvested contains on average 0.5 % nitrogen (5 kilos per tonne), a plant will only take up finite quantities of nutrients to help fill the seed head and no more, a plant and its stem will not take up and store excess nitrogen over and above what the seed head requires whilst the plant is still growing.

With reaper binder cut wheat for thatching residues of nitrogen will be present in the stem and dried leaf at harvest time, the nodes and part of the stem would normally be still green indicating that small extra nitrogen is still present and has not been taken up by the seed head at that point in time, the seed head would continue to draw some of the remaining moisture and nutrients from the stems whilst ripening in the stook. With this scenario we could expect a possible slight percentage increase of nitrogen in the straw threshed.

With this low percentage of accessible residual nitrogen in the straw it is difficult to imagine a dramatic effect on longevity of thatch on a roof through fungal decay, one has to also consider atmospheric nitrogen in rainfall at certain times of the year (electrical storms in particular) can contribute another 2 kilos per acre area per year that falls on the surface decay of thatched roofs.
Rainfall nitrogen may have some added momentary (before washing away) significance to normal surface thatch decay (brown rot), than nutrients locked up dry and safe from other species of fungal attack within the depth of thatch.

**2.6 Effects of higher nitrogen applications to the growing crops**

During the growing season, higher fertility and in particular the use of high concentration single dose applications of fast acting nitrogen top dressing during the early-mid spring period can lead to an increase of certain fungal, viral and pest presence that weakens the plant stem and leaf cell structure which further raises the risk of the crop lodging and buckling near the base of the stem, sometimes weeks before harvest time.
The increase in lodging in the high input trial is consistent with this result (2.2).

# 3 Conclusion on how the wheat varieties compared by harvest time

**Squareheads Master 13/4 :** Selection of SHM made at University of Cambridge Plant Breeding Institute. Introduced by NIAB, Cambridge in 1940.

Performance in project trials: Out of all the wheat varieties 13/4 outperformed the rest for standing consistency, good height, plant establishment in poor conditions, health and quantity for each of the husbandry methods and different fields, it also did better than the rest for least damage of the end product at the threshing point. This wheat is suitable for both Long Straw and Combed Wheat Reed production and subsequent thatching.

Principal characteristics (Peachey 1951):
Land: Suited to medium soils in average fertility and light land in high state of fertility.
Sowing: Best sown early (wheat yield), winter hardy, covers ground well.
*Note: Can be sown late autumn with no detriment to the straw for thatching*
Young plant: Prostrate habit, or nearly so. Leaf medium, inclined to flag a little.
Tillering: Average-high 0-3
Ear: Red chaff, clean and bright, medium density & size, slight tapering only both sides.
Grain: Average size, plump, red, uniform, rather soft.
Crop ripening: Early ripening, 3-4 days earlier than Squareheads Master/Standard Red.
Straw Length: Average to long (1270mm), very bright, thin walls.
*Note: Classified as relatively thick & coarse walled for thatching long straw*

**Yeoman:** Bred by Sir Rowland Biffen, University of Cambridge 1916, cross of Browick/Red Fife. This was the first of the UK adapted wheats with good bread making characteristics and is an important variety in the history of UK wheat breeding.

Performance in project trials: Yeoman performed nearly as well the 13/4, although it was slightly more prone to some lodging on the high input husbandry. This wheat is probably best suited for long straw production and thatching only as it has thin straw walls.

Principal characteristics (Peachey 1951):
Land: Best suited for medium to heavy soils in average fertility, *light land in high state of fertility.*
Sowing: A true autumn wheat best sown early (wheat yield), very winter hardy, covers ground well.
*Note: Can be sown late autumn with no detriment to the straw for thatching*
Young plant: Prostrate habit, leaf medium, inclined to flag, dark green.
Tillering: High 0-3, strong.
Ear: White chaff, clean, medium density, tapering on face view, average to long.
Grain: Dark red, average size but longer than normal, hard, uniform, good baking quality.
Crop ripening: Early /average ripening.
Straw Length: Average (1200mm), fairly stiff, bright colour. Very thin walls.
*Note: Classified as relatively thin walled for better suited to thatching long straw than combed wheat reed.*

**New Harvester** Information on this line is scarce but it has recently been established that this was an English wheat (pre 1930) also known as Webb's New Harvester. The sample originated from the NIAB museum collection of old cereals that was transferred to the public cereal collections at the Plant Breeding Institute in 1973

Performance in project trials: New Harvester's main advantage is that it is late to mature, so ready to cut several days after the others. This helps stagger the thatching wheat harvest for larger growers. It performed well on most factors but would be at risk of lodging in wind and storms on any higher input husbandry due to its height (the tallest of the wheat's trialled).

This wheat could be suitable for Combed Wheat Reed production and thatching as well as Long Straw production that it was tested for.
Straw length: Classified as a thick walled for thatching straw

**Maris Widgeon**: Cross between Cappelle Desprez and Holdfast, introduced in 1964. Plant Breeding institute variety. This was the last long strawed variety to be widely grown in the UK before the introduction of semi-dwarfing wheats

Performance in project trials: Maris Widgeon did well on most factors, it grows to an average usable thatching height with average to higher fertility growing conditions but risks lodging on high inputs, it won't grow to a particularly good height if the spring growing season is cold and dry for prolonged periods.
With good height this wheat can be used for both Combed Wheat Reed and Long Straw production and thatching, could be classified as a medium/thick walled straw. This wheat can require harder threshing than the other varieties to remove all grain from the heads.

**Maris Huntsman:** Cross between Cappelle, Hybrid 46 X Professeur Marchal. Entered the recommended list in 1972. PBI variety. One of the early shorter stemmed wheats released in the UK.

Performance in project trials: Maris Huntsman was the best for grain quantity, easily threshed and consistent shorter straw height. It also equalled 13/4 for not lodging but it did have an advantage of being under 100cm tall, effectively 30% shorter than the 13/4, which clearly lessens the risk of storm damage knocking the crop down. This wheat could be classified as a thick walled straw variety, due to its average shortness of stem. Maris Huntsman grown under low input husbandry could be classified as unsuitable for Combed Wheat Reed production and thatching due to its average shortness of stem and is only just suitable for spar coat long straw thatching (more work entailed for the thatcher for numbers of prepared yealms and fixings up a roof).
*Note: A respected long standing grower in East Anglia grew Maris Huntsman for several thatchers over the past 30 years, the crop often had 120 units plus of ammonium nitrate applied during the growing season to land depleted of nitrogen, this helped increase the height of the crop, it's interesting to note that the well thatched long straw roofs that used this straw did not suffer any notable adverse longevity during the 30 years. It could be argued that problems could have occurred without the growers attention to detail in maintaining the health of the crop using the all necessary timed chemical inputs at his disposal to keep the crop healthy and standing right up until harvest.*

## 4 Conclusions gained from the thatching crop trials and each lines reliability to produce consistent good quality straw for thatching

From the thatching straw production viewpoint the 13/4, Yeoman and New Harvester stand to do well on medium to heavy soils and do quite well on lighter soils. Maris Widgeon and Maris Huntsman in particular do better on heavier soils but would struggle to grow to a good height on lighter soils without the help of very good growing weather conditions and possible risky boosted nitrogenous fertility.

The older varieties; 13/4, Yeoman and New Harvester performed better under the husbandries of low input of artificial nitrogen and residual (1st wheat's following a legume or heavy mucking of a previous crop). Organic husbandry along the lines of residues of previous legumes and mucking etc. would also suit these varieties.
Husbandry with heavy use of artificial nitrogen (particularly fast acting), the likes of chicken manure or a mix of both would run the serious risk of a weakening the stem base and subsequent lodging and ground level decay of the crop, so not recommended.

Maris Huntsman is not suited to the husbandry of low artificial nitrogen inputs or meagre mucking, as it simply will not grow suitably tall enough for economical thatching straw. Husbandry for Maris Huntsman requires very high fertility and further numerous well-timed chemical inputs to stem the increased risk of basal fungal decay.

Maris Widgeon crop reliability lays somewhere between the husbandry requirements of the three older varieties and Maris Huntsman, probably best grown as a first wheat after a residue crop, or 50 to 70 units of slow release artificial nitrogen, or compound NPK.

The later flowering and maturity time of New Harvester could be beneficial to growers I spreading out harvesting time if it was grown alongside one of the other earlier maturing lines.

The lodged areas of the 2nd year wheat lines occurred within two weeks of harvest cutting. The stems bent close to the ground with the wheat stems leaning against each other but the lodged wheat did not collapse to the ground or subsequently dogleg and no extra significant mechanical damage to the lodged straw was noted when threshed.

All these wheat's do need careful monitoring for fungal attack, pests and diseases and take suitable measured action to keep the plants healthy. Maris Widgeon and Maris Huntsman need more care and attention than the older varieties.

Aphid 'honeydew' secretions have been suggested as a possible cause of increased fungal stem decay on thatched roofs, and the growing plant. This is not an issue commented on by growers generally and there was no sign of aphids on any of the lines for the two trial years, so this hypothesis can't be monitored on the test roofs.

There is some general confusion within the public and even thatchers when presented with the simplified statement that 'High levels of Nitrogen in thatching straw increase the decay in thatch', there is then the assumption that high applications of fertilizer to the growing wheat either always damages the stem structure or that high levels of nitrogen stay in the stems long after harvest, or a bit of both rots thatch earlier.

Most growers realise through their experience and knowledge that high fertility and unchecked disease can increase the risk of rampant basal fungal decay in crops lodged. Crops that lodge early whilst green suffer far worse, and the early lodged wheat's seriously crush and breakup in the mechanical threshing process just as if they threshed over-ripened cut sheaves. For thatchers this results in poor quality straw, and in a sense high nitrogen may have helped in the lead up to the poor quality, for a thatcher poor quality straw is problematic in yealm preparation and application to a roof.

The scenario of mechanically damaged straw can't be monitored on the thatched roof frames as all the wheat lines used did not lodge or suffer excessive mechanical damage in the threshing process.

**However, the different husbandry input lines can be monitored for possible nitrogen related decay on the WP2 thatched roof frames.**

**If for example there are sufficient nitrogen residues left in the dry harvested straw, we need to know whether there would also be sufficient moisture and warmth present at different times of the year, to enable fungal decay throughout the thickness of the thatch and not just the top 2-3cm surface thatch where normal slow decay is noticeable. The thatched roof frames could be monitored for all these factors.**

**Monitoring of the different longevities of the three different thatching specification depths and techniques will take up to a possible 20 years plus to collect data.**

## Economics

Theoretically growers that are able to consistently grow the older taller varieties standing to harvest would have a better profit margin than a grower of the modern shorter varieties as they would have increased tonnage of straw at a better price than increased grain yields and be without the costs of the increased inputs required of more modern varieties.

**End of Main Report**

# Additional comments

## Fungal decay of straw ‘models’ in the field and on the roof.

From research carried out on harvested wheat straw residual nitrogenous compounds, we know that the percentage content does not vary much from 0.5% on crops grown in either low or high fertility, research has also shown that the nitrogenous compounds within straw cell wall structures are not easily accessed by fungi for its food source.

This effectively means that nitrogenous compound content in thatch makes very little difference to straw decay by fungi once it becomes established and devours what nutrients are available, with the end result being composted and skeletal cell structure.

Research by Kirby & Rayner (1988, 1989) into the characteristics of a number of fungi families tells us that different groups of fungi populate different zones within the thatch constructed with straw, water reed (or any other thatch material). Growers of thatching straw and thatchers alike have no effective control of eliminating fungal spores whether they arrive on thatching material used or introduced from rain and wind on a completed thatch, the spores are everywhere in their billions and it only requires a few to get established under the right conditions.

Identifying specific species within groups of fungal activity on and in thatch is of interest but is effectively a pointless exercise as close cousins are so numerous and could be present alongside each other.

**The establishment of aggressive fungi and subsequent decay appears to rely on the major contributory condition of retained constant moisture which we humans do have some control over, unlike the other ‘right’ conditions of mild temperate UK climate, the presence of some nitrogenous compounds in plant tissue and fungal spores floating about.**

**We need to look at what we can control to reduce the moisture factor: Skill of the thatcher to get the suitable thatch fixed at the optimum position and at pitch, density and suitable thickness, quality thatch material, good pitch and design of roof frame, and ensure that the thatch is not surrounded by overhanging trees.**

**5.1: A detailed model (a) of how normal thatch surface decay functions on a well thatched roof.**

**Zone 1: Surface of thatch (2-3cm), Brown rot.**

Depending on the quality of the thatch material stem integrity together with the skill and material understanding of an experienced thatcher it would be normal to expect only the top surface to be decaying at a slow controlled rate. This zone is mostly populated by ‘brown rot’ fungi of the *Basidiomycota* species that degrade hemicellulose and cellulose. Cellulose is broken down by hydrogen peroxide that is produced during the breakdown of hemicellulose, the straw shrinks and shows a brown discolouration due to this type of decay. This type of fungus is unable to effectively breakdown the lignin ‘adhesive’ of the cell structure leaving modified demethyated lignin’s locking up remaining glucose compounds, brown rot fungi effectively only semi-digests plant tissue hence a slow rate of decay.

*Basidiomycota* on thatch can tolerate a moisture substrate as low as c. 14%, during dry drought periods they could then die out then be re-populated by fresh spores after it rains. It's likely that any accessible nitrogenous compounds are extremely low on the surface of thatch as rain wash's the thatch down, for the brown rot to access meagre nutrients it may also have a little help from the sun, rain and wind; mechanical stressing through expansion (moisture) and contraction (sun & wind) to help break up the stems.
**We can be certain that the remaining plant structure is gradually worn away over a long period of time by mechanical stress by way of weathering action.**
The exception to norm would be localized advanced rot as gullies, where birds droppings fall from edges of chimneys or aerials, helped on by nitrogenous compounds!

**Zone 2: (all thatch deeper in from Zone 1)**

This inner thatch is expected to be dry, how dry and to what extent it is further into the depth of the thatch could be better understood during the monitoring of the long straw thatching facsimile roofs in WP2.
Fungal decay activity is not noticeable in this inner zone of thatch of normal thatched roofs.

**5.2: This detailed model (b) below provides a better understanding of how normal decay and the abnormal 'premature decay' of thatch may function together on the same roof.**

**Zone 1: Surface of thatch (2-3cm), Brown rot.**

Depending on the quality of the thatch material stem integrity together with the skill and material understanding of an experienced thatcher it would be normal to expect only the top surface to be decaying at a slow controlled rate. This zone is mostly populated by 'brown rot' fungi of the *Basidiomycota* species that degrade hemicellulose and cellulose. Cellulose is broken down by hydrogen peroxide that is produced during the breakdown of hemicellulose, the straw shrinks and shows a brown discolouration due to this type of decay. This type of fungus is unable to effectively breakdown the lignin 'adhesive' of the cell structure leaving modified demethyated lignin's locking up remaining glucose compounds, brown rot fungi effectively only semi-digests plant tissue hence a slow rate of decay.
*Basidiomycota* on thatch can tolerate a moisture substrate as low as c. 14%, during dry drought periods they could then die out then be re-populated by fresh spores after it rains. It's likely that any accessible nitrogenous compounds are extremely low on the surface of thatch as rain wash's the thatch down, for the brown rot to access meagre nutrients it may also have a little help from the sun, rain and wind; mechanical stressing through expansion (moisture) and contraction (sun & wind) to help break up the stems.
**We can be certain that the remaining plant structure is gradually worn away over a long period of time by mechanical stress by way of weathering action.**
The exception to norm would be localized advanced rot as gullies, where birds droppings fall from edges of chimneys or aerials, helped on by nitrogenous compounds!

**Zone 2: (3cm to 20cm?), Possible Soft rot/White rot leading to what is called Premature Degradation.**

In good thatch this middle zone should be relatively dry, getting progressively dryer further into the thatch. If this zone retains a fairly constant moisture above c. 30% and is protected from drying and temperature fluctuations there is a greater establishment probability of with 'white rot' *Basidiomycota* fungi and/or 'soft rot' mostly *Ascomycete* species. Soft-rot fungi are able to colonise conditions that are too hot, cold or wet for brown or white-rot to inhabit

'White rot' fungi is the most aggressive for fast decay within the thatch; this group specializes in digesting lignin first to gain glucose compounds then quickly moves on to break down and mop up nutrients within cellulose type plant tissues. This fungi is also adept at breaking down anti-fungal compounds and protective waxes, it also has the ability to scavenge and recycle nitrogen better than other fungal species thus being able to degrade plant tissues with a very low 0.066% nitrogen dry weight (carbon to nitrogen; C:N ratio 1,500:1).

A constant initial moist middle zone can happen in two ways; firstly and more common an overly tight packed thatch surface sometimes seen with what appears to be good quality combed wheat reed and water reed thatch where outside moisture is 'thermally pumped' further up the stems and into the thatch past Zone 1 and can not evaporate away; and secondly poor loose thatching where ingress of rainwater occurs deep into the thatch.

Thatch suffering from soft rot/white rot attack will soften, shrink and crack the thatch surface, when parted the inner thatch is matted together and appears white, as the fungi becomes established it creates it own micro-environment to thrive, no longer needing 'thermal pump' it can sponge moisture from the outer thatch surface and produce its own warmth through enzyme digestion.

**Zone 3: Inner thatch, usually under the fixings.**

This inner thatch is expected to be dry, but if fungal action is present in Zone 2 one would expect this inner zone of thatch to be progressively more moist nearer the middle zone and to see the dry thatch becoming degraded by white rot enzymes or possible fungal hyphae. Given time and severity of the fungal rot, this zone would also collapse to the roof frame.

### 5.3: Model (c) Decay of harvested straw in the field

Much is known of how conventional harvested wheat straw decays, due to its low residual nitrogen content it requires extra additional nitrogen to start the field type fungal decay (brown rot?). For straw decay in the field higher nitrogen is a major contributor as it is missing, the field already has plenty of moisture and suitable temperatures. This model however is not transferable to the roof straw decay because it lacks reliable moisture content for most fungi to establish and thrive.

**References**


Fungal decay- wikipedia.org references

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