GROWER NETWORK

BIOFUELS PROJECT 2008-11

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Grower Network winter wheat trials summary

The North East of England is well suited to the production of bio ethanol on account of consistently producing relatively high yields of low protein wheat. The proximity to emerging processing plants and the opportunity for recycling Nitrogen through mixed farms also means the region has the ability to reduce Green House Gas (GHG) emissions. Whilst alcohol yield is not currently considered a basis for payment, potentially the industry could pay farmers premiums for higher alcohol levels and for producing the crop with a lower carbon footprint.The main driver remains the Renewable Transport Fuel Obligation (RTFO), which requires 10% renewable fuel inclusion in all UK petrol & diesel by 2020.

The North East has become a major centre for bio ethanol production in the UK. Ensus have now started production at the UK's first wheat to bio ethanol facility in Teesside, and will use up to 1.2 million tonnes of UK wheat per annum. Two other large bio ethanol plants are also due to commissioned in the next few years further down the coast in the Humberside region with Vivergo hoping to start production late in 2011. In total this emerging industry is likely to demand in excess of 2.5 million tonnes of wheat per annum, and presents a large opportunity for growers in the North East.

Choosing the correct variety & nitrogen strategy are the two key areas that the Grower Network are focussing on for improving the production of bio ethanol in the North east.

Nitrogen fertiliser strategy may be considered the most important factor in growing a biofuel crop for a range of reasons. Whilst its use increases yields substantially, it also increases grain protein content. Grain protein reduces alcohol yields per tonne of grain, reducing processing efficiency and hence profitability for the bio ethanol processor. Timings and rates of nitrogen have been studied in the region in recent years. Evidence from these studies suggests that applying up to 50% of the N earlier in the season would generally reduce grain protein content & increase alcohol yields per tonne, without negatively affecting grain yields, and perhaps in second cereal situations, increasing grain yields. Kindred et al (2009) found that earlier than traditional nitrogen timings improved alcohol yields by around 4l/t on a consistent basis. Whilst this may appear a relatively small increase, it could potentially bring benefits in improved bio ethanol production by more than £1 million per annum. However, all timing experiments in recent years have been conducted in dry springs; hence the increased risks of disease, lodging and fertiliser N loss to leaching or denitrification from earlier N timing in a wetter year are still unquantified.

The Grower Network study aims to carry on from the work of Kindred et al (2009) continuing to assess the implications of early nitrogen timings, and then evaluate what impact this has on the growth of the crop, and whether we need to change agronomic approaches due to the likelihood of increased disease pressure & lodging.

The 2009/10 site at Eryholme Darlington consisted of a 10 ha clay loam field following a crop of winter oilseed rape. 11 winter wheat varieties & 2 varieties of Triticale were sown at traditional seed rates. The site was sampled down to 90 cm for Soil mineral Nitrogen in February and after the Soil Nitrogen Supply was calculated a crop requirement of 220 kg/ha Nitrogen was recommended. This was to be split into two regimes. Both regimes used two applications at early timings (first application at late tillering (GS24) & second application at the start of stem extension (GS30)). The first regime split the 220 kg/ha equally into 2 halves, whilst the second regime followed a more traditional approach with just under one third of the total nitrogen applied in the first application, and the remainder in the second application.

As can be seen from the following table (TABLE 1), echoing the work from Kindred et al (2009), there was no negative effect on grain yield from applying more nitrogen early. The table also highlights large variations in grain yield between varieties & most interestingly demonstrates the potential of triticale (Bennetto & Grenado), which definitely warrant further investigation.

TABLE 1

Variety yields & fertiliser regime responses at Eryholme site 2009/10

	Variety	Fertiliser regime			
		110 / 110 kgN/ha	stat	60 / 160 kgN/ha	stat
1	Bennetto	11.27	a	10.81	b
2	Grenado	11.54	a	10.76	b
3	Robigus	10.94	b	10.06	c
4	Grafton	9.89	c	8.87	g
5	Invicta	9.77	cd	9.52	de
6	Warrior	9.16	fg	9.13	fg
7	JB Diego	9.08	fg	9.36	ef
8	Scout	9.09	fg	9.38	ef
9	CPBT 160	9.54	de	9.94	c
10	Glasgow	9.11	fg	9.31	ef

Fungicide activity

Rainfall at the site was the lowest for several seasons only 10mm in April, and 18mm in May. A typical average for each month would be in excess of 60mm & this led to a significantly reduced disease pressure & lodging risk. This led to small yield differences between fungicides. One conclusion from these findings is that fungicide programmes could be reduced in drier seasons. As fungicides only contribute about 1% of the GHG emissions of growing a wheat crop, this approach would have little environmental impact, but it could significantly reduce the input costs for growers. This conclusion should however be treated with caution, as weather conditions can rapidly alter during the season, and as prevention of cereal diseases is undoubtedly better than cure, the wrong product choice, dose rate or timing could be a false economy if conditions turn wetter potentially having a major detrimental effect on yield. Recent studies have shown that the less late disease there is, the higher the grain yield, the higher the specific weight and the higher the predicted alcohol yield. These studies would suggest that biofuel wheat should be treated like any other high value feed wheat. Even in a dry season as TABLE 2 shows, there were statistically improved yields from using some of the newer fungicide chemistry based on Boscalid & Pyraclostrobin (BAS667, Envoy & Tracker) and this is likely to be linked to physiological yield benefits that these offer over and above their fungicidal activity. It is also widely acknowledged that strobilurin fungicides improve the crops nitrogen recovery – not only is this likely to have a positive yield impact, but it could also reduced GHG emissions from growing a wheat crop.

TABLE 2 - FUNGICIDE YIELDS

TITLE: Eryholme Biofuels Project

TREATMENT LIST

	Fertiliser regime	T1 (BBCH 31)	T2 (BBCH 39)	T3 (BBCH 59)	Viscount	
					t/ha	Stat
1	110 / 110 kgN/ha	Untreated	Untreated	Untreated	9.64	fg
2	110 / 110 kgN/ha	Ennobe 1.0 + Bravo 1.0	Eclipse 1.12 + Bravo 1.0	Proline 250 0.4	9.33	g
3	110 / 110 kgN/ha	Ceando 0.75 + Bravo 1.0	Ceando 1.13 + Bravo 1.0	Proline 250 0.4	9.67	fg
4	110 / 110 kgN/ha	Envoy 1.0 + Bravo 1.0	Envoy 1.5 + Bravo 1.0	Proline 250 0.4	9.57	g
5	110 / 110 kgN/ha	Tracker 1.0 + Bravo 1.0	Tracker 1.5 + Bravo 1.0	Proline 250 0.4	10.02	c-g
6	110 / 110 kgN/ha	BAS 667 1.25 + Bravo 1.0	BAS 667 1.88 + Bravo 1.0	Proline 250 0.4	9.75	efg
7	110 / 110 kgN/ha	Proline 0.4 + Centaur 0.1 ·	Envoy 1.0 + Ennobe 0.5 + Bravo 1.0	Proline 250 0.4	9.79	efg
8	110 / 110 kgN/ha	Ceando 0.75 + Bravo 1.0	Envoy 1.0 + Ennobe 0.5 + Bravo 1.0	Proline 250 0.4	9.69	fg
9	110 / 110 kgN/ha	BAS 667 1.25 + Bravo 1.0	Envoy 1.0 + Ennobe 0.5 + Bravo 1.0	Proline 250 0.4	9.62	g
10	110 / 110 kgN/ha	BAS 667 1.66 + Bravo 1.0	Envoy 1.0 + Ennobe 0.5 + Bravo 1.0	Proline 250 0.4	9.91	d-g
11	60 / 160 kgN/ha	Untreated	Untreated	Untreated	10.83	abc
12	60 / 160 kgN/ha	Ennobe 1.0 + Bravo 1.0	Eclipse 1.12 + Bravo 1.0	Proline 250 0.4	10.56	b-e
13	60 / 160 kgN/ha	Ceando 0.75 + Bravo 1.0	Ceando 1.13 + Bravo 1.0	Proline 250 0.4	10.90	ab
14	60 / 160 kgN/ha	Envoy 1.0 + Bravo 1.0	Envoy 1.5 + Bravo 1.0	Proline 250 0.4	10.55	b-e
15	60 / 160 kgN/ha	Tracker 1.0 + Bravo 1.0	Tracker 1.5 + Bravo 1.0	Proline 250 0.4	11.54	a

Table 3 below demonstrates the theory that the higher the protein, the lower the starch, and hence the higher the alcohol yield. The table also provides some interesting information which requires further evaluation.

- Despite comparatively low starch yields per tonne, the triticale still produce the highest starch levels per hectare due to its high grain yield – this should however be treated with caution as the NIR calibration is only based on wheat samples, and hence there is no guarantee that they will be accurate for triticale. Whilst the suitability of triticale as a feedstock for biofuels is still not quantified, these results would suggest it requires further investigation. This could be particularly relevant in second & continuous wheat situations or on less fertile soils, where the ability of triticale to scavenge for nutrients may allow similar yields to wheat to be produced with lower nitrogen applications. As nitrogen is responsible for over 75% of the Green House Gas (GHG) emissions produced when growing a wheat crop, triticale could provide hugh environmental benefits.

- Hard endosperm wheats eg JB Diego can produce alcohol yields close to that of some of the softer wheats. This could be particularly relevant in second & continuous wheat situations where hard endosperm wheats tend to produce higher grain yields and therefore potentially more alcohol per hectare. Hard wheats have been traditionally dismissed from alcohol trials as the majority of trials have been carried out by the Scotch Whisky Research Institute (SWRI) who only screen soft wheats due to potential problems with residue viscosities of hard wheats and a limitation of enzymes available to extract the starch. On an industrial scale however extracting starch from hard wheats may be more practical and warrants further investigation.
- The variety Glasgow produced the highest alcohol yield per tonne. Whilst this variety is becoming a little left behind in terms of yield & agronomics, its high alcohol yield could be a useful trait in breeding newer varieties specifically for the bio ethanol market such as Denman (Alchemy * Glasgow). Denman with a further 14 varieties is being evaluated by the Grower Network in the 2010/11 trials at Eryholme.

TABLE 3 Shows interaction of fertiliser regime, variety & alcohol yield

	Variety	Fertiliser regime									
		110 / 110 kgN/ha					60 / 160 kgN/ha				
		Protein DM	Hardness	Starch	Alcohol Yield	Alc Yield /ha	Protein DM	Hardness	Starch	Alcohol Yield	Alc yield /ha
1	Bennetto	11.42	71.39	69.22	432.04	4869.11	10.63	62.68	71.98	444.84	4808.73
2	Grenado	10.47	54.15	72.56	447.84	5168.03	11.38	69.93	70.00	436.51	4696.89
3	Robigus	10.60	38.85	71.97	455.98	4988.37	11.07	26.86	71.25	451.03	4537.31
4	Grafton	11.66	58.63	69.74	443.11	4382.32	11.75	64.34	68.81	440.76	3909.52
5	Invicta	11.49	31.88	70.46	449.42	4390.87	11.28	37.45	70.45	448.40	4268.75
6	Warrior	11.33	49.61	68.14	439.72	4027.80	11.26	53.34	67.89	439.14	4009.32
7	JB Diego	11.23	54.48	70.75	446.69	4055.98	11.42	51.81	70.07	446.69	4181.00
8	Scout	11.19	52.05	69.14	444.88	4043.96	11.35	51.46	69.17	443.23	4157.46
9	CPBT 160	10.92	32.03	71.23	452.62	4318.00	11.22	27.62	70.55	449.03	4463.34
10	Glasgow	10.78	45.45	70.09	454.66	4141.92	11.00	51.21	69.79	453.05	4217.92

Following on from the results of 2009/10, the 2010/11 trial plan is summarised in Table 4.

Objectives of the trial

- Continue to apply early nitrogen to improve alcohol yields
- Continue to evaluate triticale
- Look at varietal interactions with earlier nitrogen & also compare hard endosperm wheats against soft endosperm varieties.

- Compare new & existing fungicides on stem based disease – which in a normal season is likely to be increased with early nitrogen in a second wheat situation

- Compare new & existing fungicides on foliar disease – which in a normal season is likely to be at a higher pressure earlier in the season with early nitrogen applications due to a denser canopy producing a more humid microclimate in the crop.

- Look at how application technology can improve performance of products by applying the product as accurately to the target as possible.

- Evaluate other nutritional products eg. sulphur

TABLE 4

2010/11 Winter wheat trials layout

AGROVISTA ERYHOLME DRILLING PLAN 2010

NOTE A and B = TRITICALE A BENNETTO B GRENADO Triticale drilled at 300 seed/square metre

C	TUXEDO	G	TARGET
D	GRAFTON	H	KWS 178
E	J B DIEGO	I	INVICTA
F	DUXFORD	J	HORATIO

All wheat drilled at 300 seed/square metre

Each main treatment replicated 3 times and each plot 12 metes long x drill width
Each candidate plot A-J is single plots 12 metre long x drill width duplicated

FUNGICIDE BLOCK A (STEM BASE) 2m SMALL PLOT DRILLING | **FUNGICIDE BLOCK B FLAG LEAF**

A	A	A	B	B	B	C	C	C	D	D	D	E	E	E	F	F	F	G	G	G	H	H	H	I	I	I	J	J	J	GAP	SANTIGO
A	A	A	B	B	B	C	C	C	D	D	D	E	E	E	F	F	F	G	G	G	H	H	H	I	I	I	J	J	J		DENMAN
ALCHEMY										**ALCHEMY**										**ALCHEMY**											BELUGA
OAKLEY										**OAKLEY**										**OAKLEY**											VISCOUNT
GRAVITAS										**GRAVITAS**										**GRAVITAS**											OAKLEY
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		**APPLICATION TECHNOLOGY TRIAL**

GROWER NETWORK OILSEED RAPE TRIALS

Oilseed rape is a very important crop in arable rotations, with the potential to produce the best gross margin of any break crop. However, in spite of developments in breeding, agronomy and nutrition, many growers find it difficult to achieve consistently high yields. In order for it to be a competitive biofuel crop it is important that we maximise yields in order to maintain the crops profitability and also improve the crops carbon footprint, by producing more yield from the land currently available therefore not affecting Land Use Change (LUC).

The maximum theoretical yield for winter oilseed rape in the UK on moisture retentive soils is believed to be about 9.2t/ha, and yet across the UK average yield struggles to get much above the 3t/ha level. The biggest influence on yield is undoubtedly the weather, but even when conditions are favourable, we still struggle to hit big yields on a consistent basis. Whilst this 9.2t/ha figure is going to require big improvements in genetics, husbandry & agronomy, we should focus our sites on what is currently achievable. Oilseed rape yield by definition is simply the number of seeds produced from a given area multiplied by the average weight of those seeds. We know we can achieve seed numbers in excess of 130 000 per square metre & we know we can achieve average thousand seed weights above 5g. The trick is combining these two traits and when we do yields in excess of 6.5t/ha are possible. In order to influence these traits, we need to look at the growth characteristics of the oilseed rape crop.

Seed number is determined by a period of approx 200 –300 day degrees Celsius (2-3 weeks) immediately after flowering. In order to maximise seed numbers it is important to produce the optimum canopy with a Green Area Index around 3.5. This is most likely to be achieved with a plant population in the spring of between 25 and 40 per square metre. Conventional varieties have consistently been sown at 100 seeds/m2 & hybrids at 65 seeds/m2.

Too thin a canopy and there is simply not enough green area to intercept enough solar radiation for optimum seed numbers, whereas too thick a canopy can lead to too many flowers reflecting solar radiation (up to 60% losses have been recorded). Thick canopies also tend to produce too many pods which tend to produce significantly less seeds per pod and ultimately less seeds per square metre. Pods are also relatively poor at photosynthesis compared to leaves, thus thicker canopies with lots of pods are often less efficient at utilising solar radiation. Further down the line, thicker crops are more likely to lodge & are more susceptible to diseases; hence seed fill is likely to be reduced. Thick canopies also prevent light penetration to the lower leaves. These leaves, kept in darkness, instead of photosynthesising will actually be respiring hence wasting energy. In summary by building too thick a canopy you are also building in the two biggest robbers of yield by increasing respiration and the amount of non harvestable material. The fact that around two thirds of osr yields are produced from the bottom third of the canopy highlights the need to allow light penetration and create the optimum canopy.

Once the number of seeds has been determined, the filling of these seeds is determined by the length of time available for photosynthesis & the efficiency of converting solar radiation into harvestable assimilates. To prolong this seed filling period It is vitally important to feed the plant with sufficient nutrients, ensure sufficient root structure to avoid moisture stress & keep the plant disease free for as long as possible. It should also be noted that oil content increases from 15% to 45% during the second half of seed filling further emphasising the need to keep the plant as healthy as possible for as long as possible!

Having achieved all of this it is then important to minimise harvest losses by correct timing (easier in a less dense more even canopy) and harvesting choice.

Large scale field trials have been carried out by the Grower Network over the past 3 seasons. This work has clearly demonstrated the importance of removing compaction to allow better rooting, and also to create an optimum canopy in order to achieve the highest yields.

Other work from Agrovista throughout the country, including two key sites in the north east in conjunction with Newcastle University at Cockle Park, and with Askham Bryan College at York has clearly demonstrated the potential for more consistency and higher yields when the crop is precision sown. Precision drilling however is a difficult, time consuming & expensive operation in practical farming, but is an area we are trying to emulate using practical equipment by manipulating row width and in-row plant numbers. The theory of this is to reduce inter plant competition and allow plants to exhibit their more natural prostrate growth habit rather than the erect habit they show when competing with each other for light.

Grower Network conclusions so far

- Big savings in establishments costs can be made with no detriment to yield
- Work rates & timeliness can be improved
- Evenly established low plant populations have given the most consistent yields
- Removing compaction is essential for root development
- Application technology can bring practical solutions eg. Improving performance of low drift nozzles with adjuvants can bring into play up to 8 extra spray days during April & May

The 2010/11 trial at Eryholme, Darlington is focussing on the following

- Grower Network best yields are coming from low, even plant populations. Therefore focussing on what seed rates are practically possible and how low a plant population is economically viable. From 4 seeds per square metre upwards.

- How best to manage a thick crop (sown at 120 seeds/m2) – delay nitrogen, growth regulation, topping, band spaying glyphosate etc

- 6 establishment techniques from 1 pass to 5 pass systems using latest equipment from Vaderstad, Simba, Sumo, Lemken and leading farmers from area including FT Gibbon & son, Adamsons contractors & AWSM Farms.

- Range of nutritional products to be evaluated:

    - DDGS (waste syrup from bio ethanol plant injected into stubble before drilling)
    - Various sulphur types from elemental to ammonium sulphate
    - Trace elements (in particular Boron & molybdenum)
    - Foliar potash & Magnesium
    - Late foliar nitrogen
    - Nitrogen abatement demonstration

A large scale Open Day is scheduled at Eryholme on Wednesday 29th June 2011 to demonstrate both the wheat & Oilseed rape plots & display results & conclusions to date.