Technical Note TN625

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SAC

Nitrogen recommendations for cereals, oilseed rape and potatoes.

SUMMARY

- **Nitrogen recommendations for cereals and winter oilseed rape include an adjustment for expected yield.**
- **Effects of economic changes on nitrogen rates for cereals and oilseed rape are tabulated.**
- **Nitrogen recommendations for potatoes take account of length of growing season, variety group and soil N residues.**
- **Nitrogen recommendations take account of new NVZ Action Programme rules and Nmax.**

Introduction

Nitrogen (N) recommendations for cereals, oilseed rape and potatoes have been updated in the light of recent trials results and advisory experience. Tables that take account of N released from previous crop residues, grass leys and N available from reserves in different soil types have been updated. The recommendations are consistent with the NVZ Action Programme rules and Nmax. Volatility in prices of fertiliser and grain has accentuated the need for guidelines on adjusting for the break-even ratio (BER). BER is the ratio between the purchase price of the N fertiliser per kg of N and the sale price per kg of the grain and defines the point at which further expense on fertiliser is not worthwhile. These adjustments depend on the rate of change of slope of the grain yield response curves, leaving aside the commercial issues concerning the time-lag between paying for the fertiliser and receiving payment for the grain, and judgement of which N rate should form the basis for adjustment. Cereal research has shown that the adjustment per point change in BER was relatively stable over the range of BER that has been experienced, averaging 11 and 8 kg/ha N per point increase for winter wheat and spring barley respectively (HGCA Project Report No.438, 2008). As there is insufficient research with modern oilseed rape varieties, the winter wheat adjustment is used for winter OSR and the spring barley adjustment for spring OSR.

Calculating the breakeven ratio (BER)

The breakeven ratio is the kg grain needed to pay for 1 kg of N. It is calculated as follows

$$\frac{\text{Price (£) per tonne of fertiliser} \times 100}{\text{Percent N in the fertiliser} \times 10} = \text{pence/kg of N}$$

$$\frac{\text{Price (£) per tonne of grain/seed}}{10} = \text{pence/kg of grain or seed}$$

$$\text{Breakeven ratio, BER} = \frac{\text{pence/kg of N}}{\text{pence/kg of grain or seed}}$$

Cereal recommendations are based on a standard breakeven ratio of 3:1 (i.e. 3kg grain needed to pay for each 1 kg of N), and a ratio of 2.5:1 for oilseed rape. The look-up table below shows the actual range of breakeven ratios for cereals and oilseed rape at different crop and ammonium nitrate prices.

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Cereal/OSR *(£/tonne)*	Ammonium nitrate (34.5% N) *(£/tonne)*								
	170	190	210	230	250	270	290	310	330
	Breakeven ratio								
70	7.0	7.9	8.7	9.5	10.4	11.2	12.0	12.8	13.7
90	5.5	6.1	6.8	7.4	8.1	8.7	9.3	10.0	10.6
110	4.5	5.0	5.5	6.1	6.6	7.1	7.6	8.2	8.7
130	3.8	4.2	4.7	5.1	5.6	6.0	6.5	6.9	7.4
150	3.3	3.7	4.1	4.4	4.8	5.2	5.6	6.0	6.4
170	2.9	3.2	3.6	3.9	4.3	4.6	4.9	5.3	5.6
190	2.6	2.9	3.2	3.5	3.8	4.1	4.4	4.7	5.0
210	2.3	2.6	2.9	3.2	3.5	3.7	4.0	4.3	4.6
230	2.1	2.4	2.6	2.9	3.2	3.4	3.7	3.9	4.2
250	2.0	2.2	2.4	2.7	2.9	3.1	3.4	3.6	3.8
270	1.8	2.0	2.3	2.5	2.7	2.9	3.1	3.3	3.5

Once the farm breakeven ratio is known, the following adjustments to the recommended rates should be made. Reductions in N use may not be appropriate for milling wheat where achieving a grain protein content of 13% (dry matter) is important.

Actual BER	Reduce by kg/ha N	
	Winter cereals & OSR	Spring cereals & OSR
2.5-3.5	0	0
>3.5-4.5	11	8
>4.5-5.5	22	16
>5.5-6.5	33	24
>6.5-7.5	44	32
>7.5	55	40

Where organic materials are applied full account should be taken of the fertiliser nutrients (including N) in order to optimise economic performance and to minimise leaching of excess N as nitrate. The amount of N available to the crop in the years following the application of organic materials depends on the type of material applied, the method and timing of application, and the soil type. Applications of organic materials to individual fields should not exceed 250 kg /ha of total N from the organic material in any 12 month period (this is mandatory in NVZs). The area of the field used to calculate the 250 kg/ha limit should exclude any areas where manures are not spread. Information on the N contents of organic materials can be found in SAC Technical Note TN622 (publ. Jan 2010) on manures and organic materials.

N recommendations for different crops

In order to assess the fertiliser N required for each crop in each field, the following factors need to be taken into account:

Soil type	Table 1
Previous crop	Table 2
Previous grass/clover management	Table 3
Crop to be grown and intended market	Tables 4 to 10
Winter rainfall	Tables 4 to 10

N residues from different soil types and assessment of texture

Nitrogen residues from soil reserves have been arranged into six soil types (see Table 1). "Shallow" means any mineral soil with less than 40 cm depth between the soil surface and the underground rock. Types of mineral soils can be identified by hand texturing. Take about a dessertspoonful of soil. If dry, wet up gradually kneading thoroughly between finger and thumb until aggregates are broken down. Enough moisture is needed to hold the soil together and for the soil to exhibit its maximum cohesion. There are 2 questions to be answered:

Question 1	Is it difficult to roll the moist soil into a ball?
Answer	YES, then the soil type is "Sand"; NO, then ask the second question.
Question 2	Does the moist soil feel smooth and silky as well as gritty?
Answer	NO, then the soil type is "Sandy loam"; YES, then the soil type is "Other mineral soil".

"Humose" and "Peaty soils" are identified by percent organic matter, which can be confirmed by laboratory analysis.

Where more than one soil type occurs within a field it may be practical to alter the rate of fertiliser N to suit the different soil types. If this is not practical and the field is to be treated uniformly, select the soil type that covers the largest part of the field. In mineral soils of low organic matter content, the amount of available N residues is relatively small, whereas in humose and peaty sites low N malting barley is not encouraged as N release occurs late in the season and ends up in the grain.

N residues from previous crops

The last crop grown has been allocated into one of five Previous Crop Groups. These Groups are numbered 1 to 5 in ascending order of residual available N in the soil following harvest of the previous crop (see Table 2). Residual available N in the soil following harvest will vary depending on the crop type grown. Residues following cereals are generally lower than those following break crops. The management and performance of the previous crop can have a significant effect on the actual level of N residues. Residues are expected to be lower in a high yielding season or where N application has been less than normal,

but may be higher than average if the crop has performed badly due to problems such as disease or drought. In tables of N requirements in this Note it is assumed that all previous crops have been managed well and that previous N fertiliser use has been close to the recommended rate, taking account of any use of organic manures. In Group 5, N residues can be very variable. Analysis of the crop debris for total N and C content along with an estimate of the quantity ploughed down is recommended in order to help predict release of available N for the next crop. For further information, see SAC T487 (Incorporation of C-rich organic amendments with N-rich vegetable crop residues to minimise nitrate leaching).

N residues from previous grass/clover swards

Nitrogen fertiliser and manure use in the last 2 years of the grassland, and grazing management during the months immediately prior to ploughing out grassland will have a significant effect on the level of N residues. Managements of the previous grass/clover sward have been allocated into one of five Groups. These Groups are numbered 2 to 6 in ascending order of residual available N in the soil following ploughing out of the grassland (see Table 3). Groups 2 to 5 have the same N residues as Groups 2 to 5 in the Previous Crop Groups (Table 2), whereas Group 6 has a higher residue of available N. N residues can be very variable in Groups 5 and 6.

Table 1: Description of soil types

Shallow soils	All mineral soils which are less than 40cm deep.
Sands	Soils which are sand and loamy sand textures to a depth more than 40cm.
Sandy loams	Soils which are sandy loam texture to a depth of more than 40cm.
Other mineral soils	Soils with less than 15 percent organic matter that do not fall into the sandy or shallow soil category i.e. silty and clay soils.
Humose soils	Soils with between 15 and 35 percent organic matter. These soils are darker in colour, stain the fingers black or grey, and have a silky feel.
Peaty soils	Soils that contain more than 35 percent organic matter.

Table 2: Previous Crop Nitrogen Residue Groups in ascending order of residual available N in the soil following harvest

Group	Previous Crop
1	spring barley, spring oats, spring rye, spring wheat, winter barley, winter oats, winter wheat, triticale, carrots, shopping swedes, turnips (human consumption), linseed, courgette, onions, asparagus, beetroot (red baby, other), radish, narcissus, tulip, swedes/turnips (stockfeed), parsnips, ryegrass for seeds.
2	harvested fodder (whole crop), forage maize, forage rape, winter oilseed rape, spring oilseed rape, hemp, vining peas, potatoes (<60 days, seed and punnets), potatoes (60-90 days, seed and punnets), potatoes (60-90 days, ware), potatoes (90-120 days), potatoes (>120 days), blackberries, loganberries, blackcurrants, redcurrants, blueberries, tayberries.
3	harvested fodder (root only), beans (broad), beans (dwarf/runner), beans (field vining), combining peas and whole-crop lupins, leek, rhubarb, strawberries (both types), raspberries, uncropped.
4	grain lupins, lettuce.
5	leafy brassica vegetables, leafy non-brassica vegetables, grazed fodder, turnips grazed, brussels sprouts, cabbage (all types), calabrese (broccoli), cauliflower, kale.

Table 3: Previous Grass/Clover Nitrogen Residue Groups in ascending order of residual available N in the soil following ploughing out.

Group	Previous Grass/Clover management
2	1-2 year low N* leys and not grazed within 2 months of ploughing
3	1-2 year low N leys and grazed within 2 months of ploughing 1-2 year high N leys* and not grazed within 2 months of ploughing Thin permanent grass, low N, no clover
4	1-2 year high N leys and grazed within 2 months of ploughing 3-5 year low N leys and not grazed within 2 months of ploughing Thick permanent grass, low N
5	3-5 year high N leys and not grazed within 2 months of ploughing 3-5 year low N leys and grazed within 2 months of ploughing Permanent grass, high N, not grazed within 2 months of ploughing
6	3-5 year high N leys and grazed within 2 months of ploughing Permanent grass, high N, grazed within 2 months of ploughing

* *Low N: less than 150kg/ha/year fertiliser N used on average in last 2 years.*
High N: more than 150kg/ha/year fertiliser N used on average in last 2 years, or high clover.

Winter rainfall

The drier the winter and the greater the soil capacity to hold water, the smaller the proportion of N from crop residues that will be washed out of the soil before crop growth starts in the spring. If winter rainfall between 1 October and 1 March is more than 450mm (18 inches) then standard N recommendations should be adjusted according to the information in the crop Tables 4 to 10.

Winter cereals (Tables 4 and 5)

Autumn nitrogen is NOT generally recommended, as profitable responses are not normally attained and the practice will increase N losses to watercourses. There is a possible N requirement in some winter barley that has been direct drilled, established following minimum cultivation, or established after ploughing down large quantities of straw e.g. after carrots.

Spring N is best applied as a split dressing. In general a 33%/67% (one-two thirds) split between the start of spring growth and growth stage 30-31 is recommended. A 20/80 split will improve bread-making quality and help to prevent lodging, a 50/50 split will help to reduce grain N% for malting or distilling. For wheat grown for breadmaking/milling the additional 40 kg/ha, as shown in Table 4, should be applied either as a solid fertiliser as soon as the flag leaf is fully emerged, or as a foliar spray at the milky ripe stage in order to increase grain protein. These adjustments in timing should be used in conjunction with adjustments in the amount of N applied.

Spring cereals (Tables 6 and 7)

Nitrogen recommendations should be reduced for crops which are sown ten days or more after the optimum sowing period. Pressure of spring work and adverse weather can often account for delays in excess of ten days. In these circumstances the N recommendation should be reduced for crops which are sown ten days or more after the optimum sowing period by approximately 1.5 kg/ha/day for each day of delay for feed or high N malting and 2.25 kg/ha/day for low N malting.

For crops sown up to the beginning of April apply half fertiliser N to seedbed and half at 2-3 leaf stage for low N malting and start of tillering for feed. For high N malting crops use feed recommendations. From beginning of April onwards, all may be applied to seedbed.

Combine drilling is recommended for early sown crops and crops grown in high soil pH (>6.4). Combine drilling of urea is NOT recommended as close contact with germinating seed can be damaging. Combine-drilled fertiliser should be limited to 150 kg/ha N + K_2O on sands and sandy loams.

Winter oilseed rape (Table 8)

It is important to sow oilseed rape early in order to achieve sufficient plant size to withstand winter conditions. Sowing date is particularly important in Scotland and the end of August is recognised as the latest advisable sowing date for most areas. Winter barley is generally the most suitable crop for entry of winter oilseed rape in Scotland, although in some areas and in earlier seasons spring barley may be harvested early enough to provide a suitable entry. Autumn sown rape can produce about 20-25 t/ha fresh material by December, and seedbed/autumn application of N is recommended following crops/grass in N residue groups 1, 2 and 3. N top dressing in spring is best split, applying half at the start of spring growth and half prior to stem elongation.

Spring oilseed rape (Table 9)

Spring sown crops generally utilise soil N more efficiently than winter crops. Their requirement for N coincides with the normal period of soil N release in May and June whereas winter crops require N when the soil is still too cold for soil N release in March.

Table 4: Winter wheat: N recommendations in kg/ha

Previous crop or grass N group (Table 2 or 3)	1	2	3	4	5	6
Sands and shallow soils	220	210	200	180	150	110
Sandy loams and other mineral soils	200	190	180	160	130	90
Humose soils	140	130	120	100	70	30
Peaty soils	80	70	60	40	10	0
Adjustments:						
Milling varieties	+40	+40	+40	+40	+40	+40
Grain distilling	0	0	0	0	0	0
Whole crop	0	0	0	0	0	0
Yield adjustment*						
Winter rainfall (1 Oct – 1 Mar)						
More than 450mm (18 inches)						
Sands, sandy loams, shallow soils	0	+10	+20	+20	+20	+20
All other soils	0	+10	+10	+10	+10	+10

***Triticale**: use winter wheat recommendation -20 kg/ha N. There is no yield adjustment for triticale.*

* *An additional 20kg/ha may be justified for every tonne that the expected yield exceeds 8t/ha, and is permitted in NVZs where farm average yield is backed up by at least 3 years of yield records.*

Table 5: Winter barley: N recommendations in kg/ha

Previous crop or grass N group (Table 2 or 3)	1	2	3	4	5	6
Sands and shallow soils	200	190	180	170	140	100
Sandy loams and other mineral soils	180	170	160	140	110	70
Humose soils	120	110	100	80	50	10
Peaty soils	80	70	60	40	10	0
Adjustments:						
Malt for distilling	-50	-50	-50	-50	-50	-50
Malt for brewing	-30	-30	-30	-30	-30	-30
Grain distilling	0	0	0	0	0	0
Whole crop	0	0	0	0	0	0
Yield adjustment*						
Winter rainfall (1 Oct – 1 Mar)						
More than 450mm (18 inches)						
Sands, sandy loams, shallow soils	0	+10	+20	+20	+20	+20
All other soils	0	+10	+10	+10	+10	+10

***Winter oats**: use winter barley recommendation - 40 kg/ha N for all mineral soils*
- 30 kg/ha N for humose and peaty soils

* *An additional 15kg/ha may be justified for every tonne that the expected winter barley yield exceeds 6.5t/ha (winter oat yield of 6.0t/ha), and is permitted in NVZs where farm average yield is backed up by at least 3 years of yield records.*

Table 6: Spring barley (FEED): N recommendations in kg/ha

Previous crop or grass N group (Table 2 or 3)	1	2	3	4	5	6
Sands and shallow soils	150	140	130	110	80	40
Sandy loams and other mineral soils	130	120	110	90	60	20
Humose soils	80	70	60	40	10	0
Peaty soils	50	40	30	10	0	0
Adjustments:						
High N grain distilling	+15	+15	+15	+15	+15	+15
Undersown crop	-25	-25	-25	-25	-25	-25
Whole crop	0	0	0	0	0	0
Yield adjustment*						
Delayed sowing – Reduce by 1.5 kg/ha/day for each day of delay after 10 days after your optimum sowing period						
Winter rainfall (1 Oct – 1 Mar)						
More than 450mm (18 inches)						
Sands, sandy loams, shallow soils	0	+10	+20	+20	+20	+20
All other soils	0	+10	+10	+10	+10	+10

***Spring oats and rye**: use SB (FEED) recommendations - 30 kg/ha N*

* *An additional 15kg/ha may be justified for every tonne that the expected spring barley yield exceeds 5.5t/ha (spring oat yield of 5.0t/ha), and is permitted in NVZs where farm average yield is backed up by at least 3 years of yield records.*

Table 7: Spring barley (LOW N MALTING): N recommendations in kg/ha

Previous crop or grass N group (Table 2 or 3)	1	2	3	4	5	6
Sands and shallow soils	130	120	110	*	*	*
Sandy loams and other mineral soils	110	100	90	*	*	*
Humose soils	*	*	*	*	*	*
Peaty soils	*	*	*	*	*	*
Adjustments:						
Undersown crop	-25	-25	-25	*	*	*
Delayed sowing – Reduce by 2.25 kg/ha/day for each day of delay after 10 days after your optimum sowing period						
Winter rainfall (1 Oct – 1 Mar)						
More than 450mm (18 inches)						
Sands, sandy loams, shallow soils	0	+10	+20	*	*	*
All other soils	0	+10	+10	*	*	*

* *Avoid growing malting barley after crops in groups 4 – 6 and humose/peaty soils that leave high N residues.*

Table 8: Winter oilseed rape: N recommendations in kg/ha

Previous crop or grass N group (Table 2 or 3)	1	2	3	4	5	6
Seedbed :						
All soils	30	20	10	0	0	0
Spring:						
All mineral soils	200	190	180	140	110	70
Humose soils	120	110	100	80	50	10
Peaty soils	80	70	60	40	0	0
Adjustments:						
Yield adjustment*						
Winter rainfall (1 Oct – 1 Mar)						
More than 450mm (18 inches)						
Sands, sandy loams, shallow soils	0	+10	+20	+20	+20	+20
All other soils	0	+10	+10	+10	+10	+10

* *Up to an additional 30kg/ha may be justified in spring if the expected yield is over 4.0t/ha, and is permitted in NVZs where farm average yield is backed up by at least 3 years of yield records. This adjustment should be used with caution because applying too much early nitrogen to crops with large canopies can increase lodging and may reduce yield.*

Table 9: Spring oilseed rape: N recommendations in kg/ha

Previous crop or grass N group (Table 2 or 3)	1	2	3	4	5	6
All mineral soils	100	90	80	60	30	0
Humose soils	50	40	30	10	0	0
Peaty soils	20	10	0	0	0	0
Adjustments:						
Winter rainfall (1 Oct – 1 Mar)						
More than 450mm (18 inches)						
Sands, sandy loams, shallow soils	0	+10	+20	+20	+20	+20
All other soils	0	+10	+10	+10	+10	+10

Potatoes (Table 10)

Nitrogen increases haulm growth and persistence. The increase in haulm growth is accompanied by delayed tuber initiation and growth. The main benefit of high N is the greater length of the tuber bulking period, linked to improved haulm persistence. Only moderate amounts of N are required for maximum bulking rates up to the normal 'burning off' dates for specialist seed and punnet production. Nitrogen usually increases tuber yield more than tuber number, hence average tuber size is increased as is the proportion of 'ware' in the crop. For these reasons the amount of N recommended increases as the expected burning off date is delayed.

The previous crop/grass N residue group should be used together with the anticipated length of growing season, intended market and variety group to determine the appropriate range of N rates. The length of growing season is the number of days from 50% emergence to haulm death. Recommendations are for optimum growing conditions. Where soil compaction, PCNs or free-living nematodes have the potential to reduce root growth, guidance should be sought from FACTS-qualified advisors. No adjustment is required for irrigated crops. Irrigation should be applied according to a recognised scheduling system, which minimises the risk of returning soils to field capacity and triggering leaching. For ware crops grown on sands, sandy loam and shallow soils apply half to two-thirds of the N recommendation in the seedbed and the remainder at tuber initiation.

Table 10: Potatoes: N recommendations in kg/ha

Length of growing season	Variety group[1]	*Previous crop or grass N Residue Group*					
		1	**2**	**3**	**4**	**5**	**6**
< 60 days (seed & punnets)	1	80	70	60	40	0	0
	2	60	50	40	20	0	0
	3	40	30	20	0	0	0
	4	N/A	N/A	N/A	N/A	N/A	N/A
60-90 days (seed & punnets)	1	100	90	80	60	30	0
	2	80	70	60	40	0	0
	3	60	50	40	20	0	0
	4	50	40	30	0	0	0
60-90 days (ware)	1	200	190	180	160	130	90
	2	150	140	130	110	80	40
	3	120	110	100	80	50	0
	4	80	70	60	40	0	0
90-120 days	1	240	230	220	200	170	130
	2	200	190	180	160	130	90
	3	160	150	140	120	90	50
	4	120	110	100	80	50	0
> 120 days	1	N/A	N/A	N/A	N/A	N/A	N/A
	2	220	210	200	180	150	110
	3	180	170	160	140	110	70
	4	140	130	120	100	70	30

[1]Variety group (examples):

- 1 – short haulm longevity (determinate varieties) – e.g. Estima, Maris Bard, Rocket, Premiere
- 2 – medium haulm longevity (partially determinate varieties) – e.g. Accord , Atlantic, Lady Rosetta, Maris Peer, Nadine, Pentland Dell, Saxon, Shepody, Wilja.
- 3 – long haulm longevity (indeterminate varieties) - e.g. Maincrop varieties such as Desiree, Fianna, Hermes, King Edward, Marfona, Maris Piper, Rooster, Russet Burbank, Pentland Squire, Saturna
- 4 – very long haulm longevity – e.g. Cara, Markies

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