Technical Note TN621

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SAC

# Fertiliser recommendations for vegetables, minority arable crops and bulbs

## SUMMARY


- **Vegetables and some of the minority crops can have a high value.**
- **Production costs are also often high, with fertilisers accounting for a very small percentage of variable costs.**
- **Fertilisers should be applied at rates that are likely to result in the maximum yield of crops of acceptable quality, whilst ensuring protection of the surrounding environment.**
- **Nitrogen (N) recommendations for these crops 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 those that give the best financial return for the farmer/grower. Adoption of the recommendations is consistent with the new NVZ Action Programme rules and Nmax and will minimise losses of N to the environment.**


## A. Nitrogen recommendations

**In order to assess the N fertiliser requirements for each crop, the following factors need to be taken into account:**

| | | |
|---|---|---|
| Stage A1: | Crop to be grown (taking account of the previous crop or previous grass/clover management) | Tables A1a, A1b, A1c, A1d, A1e, A1f |
| Stage A2: | Adjustments for individual crop types/markets, expected yields and Spring/Summer rainfall | |
| Stage A3: | Adjustments for soil type | Tables A3a, A3b |
| Stage A4: | Adjustments for Winter rainfall | Table A4 |
| Stage A5: | Adjustments following applications of bulky organic manures | |
| Stage A6: | Special crop requirements (N fertiliser requirements, timing and placement) | |

## Stage A1. Crop to be grown (taking account of the previous crop or previous grass/clover management)

The amount of fertiliser N which should be applied to any crop will depend on the previous crop or grass/clover management in the field in which the crop is to be grown. Details of how to allocate the correct "Previous crop/grass Nitrogen Residue Group" to the field are given in Tables A1a and A1b. The N recommendations for each of the main vegetable and minority arable crop types grown in Scotland are listed in Tables A1c, A1d, A1e and A1f. The required N can be applied wholly as manufactured fertiliser, although some may be derived from bulky organic manures and from soil reserves. Adjustments to the standard values given in Tables A1c, A1d, A1e and A1f should be made by following stages A2 to A6 as described in this Technical Note. Specialist guidance may be needed when making decisions for specific crops.

### N residues from previous crops

Where crops other than grass have been grown prior to the intended vegetable or minority crop, these have been allocated into one of five previous crop groups. These groups are numbered 1 to 5 in ascending order of residual N in the soil, following harvest of the previous crop (Table A1a). 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 leafy crops, potatoes and legumes. The management and performance of the previous crop can have a significant effect on the 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 as a result of problems such as disease or drought. In the tables of N recommendations 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 into account 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.

**Table A1a. Previous crop groups in ascending order of residual available N in the soil following harvest**

| Group | Previous crop |
|---|---|
| 1 | spring barley, spring oats, 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 (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, 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 |

*N residues can be variable in this group. Analysis of the crop debris for total N and C content prior to ploughing down is recommended in order to help predict release of available N for the next crop.

### N residues from previous grass/clover swards

Nitrogen fertiliser and manure use in the last 2 years of grassland management, and grazing management during the months immediately prior to ploughing out grassland will have a significant effect on the level of N residues. Management of the previous grass/clover sward has 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 (A1b). Groups 2 to 5 have the same N residues as groups 2 to 5 in the previous crop groups (Table A1a), whereas group 6 has a higher residue of available N. N residues can be very variable in groups 5 and 6. Analysis of the sward for total N and C content, along with an estimate of the total quantity of the sward ploughed down is recommended in order to help predict release of available N for the next crop.

For potatoes (Table A1e), the previous crop/grass nitrogen 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.

**Table A1b. Previous grass/clover 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[1] leys and not grazed within 2 months of ploughing out or during Sept./Oct. |
| **3** | 1 – 2 year low N leys and grazed within 2 months of ploughing out or during Sept./Oct.<br>1 – 2 year high N leys and not grazed within 2 months of ploughing out or during Sept./Oct.<br>Thin, permanent grass, low N, no clover |
| **4** | 1 – 2 year high N leys and grazed within 2 months of ploughing out or during Sept./Oct.<br>3 – 5 year low N leys and not grazed within 2 months of ploughing out or during Sept./Oct.<br>Thick, permanent grass, low N |
| **5[2]** | 3 – 5 year high N leys and not grazed within 2 months of ploughing out or during Sept./Oct.<br>3 – 5 year low N leys and grazed within 2 months of ploughing out or during Sept./Oct.<br>Permanent grass, high N, not grazed within 2 months of ploughing out or during Sept./Oct. |
| **6[2]** | 3 – 5 year high N leys and grazed within 2 months of ploughing out<br>Permanent grass, high N, grazed within 2 months of ploughing out |

[1]Low N means less than 150 kg/ha/yr fertiliser N used on average in last 2 years.
High N means more than 150 kg/ha/yr fertiliser N used on average in last 2 years or high clover content.
[2]N residues can be variable in these groups. Analysis of the sward for total N and C content prior to ploughing out is recommended in order to help predict release of available N for the next crop. Soil mineral N testing is not recommended in established grassland, or in the first year after ploughing out grassland, but it may be useful in the second year. In ley-arable rotations where the grass is down for 3 or more years, the most useful N is released within the first two seasons after ploughing out, although some N may be released for the third and fourth crops.

**Table A1c: Brassicas, courgettes, lettuces, alliums, asparagus and legumes: nitrogen recommendations in kg/ha**

| Crop | Previous crop/grass Nitrogen Residue Group | | | | | |
|---|---|---|---|---|---|---|
| | **1[1]** | **2** | **3** | **4** | **5** | **6** |
| Brussels sprouts | 300 | 290 | 280 | 260 | 210 | 170 |
| Cabbage (all types) | 340 | 330 | 320 | 300 | 250 | 210 |
| Calabrese (broccoli) | 270 | 260 | 250 | 230 | 180 | 140 |
| Cauliflowers | 290 | 280 | 270 | 250 | 210 | 160 |
| Courgettes | 100 | 100 | 100 | 40 | 0 | 0 |
| Lettuce | 200 | 190 | 180 | 160 | 110 | 70 |
| Leeks | 275 | 265 | 255 | 235 | 185 | 145 |
| Onions, salad | 130 | 120 | 110 | 90 | 70 | 50 |
| Onions, bulb | 160 | 130 | 110 | 90 | 60 | 0 |
| Asparagus[2] | 150 | 140 | 130 | 110 | 90 | 70 |
| Asparagus[3] | 120 | 120 | 120 | 120 | 120 | 120 |
| Lupins | 0 | 0 | 0 | 0 | 0 | 0 |
| Beans, broad | 0 | 0 | 0 | 0 | 0 | 0 |
| Beans, dwarf/runner[4] | 180 | 150 | 120 | 80 | 30 | 0 |
| Beans, field (vining) | 0 | 0 | 0 | 0 | 0 | 0 |
| Peas, vining/combining/fresh market | 0 | 0 | 0 | 0 | 0 | 0 |

[1]For descriptions of previous crop groups and previous grass/clover groups, see Tables A1a and A1b
[2]Asparagus in its establishment year
[3]Asparagus in year 2. In following years, the amount and timing of N should depend on the soil type. If the crop is on light soil and Winter rainfall was high, apply 40 – 80 kg N/ha by the end of February, with an additional 40 – 80 kg N/ha after harvest. Following moderate or low Winter rainfall, apply 40 – 80 kg N/ha just after harvest to provide N for fern growth.
[4]Runner beans only may require an additional top-dressing of up to 75 kg N/ha at early picking stage.

**Table A1d: Hemp, linseed, forage maize, forage rape and kale: nitrogen recommendations in kg/ha**

| Crop | Previous crop/grass nitrogen residue group | | | | | |
|---|---|---|---|---|---|---|
| | 1[1] | 2 | 3 | 4 | 5 | 6 |
| Hemp | 150 | 140 | 130 | 110 | 90 | 70 |
| Linseed | | | | | | |
| *Sands, Shallow* | 80 | 70 | 60 | 40 | 10 | 0 |
| *Sandy loam, Other mineral* | 60 | 50 | 40 | 20 | 0 | 0 |
| *Humose* | 30 | 20 | 10 | 0 | 0 | 0 |
| *Peaty* | 0 | 0 | 0 | 0 | 0 | 0 |
| Forage maize, rape | | | | | | |
| *Sands, Shallow* | 140 | 130 | 120 | 100 | 70 | 30 |
| *Sandy loam, Other mineral* | 120 | 110 | 100 | 80 | 50 | 10 |
| *Humose* | 70 | 60 | 50 | 30 | 0 | 0 |
| *Peaty* | 40 | 30 | 20 | 0 | 0 | 0 |
| Kale | | | | | | |
| *Sands, Shallow* | 180 | 170 | 160 | 140 | 110 | 70 |
| *Sandy loam, Other mineral* | 160 | 150 | 140 | 120 | 90 | 50 |
| *Humose* | 100 | 90 | 80 | 60 | 30 | 0 |
| *Peaty* | 60 | 50 | 40 | 20 | 0 | 0 |

[1]For descriptions of previous crop groups and previous grass/clover groups, see Tables A1a and A1b

**Table A1e: Potatoes: nitrogen recommendations in kg/ha**

| Length of growing season | Variety group[1] | Previous crop/grass nitrogen residue group | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1[2] | 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 |

| Length of growing season | Variety group[1] | Previous crop/grass nitrogen residue group | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1[2] | 2 | 3 | 4 | 5 | 6 |
| | 2 | 225 | 215 | 205 | 185 | 155 | 115 |
| | 3 | 200 | 190 | 180 | 160 | 130 | 90 |
| | 4 | 150 | 140 | 130 | 110 | 80 | 40 |

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

[2]For descriptions of previous crop groups and previous grass/clover groups, see Tables A1a and A1b

**Table A1f: Root crops and bulbs: nitrogen recommendations in kg/ha**

| Crop | Previous crop/grass Nitrogen Residue Group | | | | | |
|---|---|---|---|---|---|---|
| | **1[1]** | **2** | **3** | **4** | **5** | **6** |
| Carrots | 60 | 50 | 40 | 20 | 0 | 0 |
| Parsnips | 150 | 140 | 130 | 110 | 80 | 40 |
| Shopping swedes, turnips (human consumption) and Swedes/turnips (stockfeed) | | | | | | |
| *Sands, Shallow* | 110 | 100 | 90 | 70 | 40 | 0 |
| *Sandy loam, Other mineral* | 90 | 80 | 70 | 50 | 20 | 0 |
| *Humose* | 50 | 40 | 30 | 10 | 0 | 0 |
| *Peaty* | 20 | 10 | 0 | 0 | 0 | 0 |
| Beetroot, red baby | 185 | 175 | 165 | 145 | 95 | 55 |
| Beetroot, other | 200 | 190 | 180 | 160 | 110 | 70 |
| Fodder beet | 100 | 90 | 80 | 60 | 30 | 0 |
| Radish | 80 | 70 | 60 | 40 | 20 | 0 |
| Narcissus[2] | 100 | 90 | 80 | 60 | 30 | 0 |
| Tulips | 100 | 90 | 80 | 60 | 30 | 0 |

[1]For descriptions of previous crop groups and previous grass/clover groups, see Tables A1a and A1b
[2]Value in table relates to establishment of crops. For established crops, apply 40 kg/ha/annum, if wishing to extend flowering stem length.

## Stage A2. Adjustments for individual crop types/markets, expected yields and Spring/ Summer rainfall

Adjustments to the N recommendations given in Tables A1c, A1d, A1e and A1f may have to be made to optimise crop quality and economic performance. Crops of any given type will require slightly different amounts of N depending on the variety, the intended market and on the expected yield (based on previous yields which will be affected by management practices, soil type, soil nutrient status and topography in particular). Where yields are likely to be significantly different from those normally expected, adjust the N recommendation. The adjustment to the N recommendation would depend on the way in which yield affects rooting. If soil is relatively deep, and the increase in yield gives rise to more rooting, then the fertiliser requirement may be no different. It could also be that very low yielding crops could have higher N requirements because of very shallow rooting.

Some crop varieties will require more N than others, for example, some older varieties of Brussels sprouts may need more N in order to ensure that they reach sufficient height, and baby vegetables will require less N than fully grown crops. Where lettuce or other crops are grown twice in a season, reduce the N application to the second crop. Each crop will need to be considered with care, since the rooting depth of the lower yielding crops is likely to be less, so less soil N will be available.

Where crops are grown under protection for all or part of the season (e.g. under fleece, cloches or tunnels), it may be possible to reduce the N application. However, this may not apply to very early crops established into cold soils.

Some N may be lost from the soil profile between first and final Spring N dressings. The amount lost will depend on the amount of rain that falls once the soil is already at water-holding capacity, the crop cover and rooting depth. It may only be necessary to make an adjustment for shallow-rooted crops.

Specialist guidance may be needed when deciding on N fertiliser application rates in relation to any of the factors discussed above.

## Stage A3. Adjustments for soil type

N residues from soil reserves have been arranged into six soil types (Table A3a). "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 dessertspoon of soil. If dry, wet it 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 two 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 soils" 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 impractical, and the field is to be treated uniformly, you should 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.

The standard N recommendations in Tables A1c, A1d, A1e and A1f are for crops grown in sandy loams, other mineral soils, humose and peaty soils. For most crops grown in sands and shallow soils, the N recommendation should be increased by 10% (Table A3b). Exceptions include linseed, forage maize, forage rape, kale, shopping swedes and turnips, where extra adjustments are detailed in Tables A1d and A1f.

## Stage A4. Adjustments for 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 450 mm, then the standard N recommendations should be adjusted according to Table A4.

## Stage A5. Adjustments following applications of bulky organic manures

Many growers of vegetables and minority crops choose to apply bulky organic materials (including animal manures, composts and anaerobic digestates) as part of their fertiliser strategy and in an effort to maintain or enhance soil quality. It is important that full account is taken of the fertiliser nutrients (including N) within them in order to optimise crop quality, economic performance and to minimise any environmental impact (for example through 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 of application, the soil type and the month and year of application. 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

**Table A3a Description of soil types**

| | |
|---|---|
| **Shallow soils (SS)** | All mineral soils which are less than 40cm deep. |
| **Sands (S)** | Soils which are sand and loamy sand textures to a depth of more than 40cm. |
| **Sandy loams (SL)** | Soils which are sandy loam texture to a depth of more than 40cm. |
| **Other mineral soils (OMS)** | 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 (HS)** | 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 (PS)** | Soils that contain more than 35 percent organic matter. |

**Table A3b Adjustment to standard N recommendation for different soil types**

| Crop | Soil type | |
|---|---|---|
| | Sands and shallow soils | All other types |
| Vegetables[1] and minority crops other than linseed, forage maize, forage rape, kale, shopping swedes, turnips (human consumption) and swedes/ turnips (stockfeed) (extra adjustments are detailed in tables A1d and A1f) | Add 10% | No change |
| [1]Vegetables are grown on sands but very rarely grown on shallow soils (less than 40 cm over rock) | | |

**Table A4 Adjustment to standard N recommendation following excessive Winter rainfall**

| **Crop** | Winter rainfall > 450 mm | | |
|---|---|---|---|
| | **Sands, sandy loams and shallow soils, previous crop group 2** | **Sands, sandy loams and shallow soils, previous crop groups 3 - 6** | **All other soils, previous crop groups 2 - 6** |
| **All vegetable and minority crops** | Add 10 kg/ha | Add 20 kg/ha | Add 10 kg/ha |

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 622 on manures and organic materials.

## Stage A6. Special crop requirements (N fertiliser requirements, timing and placement)

**Starter fertiliser** - The injection of starter fertiliser containing both N and phosphate ($P_2O_5$, see Section B) below the seed or around the roots of transplants can improve the growth and quality of many crops. The amount used should be deducted from the recommended rate when applying the remainder of the N, which should be applied ideally when the soil surface is moist.

**Band spreading** – For some crops grown in rows or beds, there can be benefits from applying early N in a band, or injecting it around the plant, followed by a broadcast top-dressing (or top-dressings). This may reduce the total amount of N required.

**Brussels sprouts and cabbage** – On light soils where leaching can occur, or when crops are established by direct seeding, no more than 100 kg/ha N should be applied prior to sowing/transplanting. On retentive soils in drier parts of the country, where leaching risk is low and spring-planted brassicas are established from modules, more N can be applied prior to planting. The remaining N should be applied after establishment.

**Cauliflower and calabrese** – Where there is a risk of poor establishment or leaching, apply no more than 100 kg/ha N at sowing/transplanting. The remaining N should be applied after establishment. Where band spreading or fertiliser placement is used, reduce the applied N by up to 33%.

**Lettuce, radish, root crops and dwarf/runner beans** – Apply no more than 100 kg/ha N at sowing/transplanting. The remaining N should be applied when the crop is fully established. Runner beans only may require a further N dressing of up to 75 kg/ha N at early picking stage.

**Onions and leeks** – Apply no more than 100 kg/ha N at sowing/transplanting. For Autumn-established crops it may be advisable where soil residues of N are high, to apply as little as 40 kg N/ha at sowing/transplanting, since excess N may make the crop more prone to disease. The remaining N should be applied when the crop is fully established for Spring crops and the following Spring for Autumn-sown crops.

**Potatoes** - Nitrogen requirement depends primarily on the length of growing season but also the intended market and variety. 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.

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 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.

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 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.

# B. Phosphate ($P_2O_5$) and Potash ($K_2O$) recommendations

Many vegetable crops respond to fresh additions of phosphate and potash fertilisers, especially at low soil indices.

**In order to assess the phosphate and potash fertiliser requirements for each crop, the following factors need to be taken into account:**

| | | |
|---|---|---|
| Stage B1: | Crop to be grown | Tables B1a, B1b, B1c, B1d. |
| Stage B2: | Adjustments based on strategy for P and K use (building or maintaining) | |
| Stage B3: | Adjustments following applications of bulky organic manures | |
| Stage B4: | Special crop requirements (fertiliser timing and placement) | |

## Stage B1. Crop to be grown

The recommendations provided in Tables B1a, B1b, B1c and B1d will ensure sufficient supply of P and K for average yields of the main vegetable and minority arable crops grown in Scotland.

**Table B1a: Brassicas, courgettes, lettuces, alliums, asparagus and legumes: phosphate and potash recommendations in kg/ha**

| | $P_2O_5$ | | | $K_2O$ | | |
|---|---|---|---|---|---|---|
| | Soil P status | | | Soil K status | | |
| Crop | Low | Moderate | High | Low | Moderate | High |
| Brussels sprouts | 150 | 100 | 50 | 250 | 200 | 100 |
| Cabbage, all types | 150 | 100 | 50 | 250 | 200 | 100 |
| Calabrese (broccoli) | 125 | 100 | 75 | 100 | 75 | 50 |
| Cauliflowers | 125 | 100 | 75 | 240 | 175 | 100 |
| Courgettes | 125 | 75 | 25 | 200 | 125 | 75 |
| Lettuce | 250 | 200 | 100 | 250 | 175 | 100 |
| Leeks | 200 | 150 | 100 | 250 | 175 | 100 |
| Onions (all types) | 200 | 150 | 100 | 160 | 125 | 90 |
| Asparagus[1] | 150 | 125 | 100 | 225 | 200 | 150 |
| Asparagus[2] | 75 | 50 | 25 | 50 | 50 | 50 |
| Beans, broad | 200 | 150 | 100 | 125 | 100 | 75 |
| Beans, dwarf/runner | 150 | 100 | 50 | 150 | 75 | 0 |
| Beans, field (vining) | 60 | 40 | 0 | 60 | 40 | 0 |
| Peas, vining/ combining | 40 | 25 | 0 | 40 | 25 | 0 |
| Lupins | 50 | 20 | 0 | 65 | 30 | 0 |

[1]Asparagus in its establishment year
[2]Asparagus in year 2.

**Table B1b: Hemp, linseed, forage rape, forage maize and kale: phosphate and potash recommendations in kg/ha**

| | $P_2O_5$ | | | $K_2O$ | | |
|---|---|---|---|---|---|---|
| | Soil P status | | | Soil K status | | |
| Crop | Low | Moderate | High | Low | Moderate | High |
| Hemp | 60 | 50 | 40 | 60 | 50 | 40 |
| Linseed | 75 | 40 | 25 | 120 | 75 | 25 |
| Rape, forage | 50 | 25 | 0 | 75 | 35 | 0 |
| Maize, forage | 85 | 60 | 20 | 205 | 165 | 110 |
| Kale | 75 | 50 | 0 | 225 | 170 | 130 |

**Table B1c: Potatoes: phosphate and potash recommendations in kg/ha**

| | $P_2O_5$ | | | | | $K_2O$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Soil P status | | | | | Soil K status | | | |
| | V. low | Low | Moderate | | High | V. low | Low | Mod. | High |
| Anticipated length of growing season and intended market | | | lower (4.5-9.4mg/l) | Upper (9.5-13.4mg/l) | | | | | |
| < 60 days (seed and punnets) and 60-90 days (seed) | 265 | 225 | 175 | 100 | 50 | 200 | 160 | 110 | 60 |
| 60-90 days and > 90 days (ware) | 240 | 200 | 150 | 75 | 50 | 240 | 200 | 150 | 100 |

**Table B1d: Root and bulb crops: phosphate and potash recommendations in kg/ha**

| | $P_2O_5$ | | | $K_2O$ | | |
|---|---|---|---|---|---|---|
| | Soil P status | | | Soil K status | | |
| Crop | Low | Moderate | High | Low | Moderate | High |
| **Carrots** | 160 | 125 | 90 | 160 | 125 | 90 |
| **Parsnips** | 150 | 100 | 50 | 200 | 150 | 100 |
| **Swede, shopping** | 250 | 200 | 150 | 200 | 150 | 100 |
| **Turnips (human consumption)** | 250 | 200 | 150 | 160 | 125 | 90 |
| **Swedes/turnips (stockfeed)** | 170 | 100 | 50 | 70 | 50 | 30 |
| **Beetroot, all types** | 125 | 100 | 75 | 250 | 200 | 150 |
| **Fodder beet** | 80 | 60 | 50 | 200 | 150 | 75 |
| **Radish** | 125 | 75 | 25 | 150 | 100 | 50 |
| **Narcissus** | 100 | 75 | 50 | 200 | 150 | 100 |
| **Tulips** | 100 | 75 | 50 | 200 | 150 | 100 |

## Stage B2. Adjustments based on strategy for P and K use (building or maintaining)

It is advisable to maintain soil P and K levels at the target indices (usually high for vegetables) and for this reason, it may be necessary to apply additional P and/or K in order to increase the reserves of P and K in the soil.

The amounts needed to supply maintenance needs will depend on expected crop yields and on the treatment of crop residues. Specialist guidance may be needed when deciding on P and K fertiliser application rates in relation to expected yields and offtake for specific crops.

## Stage B3. Adjustments following applications of bulky organic manures

It is important that full account is taken of the P and K within bulky organic fertilisers applied immediately prior to cropping and in recent years, in order to optimise crop quality, economic performance and to minimise any environmental impact (for example through loss of excess P to watercourses). The amount of P and K available to the crop in the years following application of organic materials depends on the type of material applied, the method of application, the soil type and the month and year of application. Information on the P and K contents of organic materials can be found in SAC Technical Note 622 on manures and organic materials.

## Stage B4. Special crop requirements - P and K fertiliser timing and placement

Starter fertiliser - The injection of starter fertiliser containing high phosphate liquid fertiliser 2 – 3 cm below the seed or around the roots of transplants, can improve the growth and quality of crops such as bulb and salad onions, lettuce and leeks. Starter fertiliser is particularly useful for crops grown in mixed rotations in soils with moderate levels of P or less. No more than 60 kg $P_2O_5$/ha should be applied as a starter fertiliser and the amount used should be deducted from the recommended rate when applying the remainder of the P.

Root crops – High yielding root crops can take up large quantities of P and K and it is particularly important to make allowances for crop offtake when soil P or K levels are moderate or lower. Where straw is used to protect carrots, it contributes approximately 1 kg $P_2O_5$ and 8 kg $K_2O$ per tonne of straw applied and left in the ground. These quantities should be counted when calculating the P and K requirements of subsequent crops.

# C. SECONDARY AND MINOR NUTRIENTS

**Magnesium (Mg)** – All crops have a requirement for Mg, which should be applied if soil Mg levels are low or very low. For most vegetable and minority crops, apply Mg (MgO) at 150 kg/ha where the index is VL and 100 kg/ha where the index is L. The exception is peas and beans, where 100 kg/ha MgO should be applied where the soil index is VL and 50 kg/ha where the index is L.

**Sulphur (S)** - Many vegetable crops, especially brassicas have a significant requirement for S. In situations where S levels might be low, for example on light soils, following wet Winters, where there has been no previous history of manure use or S-containing fertilisers, use of S-containing fertilisers should be considered as a base dressing to supply both N and S. Apply 25 kg/ha $SO_3$ for pea crops in such situations, and up to 75 kg/ha $SO_3$ for brassica crops.

**Sodium (Na)** – Several root crops including asparagus and carrots respond to Na fertilisers, particularly on light soils. For asparagus, apply up to 500 kg/ha $Na_2O$ per year at the end of June, but not in the establishment year. For carrots (and other responsive crops, such as beets) apply 200 kg/ha $Na_2O$ as agricultural salt. Deeply cultivate the application into the soil prior to drilling.

**Boron (B)** – Some root crops, especially carrots, fodder beet, beetroot, swedes and turnips are particularly prone to B deficiency, especially where soil pH values are high, and/or on light sandy soils. Cauliflowers and other brassicas can also be affected, although care must be taken to determine whether the symptoms are caused by other factors, such as bacterial disease or uneven water supply. Where soil analysis indicates a deficiency, or for susceptible crops (those mentioned above), apply B to the seedbed (2 kg/ha B) or as a foliar spray according to manufacturer's recommendations as soon as leaf cover allows. It is usually sufficient to apply B once during a rotation, though if root crops, brassicas or carrots are being grown, it is

advisable to apply B prior to each of these crops, regardless of whether it has already been applied in the rotation. It is not advisable to over-apply B, since B toxicity can cause problems in some crops.

**Copper (Cu)** - Copper deficiency can occasionally cause problems in some crops including carrots and onions. Problems are unlikely to occur where soil Cu concentrations are maintained at values suitable for cereal production.

**Manganese (Mn)** – Manganese deficiency can occur on many horticultural crops, though it is most commonly seen as "Marsh spot" on peas (symptoms of brown centres in peas and chlorotic leaves). Manganese deficiency is most usually seen at high soil pH, especially on dry sandy soils, soft seedbeds and/or immediately after liming. Manganese application is sometimes beneficial, where symptoms occur or are thought likely.

**Molybdenum (Mo)** – Molybdenum deficiency is very rare, apart from on cauliflower, where it causes "whiptail" (symptoms of narrow, twisted leaves). Maintaining soil pH values greater than 6.5 is the main control, and no Mo applications are required.

## Worked example

A farmer intends to grow a crop of carrots in beds for a major retailer on a field where the soil texture is a loamy sand and soil P, K and Mg levels are high (Table C). The previous crop was seed potatoes. He has grown carrots before in rotation, and knows that he can obtain typical yields of around 40 t/ha in this field. Winter rainfall was less than 450 mm and Summer rainfall was normal between the first and final spring N dressings. Regular (every 3 or 4 years), moderate applications of high quality, 0 – 10 mm PAS 100 greenwaste compost have been made during the past 10 years. Fifteen tonnes of greenwaste compost was applied per hectare, and worked in prior to drilling the intended carrot crop. This was analysed and was found to contain 7, 3 and 6 kg/ fresh tonne of N, $P_2O_5$ and $K_2O$ respectively. In order to determine the fertiliser requirement for his crop, he will go through the following stages. Note that decisions made may be different depending on the machinery and equipment available and the experience and preferences of the individual farmer.

**Table C. Worked example**

| Stage | Decision | Fertiliser recommendation |
|---|---|---|
| A1 | The crop to be grown is carrots and the previous crop was seed potatoes. The N recommendation (given that seed potatoes fall within previous crop or grass group 2) is 50 kg N/ha. | |
| A2 | There is no need to adjust the N recommendation due to low/high expected yield or unusual crop type or Spring/Summer rainfall. | |
| A3 | Increase N recommendation by 10%, since the soil is a loamy sand. | |
| A4 | Winter rainfall was < 450 mm, therefore there is no need to adjust the N recommendation for that reason. | |
| A5 | The greenwaste compost contained 7 kg N/ fresh tonne, which means that 105 kg N/ha was applied. Approximately 5% (5.3 kg/ha) of this N will be available to the crop in the year of application, therefore deduct 5 kg/ha from the N recommendation. | **N = 50 kg/ha** |
| A6 | Decide to split the N requirement of 50 kg/ha into two (a base dressing and top dressing once the crop canopy is established). | |
| B1 | Soil P and K status is high, therefore crop requirements for $P_2O_5$ and $K_2O$ are 90 and 90 kg/ha respectively. | |
| B2 | Since both soil P and soil K status are already high, there is no need to build levels of these nutrients in the soil. | |
| B3 | The greenwaste compost contained 3 and 6 kg of $P_2O_5$ and $K_2O$/fresh tonne respectively, which means that 45 and 90 kg of $P_2O_5$ and $K_2O$ were applied per hectare. Since soil P and K levels are high, all of that phosphate and potash should be included in the calculation of amounts applied, therefore deduct 45 kg $P_2O_5$ and 90 $K_2O$ from the recommendations. | **$P_2O_5$ = 45 kg/ha $K_2O$ = 0 kg/ha** |
| B4 | All of the bagged phosphate fertiliser will be spread on to the beds and worked in during bed formation. | |
| C | No Mg is required, since soil Mg status is high. Since there have been regular moderate applications of greenwaste compost during the past 10 years, and since carrots have no significant requirement for S, it is decided not to apply S fertiliser. Carrots have a requirement for both Na and B. The Na will be broadcast prior to ploughing and bed formation. Boron will be applied as carrots are a susceptible crop. | **Secondary and minor nutrients $Na_2O$ = 200 kg/ha B = 2 kg/ha** |

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