Het documenteren en milieukundig bijstellen van het KNS en andere bemestingsadviessystemen in de tuinbouw met het oog op een ruimere toepassing in de tuinbouw zoals voorzien in het Actieprogramma 2011-2014

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Short summary

This project aims the optimization of the Flemish fertilizer recommendation systems for vegetables. The starting point is the German KNS. A team of experts from various extension research stations in Belgium Inagro, PCG, PSKW, PCS, PCF and the extension research station of Hoogstraten, SSB (Soil Service of Belgium), Ghent University and ILVO jointed their forces to succeed this project. First the shortcomings of the German KNS were considered in relation to the Flemish situation. It became clear that factors such as mineralization and production levels were not similar. The lack of differentiation in cultivation of certain crops and the use of cover crops were perceived as gaps in the German system. Furthermore, animal manure is frequently applied to the fields in Flanders, compared to the use of chemical fertilizers in Germany.

Initially, the amount of nitrogen released from the Flemish soils was estimated (= mineralization out of soil organic matter and crop residue / cover crops). Data about mineralization from soil organic matter were collected from the Flemish demonstration project 'nitrogen monitoring network'. Over a period of 4 years, the nitrogen content in the soil was determined every 14 days. Based on these data, it was decided that a standard mineralization rate of 0.8 kg N / ha / day can be considered. On poor land where only occasionally animal manure was used, an average mineralization rate of 0.5 kg N / ha / day seems more appropriate. On plots where in the past regularly a lot animal manure was applied, a mineralization rate of 1.0 kg N / ha / day is more appropriate.

Data from existing research were used to estimate the nitrogen release from crop residues and cover crops. On fields where two or more crops per year are grown, the nitrogen release from the crop residues from the previous crop are included in fertilizer advices. On the inquiry form required at soil sampling for fertilizer advice, three gradations of crop residues volume (low, normal and high) can be selected. For the contents of a normal amount of crop residues, the basic figures are used. For quantities lower and higher than normal, the amount is reduced or increased with a third respectively. The amount of nitrogen that is released for the following cultivation is set at on average of 50% of the N-content of the crop residue from the previous crop in the same year.

The amount of nitrogen a cover crop can release, was estimated based on field trials conducted by members of the consortium and based on additional literature. Variation on releasing nitrogen is captured within the advisory system by taking into account the type of cover crop (Gramineae, Cruciferae or Leguminosae), the moment of destruction the cover crop (spring or fall) and the development of the cover crop (good - moderate - poor).

To determine the uptake rates and production levels for Flanders, relevant field trials of different cultivars and fertilization experiments of the Flemish extension research stations were selected from the year 2000 up to now. This was done just by keeping these fertilization levels of trials, wherein a normal to good production level was obtained with acceptable product quality. It was also ensured that the selected cultivars also occur frequently in practice.

The basis of the KNS system consists of taking soil samples during the crop cultivation period to obtain the nitrogen releasing by mineralization and leaching losses. A team of experts determined the best possible time to take these samples during cropping period. These are based on the growth pattern of the crop and the technical feasibility.

Because a good advice only comes when the consultant has sufficient information, it is important to have specific field information through an inquiry form. This inquiry form collects agronomic characteristics, field characteristics and fertilization information. By using this inquiry form, it is possible to determine whether a particular factor has an effect on the nitrogen balance and how big this can be. The nitrogen expected from mineralization dependent on pH, % carbon, crop rotation, use of organic manure, cultivation period, ...

Within this project, three existing nitrogen fertilizer recommendation systems in Flanders were evaluated. It concerns the N-INDEX system, KEMA advisory system and the N-balance method. These systems were compared conceptually among each other but also with the Flemish KNS-system. All fertilizer recommendation systems gave a nitrogen fertilization advice based on the initial situation, i.e. nitrogen in the soil at the start of cultivation, or at the time of sampling during the cropping period. Also the history of the field was taken into account based on information requested on the inquiry form (field characteristics, previous crop, fertilization history, ...) when sampling.

The initial situation in which the advice was given, corresponds to the initial situation of nitrogen fertilization trials in the period 2012-2013 at the extension research stations. From these trials, only the soil analysis of the optimal fertilized object was selected for the calculation of the advice for top dressing. The yield (total, marketable or % highest quality) and residual nitrogen at harvest (until rooting depth) are known of these field trials.

By comparing the fertilizer advices to results of the nitrogen fertilization trials, a prognosis of the expected yield and nitrogen residue can be made if a certain advice would be followed.

On average, the nitrogen fertilization advices, generated by the different fertilizer recommendation systems are comparable among each other, especially if based on soil sampling prior to crop cultivation. The average fertilizer advices seems to be comparable if there is only a soil sampling at the beginning of the crop. When additional soil samples are taken during the crop period, i.e. common practice in the Flemish KNS system and N-index, there is little difference between the Flemish KNS and N-index. Within the crops themselves, the variability can be up to 60 kg nitrogen. If the Flemish KNS system with multiple samples is compared with a single sampling of the N-INDEX and N balance, the differences become larger.

The differences between the advice systems is mainly driven by the way the fertilizer advice was calculated. In the Flemish KNS system and N-Index, sampling during crop cultivation can adjust the fertilization advice based on the growing conditions. This allows in many cases to decrease the fertilizer advice.

Extended summary

For this project several extension research stations (Inagro, PCG, PSKW, PCS, PCF and extension research station of Hoogstraten), the Soil Service of Belgium, Ghent University, and ILVO are joining their forces. The aim of this collaboration was to study the German KNS-fertilization system more deeply and reshape it in a manual for Flanders.

1.1 Inventory of the German KNS

First contacts were established with the German research institute IGZ that has developed the KNS-fertilizer system. Therefore Matthias Fink was contacted. Mr. Fink has transformed the KNS-fertilization system into the computer based N-expert system. Through this contact, in the first place an authorization to use the basic data was obtained. Furthermore, additional information has been gathered about the background of the system.

*The basis of the Nmin-*advice system *was established by Prof. HC. Scharpf. Based on field experiments Nmin-*values *of 8 crops were determined. Because field experiments entailed too much work expert knowledge* was used *for additional crops. The calculations however were very complicated.* T*herefore - in a third phase - the N-*expert *computer program* was *developed in which additional experimental data were introduced and the approach of the nitrogen mineralization was adjusted. This program was developed, which gave rise to new versions. There is a plan to modernize the program. The system will run on new software (*Java*) and will also be multilingual.*

How is the KNS composed?

The basis of the KNS System are the N-uptake curves of different crops and intermediate analyzes of the nitrate content of the soil.

The obtained advice is the nitrogen uptake, determined from the N-*uptake curves between two sampling times or between the sampling and the end of cultivation, increased by the minimum buffer stock at the time of sampling reduced by the amount of nitrogen available in the rooting depth.*

The size of this buffer is under normal soil and weather conditions, mainly depending on the crop itself. More sensitive crops for nitrogen deficiency will have a higher buffer. M*any crops require a higher buffer at the beginning of the cultivation than in a later stage of cultivation, when the crops have rooted* t*he soil better.*

*The mid-*sampling gives *insight into unpredictable factors such as nitrogen mineralization and nitrogen leaching. The new N-*expert system *tries to include factors such as mineralization of nitrogen from the previous crop or* cover crop. The system figures *that 50 to 60%* of the *nitrogen from the previous crop will be linearly released within a period of 8-10 weeks after incorporation*, depending on *the method of destruction and* incorporation *(rolling* harrow, *mulching, plowing). The contents of nitrogen of crop residues are fairly well known. N-*Expert *calculates by growing seasons and thus only with crop residues from the previous crop in the same growing season.*

*Release of nitrogen from soil organic matter cannot be predicted based on soil characteristics, or based on incubation experiments. Therefore, the N-*expert system *uses a release of 5 kg N per ha per week or 0.72 kg N per ha per day for fields with a not too intensive vegetable production and in where is no manure is applied. Within the N-*expert system *the mineralization level can be adjusted and it is assumed that the N release is nearly equal over the entire growing season.*

1.2 How and why this German KNS translate into Flemish circumstances?

The German KNS book does have some limitations towards Flanders. For example mineralization and production levels in Flanders are *not comparable to those in Germany. Also small gifts of nitrogen and nitrogen distribution during the growing season are insufficiently included within the German system*.

In order to make an accurate nitrogen fertilization, both knowledge about the total nutritional needs of the plant and the timing when these elements are necessary for the plant is necessary. The original manual of the KNS system is different to the current Flemish production conditions and yields. The nutritional requirements are changed by achieving more productive varieties.

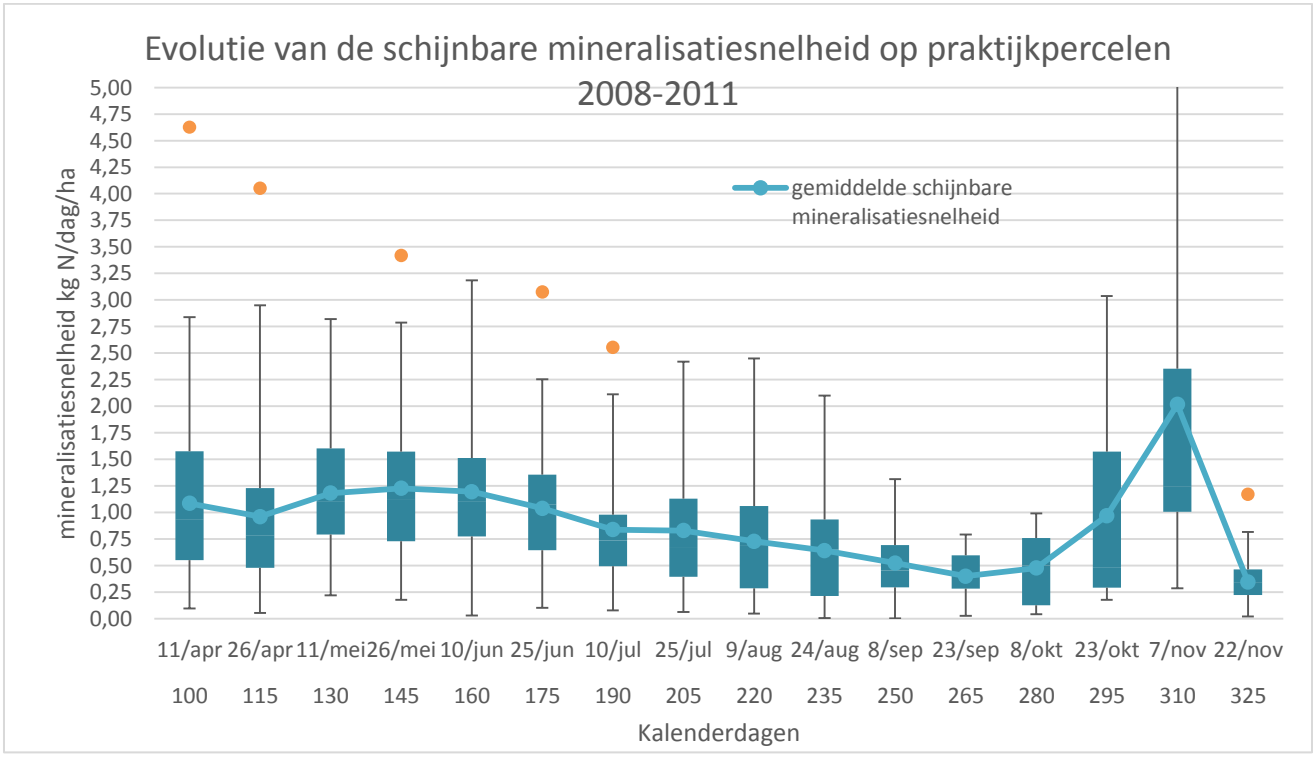
For certain vegetables the cultivation method should be taking into account. This can be explained for white cabbage: for the production of fresh market cabbage the nitrogen requirement is 200 kg N / ha, while for the industrial production the nitrogen requirement increases to 350 kg N / ha. Within the calculation of the nitrogen advice this difference should be taken into account.

To integrate all these factors in the advisory system, modular tables have been prepared which, based on the *expected production (depending on variety, cultivation time, ...)* and *the expected growth period, a nitrogen requirement until the next sampling or until the harvest can be determined.*

1.2.1 Mineralization and release of nitrogen from crop residues

Within the German KNS, a couple of factors such as mineralization and nitrogen release from crop residues and cover crops are insufficient included. Since these are important in Flanders, these *target values for Flanders have been* defined. *This was based on recent field experiments.*

For estimating the mineralization, the results obtained from the nitrogen monitoring network were used. Every 14 days over a period of 4 years the evolution of nitrogen in the soil profile (0-60 cm) on different plots was measured in the nitrogen monitoring network.



In the Flemish KNS system a standard mineralization rate of 0.8 kgN / ha / day can be used in the calculation of the fertilization advice. On poor fields where in the past no or only a small amount of manure was applied, an average mineralization rate of 0.5 kg N / ha / day seems more appropriate.

On plots where in the past regularly a lot animal manure was applied, a mineralization rate of 1.0 kg N / ha / day is expected.

For the nitrogen release from crop residues there was made use of existing studies on behalf of VLM, figures from the manure decree and experimental results obtained by members of the consortium.

On fields where two or more crops per year are grown, the nitrogen release from the crop residues from the previous crop are included in fertilizer advices. On the inquiry form required at soil sampling for fertilizer advice, three gradations of crop residues volume (low, normal and high) can be selected. For the contents of a normal amount of crop residues, the basic figures are used. For quantities lower and higher than normal, the amount is reduced or increased with a third respectively. The amount of nitrogen that is released for the following cultivation is set at an average of 50% of the N-content of the crop residue from the previous crop in the same year. The category 'low' usually corresponds with marketization for fresh market and the category 'many' usually with marketization for industry.

An estimate has been made based on field trials conducted by members of the consortium and additional literature about which amount of nitrogen a cover crop may release. The amount of nitrogen that *can be released by a cover crop depends in the first place on the nitrogen content of the cover crop. The amount of nitrogen uptake of a cover crop depends on several factors.* I*nitially the type of cover crop is important, other factors are sowing time, amount of available nutrients in the soil, rooting depth, climatic conditions, ... Also the moment of nitrogen release can vary widely. This is partly depending on the time of plowing and is also been determined by the type of cover crop. Roughly can be concluded that Leguminosae rapidly exempt nitrogen, followed by the Cruciferae. The grassy cover crops release slower (and later in the growing season) nitrogen* because of *the high C / N ratio of their roots.*

*Variation on releasing nitrogen is captured within the advisory system by taking into account the type of cover crop (Gramineae, Cruciferae or Leguminosae), the moment of destruction the cover crop (spring or fall) and the development of the cover crop (good - moderate - poor). Depending on the moment of the soil sampling a part of the N-*release *of the cover crop may already be included in the analysis of the N-*content of *the soil profile. Soil sampling during the cultivation will provide an accurate determination of N-release* from the cover crop.

1.2.2 Determining Flemish uptake figures, production levels, latent N and optimal sampling time

To determine the uptake rates and production levels for Flanders, appropriate varieties and fertilization experiments of the Flemish extension research stations were selected since the year 2000. Only the trials with a normal to good production level with an acceptable product quality were selected. By this, it was also ensured that the selected cultivars occur frequently in practice.

In some cases insufficiently results were available to come to *a reliable value. In these cases, the figure is replaced by data from other projects or international literature.*

In most trials, only the marketable production was determined. The basis to calculate the total production was the ratio between total and marketable production taken from the KNS handbook, unless otherwise indicated. In some experiments both marketable and total production was determined, in that case these data has been used.

In order to achieve uptake levels of nitrogen, on the basis *of these productions, the production was multiplied by the N-*concentration. *This was taken from the KNS manual, unless otherwise indicated.*

To get a realistic view on the amount of latent N at the end of the growing season data of nitrogen fertilization trials of recent years were collected. It was important that a determination of residual nitrogen was performed at the end of cultivation. Also, yield and quality data, and nitrate in the control period are important parameters to make this exercise. Per test different objects (N

fertilization levels) were included *in the table. An optimal step (*opt), *an unfertilized object (0), a insufficient-fertilized step (min) and an over-fertilized step (more).*

The amount of latent N that a certain crop needs, has been selected on the basis of the obtained yield and quality of the given object, the fertilization rate and the residual N at the end of cultivation period. In this way, the object with an acceptable yield and quality and lowest residual N was selected. There was no aim for high productions. Only the root depth was considered (30 or 60 cm) for the determination of the latent N.

The basis of the KNS system includes taking intermediate soil samples in order to obtain the exemption from mineralization and leaching losses. A team of experts therefore established an optimal period for taking these samples. These are based on the growth pattern of the crop and the technical feasibility.

Teelt	plant	oogst	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30	W31	W32	W33
Prei	mrt - half apr	jun-jul																																	
Prei	half apr - half juli	aug - feb																																	
prei	half juli - half aug	maar t-apr																																	
Bloemkool	mrt - half apr	mei - juni																																	
Bloemkool	half apr - juli	jun-nov																																	
Witte kool	apr - mei	juli - sept																																	
Witte kool	mei - juni	okt - nov																																	
Rode kool	mei - juni	okt - nov																																	
savooikool	apr-mei	juli - okt																																	
savooikool	mei-juni	okt-dec																																	
Bleekselder	half juni - half juli	okt - nov																																	

The moment of sampling is highly dependent on crop and period. The time of sampling a cauliflower second crop is considerably earlier than leeks. This is because cauliflower have a shorter cultivation period and cauliflower makes in the beginning of the cultivation lots of leaf mass, and on the end of the growing cycles the coal. With leek, production takes longer and at the beginning there is a low uptake of nutrients because of a weak root system, hence the later time of sampling.

There is a period between sampling the soil for top dressing and the effectiveness of the applied fertilizer. The overlap period for effectiveness of the applied fertilizer for top dressing was fixed at 3 weeks. For some crops, such as spinach, no additional sampling is provided. This is because the growing season is short and because additional fertilization would cause too much crop damage.

1.2.3 Flemish KNS tables

The following table is a concept table with Flemish data, assuming there is no disturbance of growth. It is indicated from which week the soil reserve to a certain depth should be considered (underlined and indicated in red). The sampling during that period should therefore be implemented at this depth.

Uptake levels each week were proportional adjusted by linear extrapolation based on the yield data. In function of the number of weeks after planting, the required effective amount of N in the layer of 0-30, 0-60 *or 0-90 cm is indicated*.

Bloemkool									
Plant/zaai: half apr - juli; Oogst: jun-nov; Vermarktbare productie (T/ha): 35; Totale productie (T/ha): 80									
Weken na plant	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
N-opname teelt	*1*	*4*	*8*	*20*	*42*	*64*	*57*	*32*	*12*
cumulatieve N-opname	*1*	*5*	*12*	*33*	*75*	*139*	*196*	*228*	*240*
Voorraad latente N	*120*	*120*	*120*	*120*	*120*	*80*	*80*	*80*	*80*
Bewortelingsdiepte	*30*	*30*	*30*	*30*	*30*	*30*	*60*	*60*	*60*
streefwaarde N-voorraad (0-30)	***195***	***194***	***190***						
streefwaarde N-voorraad (0-60)				***308***	***287***	***245***	***181***	***124***	***92***

In case of cauliflower the table has to interpret as follows.

The target value at the beginning of the cultivation is the sum of the N-uptake of the first 5 cultivation weeks, plus the necessary amount of latent nitrogen, minus the difference in latent nitrogen between the beginning of the cultivation and the time of sampling for additional fertilization. For weeks 2 and 3 the target value is these of the week before minus the nitrogen uptake of the previous week. The target value is based on an additional sampling period during the cultivation in week 3 or 4 after planting. In this way it is possible to conduct a top dressing at week 4 to 5 (there is ± 1 week counted for the analysis with corresponding advice). The target value *at week 4 is the sum of the N-uptake from week 4 till the yield plus the amount of latent nitrogen in week four*, minus *the difference between latent nitrogen at the sampling for top dressing and the yield. In this way, week 4 and 5* are *both counted in the target zone of week 1 and week 4. This is necessary for* having enough time b*etween sampling and* the application of the *fertilizer (or even better availability of nutrients from* the *fertilizer*). *The overlap does not cause problems in the advice because the target value is reduced by the still available nitrogen in the soil profile. If the soil sample is taken in week four, the nitrogen for week 5 which was already provided in the target at the start of the cultivation will still be measured in the profile and will be reduced from the target of 308 units N in week 4.*

The final advice is obtained by taking the target value for that week and reduce this with the present nitrogen in the rooting area of the soil , the *expected mineralization and possible exemption from crop residues or cover crops.*

***Advice = target value - soil stock - mineralization (- N crop residues or cover crops*).**

1.2.4 Inquiry form

A good advice can only be calculated if the consultant has sufficient information. Therefore, it is important to have specific information about some fields. Through an inquiry form at least the following factors are surveyed:

Culture techniques

- *Previous crop:*
    - *Crop*
    - *Harvesting date*
    - *Crop residues incorporate at moment of sampling: yes – no*
    - *Date of incorporation of crop residues*
    - *Volume of crop residues (low, normal and many)*
    - *In case of cover crops*
        - *Variety*
        - *Crop size: low, normal and high*
        - *Incorporate at moment of sampling: yes – no*
        - *Date of incorporation*
- *Common crop:*
    - *Crop*
    - *variety*
    - *Date of sowing/planting*
    - *Expected harvesting date*
    - *Expected yield*

Fertilization

- *Fertilization:*
    - *Organic (present and last year)*
        - *Type*
        - *Dose*
        - *Composition*
        - *Application date*
    - *Anorganic (present year)*
        - *Type*
        - *Dose*
        - *composition*
        - *Application date*

Field

- *Field features*
    - *pH*
    - *Carbonate*
    - *Soil texture*
    - *Rotation: arable – vegetable*
    - *Field use: farmyard manure – cover crops*
    - *Field condition: normal – compacted*
    - *Former meadow?*
        - *Year of soil cutting*

Through this information it is possible to determine whether a particular factor has an effect on the N-balance and how big this can be. The nitrogen released by mineralization depends on pH,% carbon, rotation of the field, use of organic manure, cultivation period, ...

*The use of cover crops and the previous crop will affect the nitrogen-*supplying *capacity of the soil during the cropping period. The soil sampler shall ensure that the farmer gives all this information on the inquiry form.*

1.2.5 Advice report

The report containing the fertilizer advice for vegetables is compiled on the basis of at least the following factors:

- *N-requirement of the relevant crop based on gross production*
- *Result of the nitrogen analysis, at least according to rooting depth and expressed in kg NO3-N / ha and kg NH4-N / ha*
- *Release of nitrogen by mineralization*
    - *From soil organic carbon*
    - *Crop residues*
    - *Cover crops*
    - *Organic fertilization*
- *other supply and output posts of N (deposition, losses) if they aren't already included in the system*
- *The recommended amount of active nitrogen for the given crop, the actual fertilizer advice*

** The upgrade of the KNS system is designed to work with intermediate sampling. As a result, the N -deposition and nitrogen losses also be determined by the determination of nitrogen in the soil.*

The report will also contain a reference to an explanatory note of the advice. This explanatory note shows how the analysis should be interpreted. Furthermore, an example of a concrete implementation of an advice with corresponding possibilities to carry out the fertilization (= most appropriate application techniques) is given.

1.3 *Evaluation of other existing advisory systems in Flanders*

1.3.1 N-INDEX

The N-INDEX is an expert system developed by Soil Service of Belgium for calculation of field-specific nitrogen fertilization recommendations for arable crops, vegetables, fruit cultivation and pasture, based on mineral nitrogen analyzes. The N-INDEX indicates how much nitrogen becomes available for the crop during the growing season. Not only the amount of mineral nitrogen in the soil at the time of sampling is taking into account, also the expected nitrogen mineralization in the coming months.

The N-index system is based on 18 factors which can be divided in three large groups.

I. *Factors influencing the amount of available mineral nitrogen in the soil at the time of sampling, and the amount of nitrogen uptake by the crop at the time of the sampling. The amount of available mineral nitrogen in the soil is measured by the mineral nitrogen analysis. The nitrogen that already has been taken up by the crop at the time of sampling is determined primarily by the cultivation technique and by the crop development.*
II. *Factors that determine how many mineral nitrogen the soil will deliver during the growing season: this is the nitrogen released by mineralization of soil humus, crop residues, cover crops and already applied organic fertilizers. The whole mineralization process is evaluated by the sum of various sub-processes that contribute to the total mineralization. Each sub-process corresponds to a factor in the calculation of the N-INDEX.*
III. *Factors that result in a reduced availability of mineral nitrogen during the growing season: low pH, leaching, volatilization, denitrification and leaching.*

$$\text{N-INDEX} = \underbrace{x_1 + x_2}_{(1)} + \underbrace{x_3 + \ldots + \ldots + \ldots + \ldots + \ldots}_{(2)} + \underbrace{\ldots + x_{18}}_{(3)}$$

To calculate all these factors, both the field history and the field characteristics should be well known. Therefore, at time of sampling, an extensive questionnaire is filled out by the farmer and the SSB sampling staff. Based on the gathered information and the results of the minerals nitrogen content of the soil (based on analysis of the soil sample), the N-INDEX is calculated.

The calculation of the nitrogen fertilization advice based on the N-INDEX is formulated as follows:

N-fertilizer advice Y = A-b*N-INDEX

A is the total nitrogen demand of the crop, which is for the most vegetables slightly higher than the total N uptake at harvest. For vegetables variety dependent characteristics are taken into account (specific nitrogen requirements of a variety, for example the risk of falling down of Brussels sprouts) and the growing season (early vegetables, summer vegetables, winter vegetables, ...). The values A and B were derived from field tests. For vegetables, the b value is currently always equal to 1.

1.3.2 KEMA advice system

The Soil Service of Belgium has for some outdoor crops (eg. strawberry, tree nurseries) and covered field crops a scientifically based advice system, the KEMA system. KEMA stands for: Checking the Evolution of Minerals and their Accumulation. The KEMA analysis is a standard soil analysis with additional determination of salt and mineral nitrogen.

The necessary input for the KEMA-expert system can be classified in three categories analogous to the required input for the N-INDEX:

- *Soil analysis data that show the soil fertility of that particular field: by taking a soil sample in the 0-30 cm soil layer and determining the carbon content, EC, mineral N, P, K, Mg, Ca and Na.*
- *Field information to identify the nutrient dynamics in soil: each soil sample is accompanied by an inquiry form/questionnaire containing information on both the field characteristic and the field history (eg, previous crop, fertilization, liming, etc..)*
- *Information concerning the crop for which a fertilizer advice is desired: crop (variety), sowing or planting date, any irrigation or drip irrigation, use of liquid fertilizers.*

The analysis results are the basis of the fertilization advice. A distinction is made between the standard / initial fertilization (in kg N / are) and an additional fertilization (in kg N / are).

For the initial fertilisation the advised amount of N is:

KEMA-advice (kg N/are) = (A-B)/100	*A = replenishment value in kg N/ha, crop specific* *B = N content in 0-30 cm, in kg N/ha*

This calculated advice will be, if necessary, further refined / modified by the advisor expert (eg. considering the planting or sowing date or recent organic fertilization).

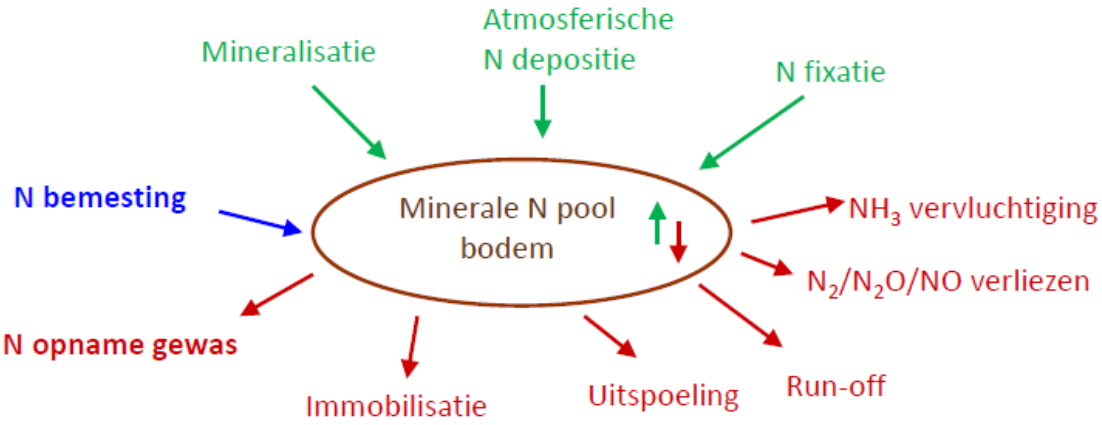
For additional fertilization of outdoor crops, the advice of N is less than the initial fertilization. This because the replenishment value is reduced as a function of the preceding nitrogen uptake of the crop.

1.3.3 N-balance

The N balance system is based on the mineral N balance method developed at the Department of Soil Management of Ghent University (Hofman et al 1981;. Van Cleemput et al 1981;. Hofman 1983). The N-balance method exists in several variants and is used in different extension research station in Flanders, for example Inagro.

The N-advice according to the N balance method is always based on an analysis of the mineral nitrogen in the soil. In addition, cultivation, soil and historical data of the field are requested.

On the demanding side are the nitrogen required quantities for a proposed yield, latent mineral N in the rooting area (in fact no real uptake) and the potential N losses during the growing season. These N losses must of course be kept to the minimum, eg. by a suitable choice of the type of fertilizer and most appropriate application technique depending on the soil type and the crop. The various components in the balance sheet are shown schematically in the figure below.



Supply Side:

- *Nmin-reserve in the soil, determined by soil sampling in the layer 0-30 cm, 0-60 cm or 0-90 cm depending on the rooting depth of the growing crop.*
- *Nmin-delivery from crop residues*
- *Nmin-delivery from cover crops*
- *Nmin-delivery from organic nitrogen fertilizers applied during the previous year*
- *Nmin-delivery from organic nitrogen fertilizers applied during the current year*
- *Nmin- delivery from soil organic matter*
- *Atmospheric N deposition is usually not charged, but can be easily introduced into the system*

Demanding side:

- *N-requirement of the crop (N uptake)*
- *Latent Nmin reserve (or N-buffer), ie the amount of mineral N that must be present over the rooting depth in addition to the maximum N uptake by the crop. This to ensure optimum nitrogen uptake.*
- *N losses during the growing season*

(Mineral) N-fertilization is the outcome of this balance. When the N-balance is negative, there should be additionally fertilized with effective N. The N-advice can, depending on the crop, formulate a fractionated application. The ratio between the fractions is depending on the crop and may also vary depending on the location of the available nitrogen in the soil profile (between the layers of 30-60 cm and 0-30 cm depth).

The N-balance system delivers a total nitrogen advice for the entire growing period as result. Depending on the crop, a fractionation of the total N-advice is formulated. Also advice calculation following an intermediate sampling is possible.

1.4 Comparison of inventoried advisory systems in Flanders.

The method of the adjusted KNS system to formulate an advice is compared with the method of the inventoried systems (N-index, KEMA and N-balance). Interpreting strengths and weaknesses of the different systems will only be done conceptual. This means that only the main components of the nitrogen cycle and their importance will be discussed within the different advisory systems.

The following items will be discussed:

1. *N-uptake of the crop*
2. *N-reserve in de soil*
3. *N exemption by mineralization of organic manure, crop residues, cover crops and soil organic matter*
4. *Mineral N losses, N-deposition and N-fixation*

1.5 Comparison of the evaluated advisory systems in a similar initial situation

Advice was given by the different advisory systems for a certain initial situation, based on a nitrogen reserve in the soil at the start of cultivation, or at the time of top dressing. The field history was known based on the information requested on the inquiry form (field characteristics, previous crop, fertilization history, ...).

How the advice is given, depends on the advice system. N-balance calculates an advice at the start of the cultivation for the entire growing period till the harvest. This system does not work with a top dressing.

The KNS system gives an advice for a particular period based on a soil sample at the start of the cultivation. This advice may be, dependent on the crop, for a number of weeks or until the harvest. The dose of top dressing after certain weeks is based on a soil sample and analysis (ie, a new initial situation).

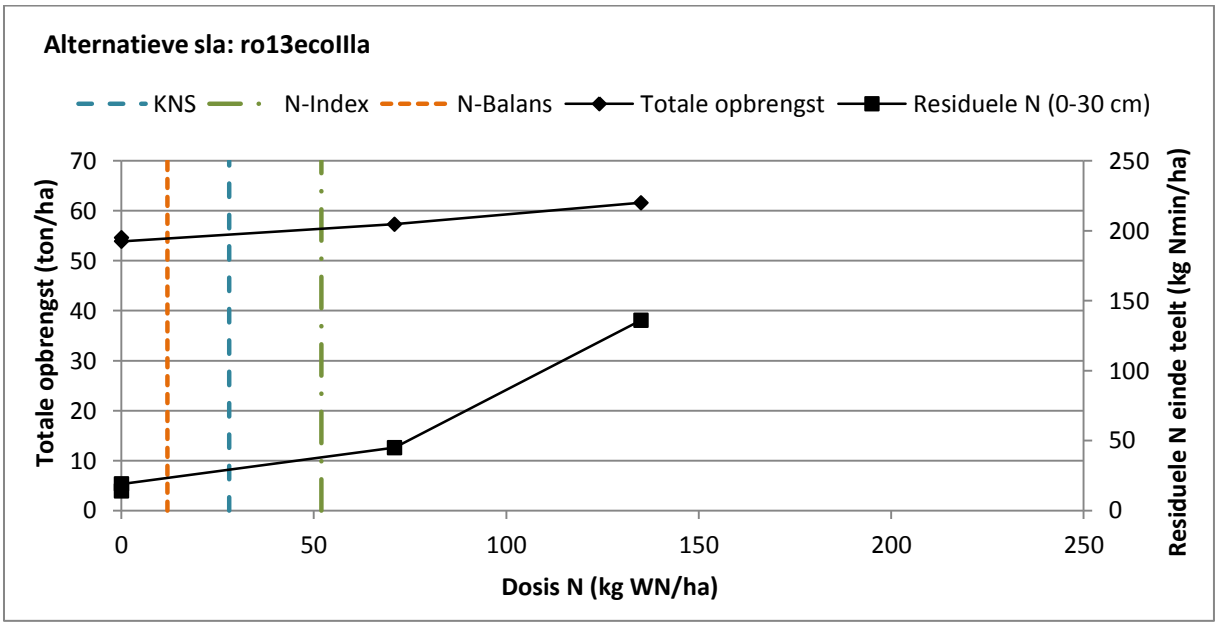
N-index calculates at the start of the growing period a fractionated advice for the entire growing period. Based on a soil sampling during the cultivation (ie a new initial situation) the N-advice is reformulated by N-index. In this way, two different advices for certain crops are formulated in this exercise by N index.

The different advisory systems indicate what the extent is before sampling of the factors mineralization, N- replenishment of crop residues, cover crops and animal manure.

1.5.1 Evaluation advices

The initial situation where advice was given, corresponds to the initial situation of N fertilization trials in the period 2012-2013 that were carried out by the extension research stations. From these tests, the soil analysis of the most optimal fertilized object was selected for the calculation of the N-advice during cultivation of this exercise. Of these N-fertilization trials the yield (total, marketable or % highest quality) and residual nitrogen(on rooting depth) after harvest is known for each dose.

By comparing the given advice related to the results of the performed N fertilization, it is possible to make an assessment (more or less) of the yield and residual nitrogen if a certain advice would be followed.



Due to a lack of data per experiment it was not possible to carry out a regression on the data. That is why the outcome of this exercise is rather an assessment whether a particular advice could lead to loss of yield or excess residual nitrogen rather than a prediction of what the yield and residual nitrogen would have been.

For certain crops with a long growing period, a N-advice for top dressing is formulated based on an intermediate sample of the soil. Both the KNS system and N-index apply this principle. On average, there is only a small difference in recommended nitrogen fertilization between KNS and N-index when taking intermediate soil sampling.

The differences between the advices is accomplished mainly by the manner in which the advice was calculated. KNS and N-Index could formulate an advice for top dressing by taking a sample during the cultivation period. This will give an adjusted advice based on the growing conditions. This provides in many cases a reduced total advice.

N balance does not work with intermediate sampling for top dressing and therefore does not have the possibility to correct the total advice during the cultivation.

For the experimental fields in 2012-2013 it is clear that there are multiple situations in which a second N-Index advice based on an intermediate sampling during the cultivation resulted in a lower top dressing advice than those based on a sampling before the cropping. The main reason for this is that the mineralization was higher than initially calculated. This mineralization rate is of course dependent on the year because the water supply plays an important role during the growing season.