Review of NMP tools

LK-Düngerrechner (Austria)

This is Austria's most widely used nutrient management plan tool, offered free of charge by the agricultural chambers of the Austrian Federal States as a downloadable spreadsheet (Chamber of Agriculture - Upper Austria, 2025). This tool is mandatory for farmers to demonstrate compliance with the Austrian Nitrate Action Programme Ordinance, which implements the EU Nitrates Directive.

The crop mineral fertiliser requirement (N_{mf} *and* P_{mf}) is computed as shown in Equation 1:

$$N_{mf} = N_{cu} - N_{cr} - N_{of} - N_f - N_{irr} \quad (1a)$$

$$P_{mf} = P_{cu} - P_{of} \quad (1b)$$

Where the crop uptake (N_{cu} *and* P_{cu}) depends on expected yield (five classes for N and three classes for P) and soil P content (five classes). This value is subtracted by the previous N crop residues (N_{cr}), the organic fertilisers nutrient supply (N_{of} *and* P_{of}), N fixation (N_f), and N from irrigation water (N_{irr}). For leguminous crops (e.g., clover, soybeans), the tool adds an estimated amount of N fixed from the atmosphere. The tool lists mineral fertilisers along with their nutrient content, while the organic fertiliser concentrations are estimated using standard values for manure, slurry, or compost, and their availability coefficients. The tool provides detailed information on organic fertilisers such as stock and type of farming as well as storage, handling and application technique.

Bulgarian tool

The most diffused method for crop nutrient requirement calculation in Bulgaria is based on compliance with the Nitrates Directive, although adoption is voluntary. It is based on a printed manual and tables and was designed for practical use by farmers and agricultural services.

The mineral fertiliser requirement (N_{mf}, P_{mf} *and* K_{mf}) is computed as shown in Equation 2:

$$N_{mf} = (N_{cu} - N_{of} - N_f - N_{cr} - N_s) \times N_k \quad (2a)$$

$$P_{mf} = (P_{cu} - P_{of} - P_{cr} - P_s) \times P_k \quad (2b)$$

$$K_{mf} = (K_{cu} - K_{of} - K_{cr} - K_s) \times K_k \quad (2c)$$

Where the crop uptake (N_{cu}, P_{cu} *and* K_{cu}) depends on expected yield and standard nutrient concentration. As inputs there are organic fertiliser supply (N_{of}, P_{of} *and* K_{of}) calculated as the total

amount applied multiplied by the standard nutrient content and an efficiency coefficient based on the time of application. In addition, crop-specific N fixation (N_f), the previous crop residue (N_{cr}, P_{cr} *and* K_{cr}), and soil supply (N_s, P_s *and* K_s) as mineral N or available P and K concentrations are also considered. Volatilisation, denitrification or immobilisation processes are included through efficiency coefficients (N_k, P_k *and* K_k) that increase the requirement (to account for volatilisation or immobilisation in clay-rich soils), or decrease it (to account for SOM mineralisation above a certain SOM content threshold). Soil P and K statuses and soil pH are also used to increase or decrease fertilisation requirement through a coefficient (NPK_{Ks}) that can be greater or smaller than 1 (Nikolova et al., 2014).

Nutrient Expert (China)

Nutrient Expert (NE) system is a digital decision support tool operable on computers or mobile devices (He et al., 2022; Xu et al., 2016). NE can assess farmland nutrient balance and soil productivity and provide fertilisation advice using existing site information. It focuses on major field crops, and some fruit trees and grassland types, for a total of more than 20 types of crops.

The crop mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed shown in Equation 3:

$$N_{mf} = \frac{1}{Ie}\,(N_{cu} - N_{of} - N_{cr} - N_s) \qquad (3a)$$

$$P_{mf} = \frac{1}{Ie}\,(P_{cu} - P_{of} - P_{cr} - P_s) \qquad (3b)$$

$$K_{mf} = \frac{1}{Ie}\,(K_{cu} - K_{of} - K_{cr} - K_s) \qquad (3c)$$

Where N_{cu}, P_{cu} *and* K_{cu} is the crop uptake computed as expected yield multiplied by standard concentration for different crops; N_{of}, P_{of} *and* K_{of} *is organic fertiliser nutrients supply,* N_{cr}, P_{cr} *and* K_{cr} is previous crop residues, and N_s, P_s *and* K_s is soil nutrient supply. NE scales maximum attainable yield for a geographic region according to site characteristics, and farmers' actual yield to estimate attainable yield with and without the fertiliser addition, and also considering nutrient interactions. The fertilisers amount is divided by the internal nutrient efficiency coefficient (I_e) that is defined as the amount of grain produced per unit of nutrient taken up by the plant. It is incorporated in the quantitative evaluation of the fertility of tropical soils (QUEFTS) model (Janssen et al., 1990; Smaling & Janssen, 1993), on which Nutrient Expert is based. In addition, the soil nutrient supply considers soil characteristics (such as texture, colour and content of organic matter), historical use of organic inputs, and the residues from the previous crop for P and K (Pampolino et al., 2012).

Czech tool

Farmers form Czech Republic typically use a spreadsheet linked to the Nitrates Directive that computes an N balance that is updated annually. The tool has a legal basis and an administrative purpose (National Center for Agricultural and Food Research, 2025).

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 4:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} + N_l \quad (4a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} \quad (4b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} \quad (4c)$$

Where the crop uptake (N_{cu}, P_{cu} *and* K_{cu}) is based on expected yield (both main and secondary products) and standard nutrient content values for different crops. The inputs are the organic fertilisers (N_{of}, P_{of} *and* K_{of}) and the previous crop residue (N_{cr}, P_{cr} *and* K_{cr}). The efficiency of manure distributions does not vary with timing or conditions, and losses are not computed. Only N losses (Nl) in the form of damage due to external influences (drought, flooding) are considered.

The mineral fertiliser requirement does not include P and K available in the soil.

MEM-NAK (Hungary)

This crop nutrient requirement calculation method was developed at the Centre of Plant Protection and Agro-chemistry, Ministry of Agriculture and Food in the 1970s, at a time of socialist cooperatives when increasing production was the main objective and environmental issues gained limited attention (Csathó et al., 1998). Farmers are offered a choice of four different fertilisation options corresponding to different targets, including maximum yield and environmental protection (Loch, 2015).

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 5:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_s \quad (5a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} - P_s \quad (5b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} - K_s \quad (5c)$$

Where crop uptake (NPK_{cu}) depends on yield and the nutrients content that varies according to crop, site, and soil nutrient supply category (N_s, P_s *and* K_s). Realistic yield levels have been determined for each crop on each growing site. Concerning soil fertility, N is classified based on humus content,

while P and K are classified based on ammonium lactate soluble forms. The inputs considered only the previous organic fertilisers (N_{of}, P_{of} *and* K_{of}) and previous crop residues (N_{cr}, P_{cr} *and* K_{cr}).

ProPlanta (Hungary)

This crop nutrient requirement calculation method was first released in 2003 and continuously developed since by the National Centre for Agricultural Research (Csathó et al., 2009; Fodor et al., 2011). The algorithm is based on long-term experiments carried out over the last few decades in several places in Hungary.

The mineral fertiliser requirement N_{mf}, P_{mf} *and* $K_{mf}$is computed as shown in Equation 6:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_{atm} - N_{irr} - N_f - N_s \quad (6a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} - P_s \quad (6b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} - K_s \quad (6c)$$

Where N_{cu}, P_{cu} *and* K_{cu} is expected crop uptake that consider the expected yield and specific nutrient content depending on the planned yield level for different crops and the soil nutrient supply category (N_s, P_s *and* K_s). The inputs considered are previous organic fertilisers (N_{of}, P_{of} *and* K_{of}), previous crop residues (N_{cr}, P_{cr} *and* K_{cr}), atmospheric deposition (N_{atm}), N from irrigation (N_{irr}), and symbiotic N fixation N_f) (Fodor et al., 2011).

Digifert (Italy)

This free tool for farmers of the Piedmont Region (NW Italy) matches two different and diverging norms: one linked to the Nitrates Directive, and one linked to the integrated production agriculture (IPA) guidelines. It was conceived as a planning and administration tool, linked to official climate and soil maps.

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 7:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_{atm} - N_f - N_{som} \quad (7a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} \quad (7b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} \quad (7c)$$

Where crop uptake (N_{cu}, P_{cu} *and* K_{cu}) is computed from the expected yield multiplied by the specific nutrient content; N_{of}, P_{of} *and* K_{of} is the available organic fertiliser supply, N_{cr}, P_{cr} *and* K_{cr} is the

previous crop residues, N_{atm} is atmospheric deposition, N_f is the symbiotic N fixation (from a crop-based standard table), and N_{som} is the N derived from soil organic matter mineralisation (based on a SOM content and a texture-dependent coefficient). Specifically, the amount of available N from organic fertilisers depends on the soil status and timing of fertilisation, through an efficiency coefficient. Soil P and K supplies are not included as direct sources, but soil contribution is indirectly included in nutrient requirement: the plant theoretical requirement is reduced by a factor (ranging from 0 to 100%) based on the soil nutrient status, and in particular fertiliser requirement is set to 0 in rich soils.

Fert_Office (Italy)

This spreadsheet calculator allows creation of a fertilisation strategy for IPA systems, respecting national and local standards used in the Emilia Romagna region (North-Est of Italy) (Regione Emilia-Romagna, 2025a). It is freely available online, and updated every year based on regional rules for IPA. The calculation of fertilisation plans and their updates during the growing season are registered as administrative documents.

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 8:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_s - N_{atm} - N_f - N_{som} + N_{leach} + N_{imm} \quad (8a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} - P_s + P_{imm} \quad (8b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} - K_s + K_{imm} \quad (8c)$$

Where the crop uptake (N_{cu}, P_{cu} *and* K_{cu}) is computed as the expected yield multiplied by the specific nutrient contents. Organic fertilisers (N_{of}, P_{of} *and* K_{of}) efficient supply depends on the type, frequency of application and soil texture, through an efficiency coefficient for N. Previous crop residues (N_{cr}, P_{cr} *and* K_{cr}) can provide extra N or rather immobilise it (N_{imm}), based on the residue C/N ratio. N derived from SOM mineralisation (N_{som}) depends on soil texture, SOM content and C/N. The soil (N_s, P_s *and* K_s) supplies mineral N (depending on soil texture and total N content) and available P and K. N leached (N_{leach}) is estimated as function of the winter rainfall and soil mineral N content as estimated by the SOM content. The N immobilisation or dispersion term depends on soil texture and estimated soil oxygen availability. P immobilisation considers soil texture and soil $CaCO_3$ content, while K immobilisation and leaching consider clay content. P and K additions can be increased or reduced based on the soil status. Other terms include atmospheric deposition (N_{atm}), and crop-based symbiotic N fixation (N_f) (Regione Emilia-Romagna, 2025b).

Grano.net® (Italy)

Grano.net® is a web-based decision support system (DSS) designed to assist wheat farmers using sustainable and precision agriculture techniques. In addition to grano.net, more than 10 specific DSSs are available for other crops. Developed by the private company Horta Srl, it provides agronomical information such as real time weather, disease risk evolution, soil water monitoring and irrigation, crop growth and yield forecast through satellite images and fertilisation plan.

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 9:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_s - N_{atm} - N_{irr} - N_f - N_{som} + N_{leach} + N_{imm} \quad (9a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} - P_s \quad (9b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} - K_s \quad (9c)$$

Where the crop uptake (N_{cu}, P_{cu} *and* K_{cu}) considers the crop expected yield and specific nutrient concentration according to the cultivated variety. The entries are the organic fertilisers (N_{of}, P_{of} *and* K_{of}) that varies with type, soil texture, timing of distribution through an efficiency coefficient. In addition, to previous crop residues as main crop and cover crops (N_{cr}, P_{cr} *and* K_{cr}), N from atmospheric deposition (N_{atm}), nitrate from irrigation (N_{irr}), the symbiotic N fixation (N_f), N derived from SOM mineralisation (N_{som}), and measured soil nutrient supplies (N_s, P_s *and* K_s) are considered. The N leached term (N_{leach}) is strictly related to winter rainfall rate, while the amount of N immobilised in the soil or dispersed (N_{imm}) is influenced by physical-chemical soil properties and estimated soil oxygen availability (Ruggeri, 2014).

Overseer® (New Zealand)

Overseer® is an online software that aims to support optimal nutrient use on farms to increase profitability and management within environmental limits (Wheeler et al., 2006), focused on grazed grassland systems and also includes other crops commonly grown nationwide. It provides information on both the use and flow of nutrients and on losses as greenhouse gases. Overseer® allows the technical and administrative monitoring of nutrient management.

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 10:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_{atm} - N_{irr} - N_f - N_{som} + N_{leach} + N_{vol} + N_{den} + N_{imm} \quad (10a)$$

$$P_{mf} = P_{cu} - P_{of} - P_s - P_{cr} - P_{run} \quad (10b)$$

$$K_{mf} = K_{cu} - K_{of} - K_s - K_{cr} \quad (10c)$$

Where the entries are crop uptake (N_{cu}, P_{cu} *and* K_{cu}), organic fertilisers (N_{of}, P_{of} *and* K_{of}), nutrient soil supply (PK_s), previous crop residues (N_{cr}, P_{cr} *and* K_{cr}), atmospheric deposition (N_{atm}) as 2 kg N ha^{-1} year^{-1}, nitrate from irrigation (N_{irr}), symbiotic N fixation (N_f), N from SOM mineralisation (N_{som}), N leached from urine (N_{leach}), N volatilised form urine (N_{vol}), N denitrification from urine (N_{den}), immobilised N (N_{imm}) and P runoff (P_{run}). Organic sources include manure, compost, dairy and piggery effluents with timing (month of application) considered as a risk factor for losses. N fixation amounts are adjusted for clover coverage, development status, herd grazing, and balancing when setting up a block N budget (a block is defined as an area of the farm that has common physical and management attributes). Runoff P losses are sourced from dung deposited on the block and particulate and dissolved nutrients derived from sediment. Other paths and processes involving C and N that are specific to pastoral blocks are included in the model (Wheeler, 2022).

PLANET and MANNER-NPK (United Kingdom)

PLANET (Planning Land Application of Nutrients for Efficiency and the environmenT) is a software decision support system that provides crop-specific fertiliser recommendations based on Defra's "Fertiliser Recommendations (RB209)" publication (Dampney & Sagoo, 2008; PLANET, 2025). MANNER-NPK (MANure Nutrient Evaluation Routine) is a software decision support tool for quantifying manure crop available nutrient supply (MANNER-NPK, 2025; Nicholson et al., 2013). These tools are introduced together because they are complementary (ADAS, 2022).

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 11:

$$N_{mf} = N_{cu} - N_{of} - N_s - N_{som} - N_{cr} + N_{leach} + N_{vol} + N_{den} \quad (11a)$$

$$P_{mf} = P_{cu} - P_{of} - P_s \quad (11b)$$

$$K_{mf} = K_{cu} - K_{of} - K_s \quad (11c)$$

Where the crop uptake (N_{cu}, P_{cu} *and* K_{cu}) is based only on the type of crop and soil nutrients supply (AHDB, 2023). The current soil nutrient status (N_s, P_s *and* K_s) is expressed as semi-quantitative soil indices (0-5 for N and 0-9 for P and K). Soil N supply includes soil mineral N, and that derived from SOM mineralisation (N_{som}) and the previous crop residues (N_{cr}). Soil P and K supply rely on soil analyses. The organic fertiliser supply (N_{of}, P_{of} *and* K_{of}) includes readily available NPK and slowly available N after mineralisation computed from MANNER-NPK based on growing degree days and manure type (Nicholson et al., 2013). Nitrate leaching (N_{leach}) is estimated considering soil type,

historical rainfall and temperature at a monthly timescale. Ammonia volatilisation (N_{vol}) considers many factors such as manure type, soil moisture content, wind speed, soil incorporation technique and timing. N losses via denitrification and nitrification (N_{den}) as N_2O and N_2 are also estimated. All the losses are computed by MANNER-NPK.

FertiliCalc (Spain)

FertiliCalc is a software decision support system designed for rational fertiliser management developed by the University of Cordoba (Universidad de Córdoba, 2025; Villalobos et al., 2020). It computes the seasonal N, P, and K fertiliser requirements and determines the most cost-effective combination of mineral or organic fertilisers.

The fertiliser requirement $N_{mf,}\ P_{mf}$ *and* K_{mf} is computed as shown in Equation 12:

$$N_{mf} = \frac{1}{1-n}\,(N_{cu} - N_{atm} - N_f - N_s\,) \qquad (12a)$$

$$P_{mf} = P_{cu} - P_s \qquad (12b)$$

$$K_{mf} = K_{cu} - K_s \qquad (12c)$$

Where *n* represents the fraction of applied N that is lost (as leaching, volatilisation, denitrification). Losses are therefore estimated altogether as an inefficiency coefficient, given by the sum of the single losses. For leaching estimation total annual rainfall, rainfall during autumn and winter, soil hydrological groups (following USDA classification) and nitrate water content are considered, while for NH_3 volatilisation soil pH, Cation Exchange Capacity and climatic conditions are considered (Villalobos & Fereres, 2024). Crop uptake ($N_{cu,}\ P_{cu}$ *and* K_{cu}) is computed as expected yield multiplied the nutrient concentration plus crop residues and a fraction of the root (Villalobos et al., 2020). Soil nutrient supply ($N_s\,,\ P_s$ *and* K_s) depends on values inserted by the user and soil properties including those related to P and K dynamics, such as clay content. Only the mineral N present in the soil at the end of the growing season is considered in the balance as standard value of 10 kg N ha^{-1}. The N supplied by symbiotic fixation (N_f) depends whether the legume is annual or perennial, and on the SOM content. The atmospheric deposition (N_{atm}) has a default value of 10 kg N ha^{-1}.

One of the key features of FertiliCalc is the different P and K input strategies that can be selected by the user: a) sufficiency strategy: apply P or K when the soil test level is below the threshold for fertiliser response; b) accumulation and maintenance (minimum) strategy: add fertiliser to compensate for P and K exports and bring soil test levels up to the threshold; c) accumulation and

maintenance (maximum yield): similar, but using the parameters for maximum yield; d) maintenance: when soil analysis is not available.

Fast Navigator (European Union)

The Fast Navigator tool was developed in the project "Study for the development of a common framework for the quantitative advice of crop nutrient requirements and greenhouse gas emissions and removal assessment at farm level", commissioned by DG AGRI in 2020 (European Commission, 2025). It combines four different NMP tools (F1 through F4) working at different timescales, with the F3 module described below as this runs across a seasonal scale (European Commission, 2025).

Equations 13a–13c shows the mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} as:

$$N_{mf} = N_{cu} - N_s - N_{irr} - N_f - N_{som} + N_{leach} + N_{vol} + N_{den} \quad (13a)$$

$$P_{mf} = P_{cu} - P_s \quad (13b)$$

$$K_{mf} = K_{cu} - K_s \quad (13c)$$

Where N_{cu}, P_{cu} *and* K_{cu} *is* the crop uptake based on the FertiliCalc model. As soil nutrient soil supply (N_s, P_s *and* K_s), the initial and final mineral N, the available P and K are considered. N derived from irrigation (N_{irr}) is computed by the irrigation type and amount, and irrigation water N concentration. The symbiotic N fixation (N_f) for legumes is estimated as in FertiliCalc. N from SOM mineralisation (N_{som}) is estimated based on SOM, humidity and soil texture. N leached (N_{leach}) depends agro-climatic zones, seasonal rainfall, annual rainfall, and soil characteristics such as soil drainage. N volatilised (N_{vol}) varies with crop type, fertiliser type and application mode, climate type, soil pH and CEC. N denitrification (N_{den}) is computed as an exponential function that considers the amount of N applied from fertilisation. P and K fertiliser requirements are based on FertiliCalc (Osann et al., 2022).

TUdi (European Union)

The NMP developed by the TUdi EU project is based on several sources, and mainly the FaST Navigator F3 Tool, Digifert and ProPlanta (López et al., 2025). In addition to the fertilisation plan, indicators of actual fertilisation surplus and efficiency, and a Carbon input calculator were included.

The mineral fertiliser requirement N_{mf}, P_{mf} *and* K_{mf} is computed as shown in Equation 14:

$$N_{mf} = N_{cu} - N_{of} - N_{cr} - N_{atm} - N_{irr} - N_f - N_{som} + N_{leach} + N_{vol} + N_{den} \quad (14a)$$

$$P_{mf} = P_{cu} - P_{of} - P_{cr} \quad (14b)$$

$$K_{mf} = K_{cu} - K_{of} - K_{cr} \quad (14c)$$

The crop uptake (N_{cu}, P_{cu} *and* K_{cu}) is computed considering expected yield multiplied by the specific nutrient content. Organic fertilisers additions (N_{of}, P_{of} *and* K_{of}) depend of the type, amount and distribution method. Additional inputs are previous crop residues (N_{cr}, P_{cr} *and* K_{cr}), N from atmospheric deposition (N_{atm}) (country-based reference table) and nitrate from irrigation (N_{irr}). The symbiotic N fixation (N_f), SOM mineralisation (N_{som}) and N leached (N_{leach}) are estimated similarly to Fast Navigator. Ammonia volatilisation (N_{vol}) consider the type of fertiliser, temperature, soil pH and emission coefficients for good management options (Bittman et al., 2014; Hutchings et al., 2019; Quemada et al., 2024). Denitrification (N_{den}) considers N_2O emission computed using the IPCC standard for direct emissions that uses fertiliser amount and type, efficiency (based on fertiliser types), and climate (López et al., 2025). Like Digifert, P and K requirements consider crop uptake, inputs from mineral and organic fertilisation and crop residue, plus a reduction coefficient applied in nutrient-rich soils.

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