# Guidance Information to Complete Nutrient Management Worksheets

*The Nutrient Budget Worksheet is intended to help you gather and document the information you use to make informed decisions regarding nutrient management. You are encouraged to make nutrient management decisions carefully, observing results in your crop and soil/tissue test results to monitor how well you are balancing supply and demand in your particular crop/soil environment. Keeping detailed notes about crop condition and yield as well as your nutrient management practices will help you fine tune management over time.*

*Nutrient budgets are helpful both for maximizing crop yield and quality and for minimizing environmental problems associated with excess nutrients. They may be done to plan nutrient applications (look forward) or to evaluate past nutrient management decisions (look back). The approach presented in these spreadsheets emphasizes documenting all inputs, but from a production standpoint it is important to recognize that some nutrient inputs may not be available to the crop, or may become available over time. Notes of things to consider when information is used for nutrient management in production planning are included throughout.*

*The information in this document will help you complete the Nutrient Management Worksheets step by step. It is organized by line number in the Nutrient Inputs worksheet. Other worksheets calculate nutrients added with fertilizer, cover crops and organic amendments, and provide information about crop specific nutrient management considerations.*

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***<u>Before you sit down to complete the worksheet, assemble the following</u>:***

- ☐ *Soil test result for the ground where the crop for which you are going to complete the budget will be planted*
- ☐ *Irrigation water test result from water source you will use to irrigate (with nitrate analysis)*
- ☐ *If you planted a cover crop prior to the crop for which you are completing this budget, the percentage of the established stand that was legume, and knowledge of what the height of the cover (inches) when the cover crop was killed.*
- ☐ *Analysis of any fertilizer or organic soil amendments added to your field, records of application amounts of each. It is often easiest to keep a copy of the label for fertilizer products, typically available online.*
- ☐ *A calculator*

# Nutrient Inputs Worksheet Tab

## 1. IDENTIFYING INFORMATION AND SITE CHARACTERISTICS

**1.1. Today's Date:** Enter the date on which you are completing the budget sheet.

**1.2. Field/Ranch Location:** Describe the production block or field in a way that allows you to locate it both now and at some point in the future (e.g. 2 acre June 2012 romaine planting, High Ho Ranch, block 45A).

**1.3. Irrigation Method:** For example, drip, sprinkler, furrow, flood, etc.

**1.4. Planned Crop:** Choose one crop for this sheet

**1.5. Expected Yield (including units):** This number will depend on many factors. Chose a yield goal that you believe you can realistically achieve on the block/field in question. Be careful not to put what you *hope* to harvest, but what you realistically think you *can* harvest.

**1.5A. Expected N Removal at Harvest:** If no other estimate available, you can use the USDA Nutrient Removal Tool found here: http://plants.usda.gov/npk/main

**1.6. Planting date for planned crop:** for the crop for which you are completing the budget

**1.7. Soil type and texture:** Mapping unit and texture of soil

## 2. NUTRIENT STATUS AND SOURCES

**2.1. Soil Test Results (date of test):** Enter the date soil sample was collected and date sample was analyzed by lab.

**2.1.1. Nitrate Nitrogen ($NO_3^-$-N ) ppm:** Using assumptions about the weight of soil to 12 inch depth, a calculation of ppm x 4 is a reasonable estimate of lbs N/A. ***Note:*** *Nitrate levels may change rapidly, particularly when rain or irrigation contribute to leaching losses. Interpret the soil test number carefully. Consider use of Soil Nitrate Quick Test for a real time assessment of nitrate levels in the soil.*

**2.1.2. Available P ppm** Available P may be measured different ways. Generally, if the soil pH is greater than 6.0, Olsen P is a better indicator of available P. Olsen P is the same as Sodium Bicarbonate P. If the pH is less than 6.0 the Bray P is a better indicator of available P. The different names refer to different solutions used to extract the P from the soil sample. You may need to look down in the smaller print section to find this number on some lab reports.

**2.1.3. Available K ppm** This is typically shown on the soil test result as $NH_4OAc$ extractable K. You may need to look down in the smaller print section to find this number on some lab reports.

**2.1.4. % SOM and expected N release:** Often % SOM is an extra analysis, so make sure to request it when taking in a soil sample for analysis. Keep track of what might cause an elevated number and be sure you are not "double counting" N inputs. For example, is there a lot of recently incorporated organic matter in the sample (e.g. compost, cover crop, crop residue)? The gray box calculates estimated N release from SOM. See notes under the Nutrients from Organic Amendments section regarding nitrogen release from soil organic matter when using nutrient input information to guide fertility management.

**2.2 Irrigation Water Test Results (date of test)** Enter the date soil sample was collected and date sample was analyzed by lab.

**2.2.1. Irrigation water $NO_3^-$-N ppm.** If value is given as **$NO_3^-$** see step 1 in the box below.

**2.2.2. Inches of water applied during crop cycle** If you do not know how much water you apply, seek approximate values based on UC Cost Study analyses. See searchable archives here http://coststudies.ucdavis.edu/. Note that where you grow the crop may have a significant impact on water use, so be sure to find a report relevant for your area.

**2.2.3. lbs N applied with irrigation water** This value is calculated for you based on water analysis and amount of water applied. The assumptions and calculations are shown below.

**Calculating the N Contribution from Irrigation Water**

Nitrate contains both nitrogen and oxygen, as seen in the formula, $NO_3^-$. To calculate just the nitrogen, if the report gives nitrates as pp $NO_3^-$ (parts per million nitrate) you must first convert to ppm $NO_3^-$-N (parts per million nitrate-nitrogen).

**Step 1:** Calculate ppm $NO_3^-$-N in irrigation water = ppm $NO_3^-$ x 0.222

**Step 2:** Calculate lbs N/acre inch irrigation water = ppm $NO_3^-$-N in irrigation water x 0.227

**Step 3:** Estimate acre inches of water applied to your crop through the growing season

**Step 4:** Multiply value from Step 2 by inches of water applied. This is the value that is calculated in the gray box in 2.2.3.

**NOTE:** The N contributed from irrigation water may move below the rooting zone before the plant can capture it. Thus, it is important to consider irrigation practices, system efficiencies and uniformities, wetting depth, rooting depth, and other factors that may influence the extent to which N applied with irrigation water may be "seen" by the crop. This budget includes all applied N because it is concerned with N loss as well as N uptake by the crop. A useful estimate of irrigation water N that a plant will likely "see" can be calculated using crop ET values. Find an estimated ET for your crop by region and irrigation type here: http://www.itrc.org/etdata/irrsched.htm. Note that you can choose a dry, wet or typical year. The list of crops is not exhaustive, pick the best match for the crop in question. To estimate N from irrigation water to consider in a production nutrient budget using this method calculate as follows:

(ET acre inches/total inches applied) * total N applied with irrigation water (gray box 2.2.3)

**Helpful Conversions for Water Measurement**

It is sometimes helpful to be able to convert from gallons to acre feet or acre inches.

1 acre inch = 27,154 gallons (often rounded to 27,000)

1 acre foot = 325,850 gallons (often rounded to 326,000)

To convert gallons to acre inches, divide the number of gallons by 27,154.

Example: 123,455 gallons => 123,455/27,154 = 4.5 acre inches

**2.3 Organic Soil Amendments** Follow guidance on Nutrients in Organic Amendments Tab. Note date applied.

**2.3.1. N applied (lbs/A)** see Nutrients in Organic Amendments sheet

**2.3.2. $P_2O_5$ applied (lbs/A)** see Nutrients in Organic Amendments sheet

**2.3.3. $K_2O$ applied (lbs/A)** see Nutrients in Organic Amendments sheet

NOTE: The nutrients applied with organic amendments are released over time and some may carry over from one season to the next. N release may vary among materials. We calculate the total values in the inputs summary, but recognize that similar to nutrient release from soil OM, nutrient release from organic amendments is hard to predict precisely. Only a fraction of the calculated value should be assumed available in the current growing season. See notes under the Nutrients from Organic Amendments section regarding nitrogen release from organic materials when using nutrient input information to guide fertility management. If manure is routinely applied to cropland it is advised that a manure management tool be used to predict both N and P release.

**2.4 N Contributed from Cover Crops** Follow guidance on N from Cover Crops tab. Note date killed and/or incorporated.

**2.4.1** See values and information in the Cover Crop Tab on worksheet.

NOTE: As with N release from Soil OM and organic soil amendments, precise predictions of N release from decomposing cover crops are not possible. Nitrogen content of legume cover crops may vary depending upon how well the crop establishes and forms N-fixing nodules. Leguminous cover crops incorporated in the soil are typically fairly readily decomposed (unless they have been allowed to grow to a woody stage, not typical) and it is reasonable to assume N release from these materials during the growing season. See notes under the Nutrients from Organic Amendments section regarding nitrogen release from cover crops when using nutrient input information to guide fertility management.

**2.5. Other** Are there other materials that may have contributed nutrients to the soil? If you are looking back at a cropping season and have already applied fertilizer materials you can include N, P and K additions from fertilizer materials here. See below guidance to calculate based on fertilizer applied. The Nutrients in Fertilizer tab can be used to make the same calculations shown in the grey box below.

**2.5.1. Other N (lbs/A):** Include any other materials that are added to the soil that may contribute N. Crop residues may contribute significant N in some cases, and where appropriate should be added here. Numbers for this will depend on N uptake, total biomass, harvested portion, field trimming practices, etc. See further discussion under Predicting N Release from Crop Residues in the Release of N from Organic Materials sections below.

**2.5.2. $P_2O_5$ applied (lbs/A):** Include any other materials that are added to the soil that may contribute P. An example might be phosphoric acid as an anti-crustant to improve seedling emergence.

**2.5.3. $K_2O$ applied (lbs/A):** Include any other non-fertilizer materials that are added to the soil that may contribute K.

### Calculating N, P and K added from Fertilizer

By convention, fertilizer analysis is given in the oxide formation for both phosphorus and potassium. The analysis is typically given as N-P-K, but in fact shows a guaranteed analysis by weight of N, $P_2O_5$ and $K_2O$. Thus for example a fertilizer label that reads N-P-K 18-8-13 has the following analysis:

18% N        8% $P_2O_5$        13% $K_2O$

If 250 lbs of this fertilizer is applied this would mean that:

250*0.18 = 45 lbs of N are applied

250*0.08 = 20 lbs $P_2O_5$ are applied

250*0.13 = 32.5 lbs of $K_2O$ are applied

If the fertilizer is in a liquid formulation, then the calculations must also include consideration of the density of the liquid fertilizer. So using an example with CAN 17 (a liquid fertilizer) with a guaranteed analysis of 17% N, a density of 12.7 lbs/gallon and an application rate of 14 gallons/acre:

Each gallon weighs 12.7 lbs

Each pound of product has 17% N, so 12.7 * 0.17 = 2.2 lbs N per gallon

Thus in 14 gallons there are 14 * 2.2 lbs = 30.8 lbs N

Sometimes it is helpful to be able to convert back and forth from the oxide to the element form for P and K. It is easily done with the following conversion factors:

$P * 2.3 = P_2O_5$ and $P_2O_5 * 0.44 = P$

$K * 1.2 = K_2O$ and $K_2O * 0.83 = K$

# Nutrient Management Records

Use of this sheet or similar will ensure that you have all considered the information needed to evaluate your nutrient management decisions either at the end of the season (looking back to evaluate decisions already made) or at the start of a season (looking forward to plan fertility management).

# Nutrients in Fertilizer

Follow directions in the tab to guide data input. It is helpful to have the label for fertilizer materials applied. You will need the guaranteed analysis, density (if a liquid formulation) and rate (lbs/A) applied. Transfer values to the Nutrients Input Sheet.

# Nitrogen from Cover Crops

Follow directions in the tab to guide data input. Transfer values to the Nutrient Inputs Sheet.

# Nutrients In Organic Amendments

Follow directions in the tab to guide data input. Transfer values to the Nutrient Inputs Sheet.

### Release of available N from organic materials

Nitrogen (N) release from soil organic matter, organic soil amendments, cover crops and crop residues is hard to predict precisely. The amount of N that becomes plant available is dependent upon a wide range of factors. In general it is safe to assume that only a fraction of the total N applied in organic materials, or present in soil organic matter, will be available for plant uptake during a crop cycle.

Factors in the environment influence the rate of decomposition of organic materials, and N release from them. Conditions that favor microbial activity in the soil will support decomposition and N mineralization. Generally speaking, well-aerated soils with adequate moisture and moderate temperatures that also lack any toxicity or salinity concerns will support decomposition of organic materials in the soil.

Provided conditions in the soil support microbial decomposition processes, it is reasonable to expect that some fraction of the nitrogen contained in the materials will become plant available. However, where the organic materials have a low nitrogen content, with a carbon to nitrogen ratio (C:N) greater than 24:1, it is possible that nitrogen released from organic materials will be tied up in microbial biomass before it is taken up by the plant. A discussion of C:N and the importance of this in understanding N mineralization can be found in *Carbon to Nitrogen Rations in Carbon Systems* found here: http://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download/?cid=nrcs142p2_052823&ext=pdf

Various guidelines have been suggested to estimate N release from organic materials. See below for some basic information for various organic materials to help guide management decisions.

#### Predicting N Release from Soil Organic Matter

A UC ANR publication *Soil Fertility Management for Organic Crops* (http://anrcatalog.ucdavis.edu/pdf/7249.pdf) makes a series of assumptions and predicts N release from soil organic matter as follows:

1. 12” depth of soil per acre weighs approximately 4,000,000 lbs
2. Soil Organic Matter is approximately 7% nitrogen (0.07 for calculations)
3. Approximately 2% of SOM will decompose in a two month period with temperatures around 77$^{o}$F

Thus the following equation can be used: (% SOM) * (4,000,000 lbs soil to 12”/A) * (0.07) * (0.02) to predict lbs N/A from SOM. The grey box in the spreadsheet uses the above assumptions to calculate estimated N release from SOM. One adjustment has been made from the UC publication assumptions. In the spreadsheet calculations the SOM %N is assumed to be 6%, not 7% as the lower value is a more conservative figure that still reflects values for %N in SOM found in the literature.

The Sustainable Agriculture Research and Education (SARE) publication *Managing Cover Crops Profitably*, predicts that 10-40 lbs N/A will become available for each 1% of SOM. This is a slightly more conservative prediction, and is more in line with that of the soils textbook, *The Nature and Property of Soils* by Brady and Weil, which uses the same reasoning as the UC publication, but assumes a lower weight for an acre of soil to 12" depth and a lower % N in SOM (5% instead of 7%).

Natural systems are highly variable and it is not possible to be precise in predictions of N release from SOM, but all of the above described methods will give you a basic idea of how much of the N in your SOM you might consider in fertility management.

**Predicting N Release from Cover Crops**

The Cover Crop tab estimates total N inputs from cover crops. The SARE publication *Managing Cover Crops Profitably*, recommends assuming the following regarding how much of the total N will become available in the year following a cover crop:

- Half (50%) if the cover crop will be conventionally tilled OR if it will be left on the surface in a no-till system in Southern climates
- A quarter (25%) if left on the surface in a no-till system in Northern climates

Note that when there are low levels of mineral N in the soil, the cover crop decomposition process *could* immobilize nitrogen and decrease nitrogen availability temporarily. The UC ANR publication *Cover Cropping for Vegetable Production: A Grower's Manual* offers the following guidance in Table 5.1: Effect of cover crop nitrogen on nitrogen release (pg 38):

| % N in cover crop | Effect on N release | Examples of cover crops |
|---|---|---|
| 0.5-1% | Will tie up N | Cereal straw |
| 1.5% | Will tie up N | Cereal at heading |
| 2.0 | May tie up N (depends on level of N in soil) | Cereal before heading |
| 2.5 | May tie up N (depends on level of N in soil) | Mustards at heading, immature cereal |
| 3.0 | Will release N | Mustards, legumes, juvenile cereals |
| 3.5 | Will release N | Legumes and immature mustards |
| 4.0 | Will release N | Legumes |

Note: Most cover crops are killed in the early growth stages representing the higher %N. If weather or other factors delay the kill date, it is important to carefully note growth stage to make accurate predictions of N dynamics.

**Predicting N Release from Compost**

The UC ANR publication cited above, *Soil Fertility Management for Organic Crops* (http://anrcatalog.ucdavis.edu/pdf/7249.pdf), states that typically no more than 15% of N from compost is available in the first year. However, where compost has been routinely applied over the course of many years, N mineralization from compost will continue in subsequent years. Take care not to double count N contributions from compost applied in previous years if you are also considering N mineralized from SOM, nor to count the current year compost application if your soil sample was taken after compost was applied.

In a 1995 publication by UC ANR *Compost Production and Utilization: A Grower's Guide,*(available for purchase here: http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=21514) the author notes that N mineralization rates from compost average 10-30% in the first year, but numbers both higher and lower are found.

As with N mineralized from SOM, precise predictions are not possible, and growers should observe their systems over time to fine tune their predictions and management.

**Predicting N Release from Crop Residues**

As with cover crops, release of N from crop residues depends on C:N ratio. Many vegetable crop residues are high in N and can also be expected to release N during the following crop cycle. To give you some idea of the amounts of N that crop residues may contribute, consider the following:

| | |
|---|---|
| **Mitchell et al. 1999** http://ucce.ucdavis.edu/files/repositoryfiles/ca5304p37-67398.pdf | |
| | 157 lbs N/A in broccoli crop residues in San Joaquin Valley |
| | 66 lbs N/A in lettuce crop residues in San Joaquin Valley |
| **Smith, Cahn & Hartz 2013 CA Dept. of Agriculture Fertilizer Research and Education Program 2013 Annual Report pg. 117** | |
| | 243 lbs N/A in **summer** broccoli crop residues Salinas Valley |
| | 156 lbs N/A in **winter** broccoli crop residues Salinas Valley |
| | 230 lbs N/A in **summer** cauliflower crop residues Salinas Valley |
| | 175 lbs N/A in **winter** cauliflower crop residues Salinas Valley |
| | 142 lbs N/A in **summer** cabbage crop residues Salinas Valley |

In a different report Hartz (see here: http://www.vineyardteam.org/files/resources/Hartz_2013%20Hartz%20San%20Luis%20Nov%20Expo%20final.pdf) found approximately 60% of crop residue N (tested crop residues were celery, broccoli and lettuce) was released in an 8 week incubation period. Taken together, it is evident that crop residues may be expected to contribute significant N and should be considered when planning N management in following crops.

# Crop Information Vegetable Crops and Crop Information Fruit and Nut Crops

**Complete nutrient management requires consideration of the 4 Rs: Right Time, Right Placement, Right Form and Right Rate.** To optimize the 4 Rs it is important to consider differences among nutrients as well as among crops.

## Nitrogen: Here Today Gone Tomorrow

1. Nitrogen moves in and out of available pools due to leaching, immobilization in soil microbial biomass and release from soil organic matter. It is important to review the N values with consideration of factors such as irrigation efficiency, rainfall, tillage, and other factors that may influence leaching and biological activity in the soil.
2. In the Crop Information tabs (for either Vegetable or Fruit and Nut Crops) click on the links for nutrient management documentation for the crop and read the section on N management. Using this information, consider what N levels you want in your soil for optimum crop yield and quality. Now consider factors noted in the Nutrients from Organic Materials section above, as well as other factors that may influence N availability in your soil (e.g. irrigation water management, N release rate of fertilizer, possible gaseous losses, etc.). Note that use of a tool such as the Soil Nitrate Quick Test is an excellent way to guide in-season N management and avoid over-application of N at times when adequate levels are present and/or crop needs are minimal (e.g. in early development stages of growth, during cool seasons when growth is slower, when other conditions limit crop growth, etc.).

## Sufficiency Levels for P and K

1. Often P and K fertility management decisions are based on soil levels pre-plant as these nutrients are less likely to be lost or depleted rapidly during the growing season. The critical level for crop production is often called a sufficiency level. Sufficiency levels for each nutrient vary by crop.
2. Find the crop for which the planning exercise is being completed. Compare P and K levels from Nutrient Inputs Worksheet (2.1.2 and 2.1.3) to sufficient P and K levels for the crop shown in the Crop Information spreadsheets. If below sufficient values in soil, production may require nutrient additions. Review total P and K additions to the crop (3.2 and 3.3) to determine if additional P and K may be required for optimum crop yield and quality.