TEST DRIVING A NEW NRCS NUTRIENT BUDGET CALCULATOR FOR NUTRIENT MANAGEMENT PLANNING IN CALIFORNIA

Brook Gale and Zahangir Kabir, PhD
USDA-NRCS, CA
Brook.gale@ca.usda.gov Zahangir.Kabir@ca.usda.gov

ABSTRACT

In executing its mission to aid landowners in making conservation improvements, the USDA-Natural Resources Conservation Service (NRCS) assists landowners in identifying their operation's potential risks to natural resources, if any.

For assessing a cropland producer's nutrient management, determining whether their nutrient applications rates might be considered excessive or has a potential to load up soil levels is key.

However, NRCS does not make prescriptive nutrient application recommendations for production purposes but rather helps the producer develop a plan for how they will select the right nutrient **source** and determine the **rate**, **method**, and **timing** of applications.

NRCS-California had develop several tools to help planners & producers assessing a cropland producer's nutrient management program.

This presentation will review a new MS-Excel spreadsheet used to estimate the field and farm-wide nutrient balance and whether applications have a potential to load soils. The focus will be on how the tool assesses Phosphorous (P) and Potassium (K) amounts, as current soil test interpretation does not accurately convert these nutrient to pounds available per acre.

In the tool, the planner uses their professional judgement in setting ratings for soil sufficiency levels. Based on these ratings and estimated contributions from other sources (i.e., cover crops, irrigation water, fertilizer & manure applications, etc.) the tool helps the planner document whether the producer should consider increasing, maintain, or decrease P or K application rates and what the risk potential might be.

INTRODUCTION

Although the USDA-Natural Resources Conservation Service (NRCS) does not provide specific fertilizer or amendment recommendations to its customers, it is tasked with aiding Ag producers identify potential resource concern on their land and to offer mitigating alternative(s). One of these resource concerns (RC) is excessive nutrients in surface and groundwater.

Nitrogen (N) and phosphorous (P) pollution has been s identified as a natural resource concern to surface and/or groundwater in some water bodies and aquifers in California. Over applications of nitrogen (N) and phosphorous (P) to cropland has been suggested as a key

contributor to the elevated N & P levels.

The USDA-NRCS California has several 'tools' available to NRCS planners to aid in N & P nutrient budgeting. These include the Manure Management Planner (MMP) software, maintained by Purdue University, and various Microsoft Excel spreadsheets and Word documents developed at the NRCS state level. These tools use commonly accepted university methods of budgeting nutrient application amounts. However, their format does not generally lend themselves to documenting the management setting, assumptions used, source references and rationale for adjustments in a quick and easy manner.

Because nitrogen (N) budgeting, with all its forms and behavioral characteristics, is often debated, it will not be addressed in this article. Instead, a new method of assessing / documenting phosphorous (P) risk potential will be proposed.

Current P Assessment

Current university guidelines for P fertilization in CA typically centers on soil or in-season tissue sufficiency levels that are not directly convertible to pounds P available to the crop. That is, it would not be appropriate to multiplying 10 ppm P (Olsen) by 4 (million pounds of soil per acre-foot) to estimate there will be 40 lbs./acre P per acre available to the crop, as is often done with nitrate-nitrogen (NO_3-N) budgeting. Furthermore, many university recommended crop applications rates were established for yield response, not necessarily on crop utilization or an environmental fate basis.

For example, with broccoli, University of California guidelines say that when soil P is less than 50 ppm, then 40-80 lbs/ac P fertilizer is warranted. At roughly 4 million pounds per acre-foot, that would be equivalent to 200 lbs/ac of P in the soil. However, only 30-35 lbs P is removed in an 8 to 9 tons/ac crop.

The output of current P planning tools only gives quantitative amounts over/under applied. They do not offer means to set subjective determinations for level of application (such as, Above, Sufficient, Below) nor risk potential. Secondary documents are needed for this. The current tools also relies on secondary documents to record the specific resource setting, assumptions made, and rationale for variances. They also require that each planner search out even the basic crop utilization, sufficient level, etc. data themselves.

Proposed Nutrient Balance Assessment Tool

The proposed assessment method is executed in NRCS-CA's **590-Nutrient Balance Assessment, Planning & Records** Excel workbook. This workbook can assess 3 different crops, management methods, and/or resource settings. It can also evaluate up to 3 crops in a rotation or series (i.e., double/triple cropping). The workbook has tabs or spreadsheets to identify the associated fields and to calculate nutrient contributions from various sources (cover crop, irrigation, solid manure/compost, and liquid manure) and crop & fertilizer references. The spreadsheet includes a data set for common crops and fertilizers that planners can use to develop a quick baseline assessment.

The main view of the workbook is the **Crop Balance** tab, where resource setting and rationales are documented, calculations are summarized, and determinations are made (see Table 1 below). This tab also has a brief description and/or guide for each item in the summary tab (located to the right of the main body). To help correspond each item with the description and /or guide, an **Item Ref. #** has been assigned on the left margin (column A). It also offers a place to record planner's rationales and brief notes [Item Ref. # 7.0 & 8.0 not shown].

Table 1

Nutrient Balance by Crop

Estimate of Crop Needs and Nutrient Contributions from Various Sources on **Per Acre Basis**

Item Ref. #										
1.0.	Producer:							Date:		
1.1.	anch/Field (CMU) with similar setting				FSA Farm:		Tract(s):		Field(s):	
1.1.1.	Additional Site Identification (optional):									
1.2.	Predominent Soil Texture:									
1.2.1.	H.S.G. & Leach'g Potent.									
1.3.	Irrigation Method:									
1.3.1.	Irrig.D.U. & Comments:									
1.4.0	**Crop Information**	**Crop # & Sequence:**	36	Primary Crop	42	2nd Crop (optional)		35	3rd Crop (optional)	
1.4.1		Crop Name	Tomato (Solanum lycoper		Broccoli			Strawberry		
1.5.		Cropped/Planted Land Area	1.0	Acres	1.0		Acres	1.0		Acres
1.6.		Typical: Plant Date		Days cropped			Days cropped			Days cropped
		Harvest Date		0			0			0
1.7.		Yield/ Acre / Season	50.0	tons	8.8	Tons		33.0	tons	
		Crop Nutrient Needs:	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
		In-season Plant tissue levels:									
1.8.		**Est. Nutrient Removal for Yield Goal** (Lbs/Ac)	150	69	315	102	31	77	73	30	136
1.8.1		Adjustment Factor * [1]:	1.40	0.75	1.00	1.40	1.00	1.00	1.40	1.00	1.00
1.8.2		**Target Nutrient Requirement for Yield Goal** [2]	210	52	315	142	31	77	102	30	136
2.0	**Nutrients Available Credited Sources - other than fertilizers, amendments or manures (Lbs/Ac)**										
2.1.		**Soil Data:** oil Sample Depth (ft) & Soil pH:	1.0	pH=		1.0	pH=		1.0	pH=	
2.1.0		P & K Sufficiency Levels (PPM)		20	135		50	150		50	200
2.1.1		Nutrient Analyses for Depth (ppm)	10.0	10	150	50.0	10.0	150.0	25.0	10.0	150.0
2.1.2		**N in sample depth** (Lbs/Ac) & P K "Sufficiency"	40.0	Low	Med	200.0	Med	Med	100.0	Med	Med
2.2.		**Organic Sources:** Legume N Credit		Lbs/Ac							
2.3.		**Cover Crop or Green Manure N Credit**	0.0	Lbs/Ac		0.0	Lbs/Ac		0.0	Lbs/Ac	
2.4.		**Expected N release from SOM** (Lbs/Ac)	0.0		%SOM	0.0		%SOM	0.0		%SOM
2.5.		**Other N** ** and ' & K Mgt Chang	Atmosphere	Consider Increasing P via UC Guidelines	Consider Maintaining Current K Rate		Consider Maintaining Current P Rate	Consider Maintaining Current K Rate		Consider Maintaining Current P Rate	Consider Maintaining Current K Rate
2.6.		**Total Available from Credited Sources**	40			200			100		
2.7.		Additional Nutrients Needed for Target:	170.0			-57.5			1.6		
3.0.	**Nutrients Available, By Added Sources - Intentional semi-controlled applications (Lbs/Ac)**										
3.1		**Irrigation Data:** Crop Water Requirement	28	Ac-In/Ac		0	Ac-In/Ac		29	Ac-In/Ac	
3.1.1		**Irrigation Water Nitrate (NO_3-N) Content**	10.0	PPM		5.0	PPM		1.0	PPM	
3.1.2		**NO_3-N in Irrigation Water** (Lbs/Ac)	64	Lbs/Ac		0	Lbs/Ac		7	Lbs/Ac	
3.2.		**Commercial Fertilizer**	8	8	8	8	8	8	8	8	8
3.3.		**Solid Manure/Compost/Organic Amend**	0	0	0	0	0	0	0	0	0
3.4.		**Liquid/Slurry Manure**	0	0	0	0	0	0	0	0	0
3.5.		**otal Applied & Available Water/Manure/Fert.:**	71	8	8	8	8	8	14	8	8
4.0.		Total Available Nutrients (Lbs/Ac):	111	8	8	208	8	8	114	8	8
5.0.		Results: Nutrients Needed or (Excess) Lbs/Acre	99	44	307	-65	24	70	-12	23	128
5.1.		Applied Availability Rating (from Removal Rate)[2]:	Mod Less	Signif Less	Signif Less	Signif Excess	Signif Less	Signif Less	Mod Excess	Signif Less	Signif Less
5.2.		**Soil Loading Risk Potential** [3] Based from: Total Avail./ Removal Rate	Within Adequate Range	Potential for P deficiency	No Risk of K loading	Very High Risk of N loading	No Risk of P loading	No Risk of K loading	High Risk of N loading	No Risk of P loading	No Risk of K loading
6.1.		Total Available to Removed Ratio:	0.74	0.11	0.02	2.04	0.24	0.10	1.57	0.25	0.06
6.2.		Total Applied to Removed Ratio:	0.47	0.11	0.02	0.07	0.24	0.10	0.19	0.25	0.06
6.3.		Total Available to Target Ratio:	0.53	0.15	0.02	1.46	0.24	0.10	1.12	0.25	0.06

Intro. | Land | Crop Balance | CB Instructions | Annual Balance | Cover Crop N | Irrig

MATERIALS AND METHODS

Microsoft Excel format was chosen because it is widely accepted in the workplace and can be easily modified to refine the assessment approach. The proposed spreadsheet uses LOOKUP reference tables to reference a default crop database [Crop Ref. tab], which includes default 'book values' source documentation. By entering appropriate Crop # [Item Ref. # 1.4.] into the "Crop Balance" spreadsheet, the following are auto-populated from a corresponding LOOKUP table book values. If the planner has actual on-farm data, the book values can be over-written):

- Typical yield/acre [Item Ref. # 1.7.];
- Estimated N, P, & K crop removal rate (lbs/acre) [Item Ref. # 1.8.];
- P & K Sufficiency Levels (PPM) when available [Item Ref. # 2.1.0.].
- Crop Water Requirement

Look-up table (see Table 2 below)

The crop information look-up table is located in the **Crop Ref. tab** or worksheet. It is fully editable, and as such, the user is free to update existing data or add their own data. The table has room to record the source of the information &/or add comments, so the planner or subsequent users can defend or amend their determinations. Users are cautioned about changing existing data and are encouraged to add records (rows) in the data set

Currently, the data set only includes a portion of the hundreds of crops grown in California. As individual planners discover more information, they can enter it here (documenting source) and easily share it with others. To date, most of the "Typical" yield data comes from county Ag statistic reports and the University of California, while the crop removal is generally from the USDA-NRCS Plant Database. Because of limited format capability of this workbook and that the university reporting format for P & K sufficiency levels varied considerably, the current values shown were extrapolated from the CDFA-FREP-UC Davis website.

Table-2 Excerpts of Crop Ref. tab look-up table

Crop Removal & Reference Guidelines

Crop Removal information is only to be used as rough estimates, NOT intended to be nutrient application recommendations.

Crop Code	Crop Name, use, & stage	Typical Yield	Yield Units	Pounds of nutrient per unit of yield					Standard Moisture %	Typical Irrig. Ac-In/Ac/Yr		Notes	* Soil P levels are Olsen-P. If soils test pp: Soil Sufficiency P ppm*	K ppm	Notes Source
				N	P	P_2O_5	K	K_2O							
1	2	3	4	5	6	7	8	9	10	11	12	13			
Fiber & Misc. Crops															
1	Cotton, for seed w/ lint or seed cotton	3	Bales	15.2	1.9	4.4	2.3	2.7	8%	36	ETc		5	120	State of CA Fertility Guidelines fa Tomatoes http://appr.cdfa.ca.gov/frep/doc
2	Sugarbeet, root with crown	32	Tons	5.3	1.0	2.2	6.0	7.3	80%						
Forage/Grain Crops															
3	Barley, grain	2.5	tons	37.0	7.0	16.0	10.0	12.0	10%	22	ETc				
4	Barley silage, boot stage	8	tons	16.0	2.6	6.0	11.6	14.0	70%	12					
5	Barley silage, soft dough	16	tons	10.0	1.6	3.7	8.3	10.0	70%	18					
6	Corn, grain	5	tons	29.0	5.5	12.6	6.0	7.2	10%	33	ETc				
7	Corn silage	30	tons	8.0	1.5	3.5	6.6	8.0	70%	29	ETc	Range 25-2	6	N/A	State of CA Fertility Guidelines fa Tomatoes http://appr.cdfa.ca.gov/frep/doc
8	Oats, grain	1.6	tons	44.0	6.5	14.9	7.5	9.0	10%	22	ETc	Range 25-2			
9	Oats silage, soft dough	16	tons	10.0	1.6	3.7	8.3	10.0	70%	20					
10	Rice	3.965	tons	12.3	2.5	5.73	4.0	4.84	11%	45	ETc		9	120	http://appr1.cdfa.ca.gov/Fertilizer/ Rice.html
120	Quinoa	2	tons	16.6	8.7	20.0	40.0	48.0	65%	15	ETc				
11	Safflower	2	tons	100.0	11.0	25.0	62.0	75.0	7.60	32	ETc				
12	Sorghum	4	tons	50.0	8.7	20.0	40.0	48.0	10%	33	ETc				
13	Sudangrass silage	8	tons	11.0	1.7	4.0	12.0	15.0	70%	12		8 t/cuttin			
14	Sugar beets	30	tons	8.5	0.9	2.0	15.0	18.0		50					
15	Sunflower									32	ETc				
16	Triticale, boot stage	12	tons	15.0	2.7	6.1	11.6	14.0	70%	12					
17	Triticale, soft dough	22	tons	10.0	1.7	3.8	7.5	9.0	70%	12					
18	Wheat, grain	3	tons	58.0	10.9	25.0	50.0	60.0	10%	22	ETc				

... Solid Manure App | Liquid Manure App | Timing | Crop Ref. | Fert. Ref. | Crop LGU-Annual | Crop LGU ...

Proposed P Assessment

Professional Judgement Determinations [see Table 1 above

Once the crop P & K soil sufficiency levels are determined and entered [Item Ref.# 2.1.0.], the current soil levels are reported (using actual data or estimated) [Item Ref.# 2.1.1.], and other resource setting information are considered, the planner must manually select the "**P-K Sufficiency" rating** [Item Ref. # 2.1.2.]. The rating ranges from below, sufficient, above, or N/A.

Each of these sufficiency ratings has a corresponding suggested action that is offered [Item Ref. # 2.7.]. , such as,

If "Below", then "Consider Increasing P via UC Guidelines",
If "Suff.", then "Consider Maintaining Current P Rate",
If "Above", then "Consider Reducing P to UC Guidelines",
If "N/A", then "N/A & document in Additional Notes"

To compare total available nutrients amounts (credited & applied) with crop removal, another rating is assigned based on a range of available to remove ratios, as reported in the **Total Availability Rating (from Removal Rate)** [Item Ref.# 5.1.]. They are:

IF	Available to Removed Ratio is:	THEN:	Applied Availability Rating	
	> 1.25		"Signif. Excess"	**Ratio rating breaks have been arbitrarily set. User can adjust according to professional judgement**
	> 1.1		"Excess"	[adjust in cells C67 thru G73]
	> 0.9		"Maintains"	*The number of ratings can be reduced or expanded depending on academic and industry feedback*
	> 0.75		"Less"	
	< 0.75		" Signif. Less"	

The Applied to Removed ratios values that trigger a different Total Availability Rating **values are arbitrary** and are intended to help NRCS planners and their customers separate into general categories to make rough determinations quickly. They are not intended to be scientific and can be over-written in Crop Balance [cells C67 thru G73] based on professional judgement.

The **Soil Loading Risk Potential** is determined based on the P & K Sufficiency Rating (based on professional judgement) **and** the Total Available to Removed ratio, as compared against the Availability Rating breaks above. This rating uses a sliding scale determination starting at "Very High Risk Potential" (when soil P levels are "Above" sufficiency AND the A/R ratio is greater than 1.25) to "Potential for P deficiency" (when soil P levels are "Below" sufficiencies AND the A/R ratio is less than 0.75) [see table 3]

Soil Loading Risk Potential (from Total Available [4.0.]/ Removal Rate [1.8.])

Logic Statement Levels [Item Ref.# 5.2]

IF	Total Available [4.0.] To Removed [1.8.] Ratio is:	**AND**	Soil Sufficiency Levels [2.1.2.] are:	THEN:	Risk Potential Rating
	> 1.25		"Above"		"Very High Risk of P loading"
	> 1.1		"Above"		"High Risk of P loading"
	> 0.9		"Above"		"Mod High Risk of P loading"
	> 0.75		"Above"		"Risk of P loading"
	<= 0.75		"Above"		"Low Risk of P loading"
	> 1.25		"Suff."		"Mod High Risk of P loading"
	> 1.1		"Suff."		"Risk of P loading"
	> 0.9		"Suff."		"Low Risk of P loading"
	> 0.75		"Suff."		"Min. Risk of P loading"
	<= 0.75		"Suff."		"No Risk of P loading"
	> 1.25		"Below"		"Risk of P loading"
	> 1.1		"Below"		"Low Risk of P loading"
	> 0.9		"Below"		"Min. Risk of P loading"
	> 0.75		"Below"		"No Risk of P loading"
	<= 0.75		"Below"		"Potential for P deficiency"

Risk Potential - For soil loading & chemistry imbalance, NOT for transport to water bodies (ground &/or surface water) or crop response. Poor irrigation management and soil

permeability, erosion tolerances, slope, and surface conditions effect transport risk to water bodies.

If there is a soil P loading risk potential ("Risk of P Loading", "Mod Risk of P Loading", or "High Risk of P Loading", or "Very High Risk of P Loading) them NRCS CA P-Index must be run.

Regardless of the rating, NRCS planners will almost always recommend implementing NRCS' CPS 590-Nutrient Management to sample and test more aggressively and improve record keeping to validate determinations.

RESULTS AND DISCUSSION

When beta tested, once a grower interview is conducted and appropriate data is assembled, a risk potential determination was made a very short time.

SUMMARY

Although not scientific, the proposed P & K rating system provides NRCS planners a reasonably accurate and documented determination quickly. Admittedly, the spreadsheet is complicated but NRCS, CA does not intend to deploy this tool without proper training. Furthermore, NRCS, CA has support staff to assist planners in its use.