



# Using a simple nutrient balance calculator to build awareness of soil nutrient removal in harvested produce and the importance of fertilizers in soil fertility

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October 2017

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# Maintenance of soil fertility

Lowers **long-term risk** of reducing agricultural productivity

- Soil nutrient decline can accelerate:
  - Organic matter decline
  - Soil erosion

However, farmers manage to minimize **short-term risk**

- By minimizing input costs to reduce risk of financial losses due to:
  - Increasing input costs versus declining commodity prices
  - Crop losses due to drought, flooding, pests, diseases

## Outcome:

- Under application of fertilizer
- Long-term soil nutrient decline
- Declining productivity in long-term

# Soil nutrient balance

## Lack of awareness

Our experience in Brunei and Philippines:

- Farmers (and advisors) often unaware of the concept of nutrient balance
- Improving understanding of nutrient balance is an essential first step to
  - Improving soil nutrient management
  - Arresting soil nutrient decline

In our current project in Pyawbwe we have observed 'nutrient mining'

- Little use of fertilizers
- Consumption of crop residues by cattle and sheep
- Export of animal manure to producers of high value crops in Shan State

# A simple nutrient balance calculator

- Estimates crop nutrient requirement using
  - Nutrient removal in produce – assumes retention of crop residues
  - Soil nutrient status
- Calculates fertilizer to meet nutrient requirement
  - a) To replace nutrients removed by crops – **based on actual yields**
  - b) To build up soil fertility if necessary
- Based on database of published nutrient contents
- Only measurement required is crop yield
  - Intended to encourage record keeping by farmers
- Can use soil nutrient measurements if available
- Uses Excel® spreadsheet linked to Access® database



# 1. Previous & next crops and 2. Yields

## Measured yield of previous crop – estimate of next crop



CSIRO

Soil Fertility Evaluation/Advisory Service in Negara Brunei Darussalam

### Fertilizer and Lime Calculator



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All fields marked \* must be completed

#### 1. Crops

a) Type:

b) Crop:

DOA ref.:

Malay:

English:

Scientific:

Previous

\* Short duration crops

\* Rice

C

Padi

Rice

*Oryza sativa*

Next

\* Short duration crops

\* Mung bean

D09

Kacang hijau

Mung bean

*Vigna radiata*

#### 2. Yield

a) Type of measurement area

b) Area

c) -

d) Measurement area

e) Total weight of produce and other plant material removed from measurement area

f) Yield

Measurement

\* Field (ha) 2

\* 1.0 ha

1.0 ha

\* 3.5 t grain

0.35 kg/m<sup>2</sup>

3.50 t/ha

3.50 t/1 ha

Flexible measurement area

- Rectangle
- Length of row
- Trees

0.10 kg/m<sup>2</sup>

1.00 t/ha

1.00 t/1 ha

# 3 & 4. Nutrient removal

= yield x nutrient content

3. Crop nutrient content		Soil Fertility Evaluation		(Tick if there are measured values)	
<b>4. Nutrient removal by crop</b> * must be completed					
<b>1. Crops</b> a) Type: b) Crop: c) DOA ref.: d) Malay: e) English: f) Scientific:		E 5.25 g/m <sup>2</sup> E 0.00 g/m <sup>2</sup> E 0.88 g/m <sup>2</sup> E 0.88 g/m <sup>2</sup> E 0.18 g/m <sup>2</sup> E 0.35 g/m <sup>2</sup>		E 5.50 g/m <sup>2</sup> E -4.13 g/m <sup>2</sup> E 0.40 g/m <sup>2</sup> E 1.70 g/m <sup>2</sup> E 0.40 g/m <sup>2</sup> E 0.30 g/m <sup>2</sup>	
		M. Value based on measured crop nutrient content E. Value estimated from published crop nutrient content Both multiplied by measured yield of previous crop or estimated yield of next crop.		Mung bean <i>Vigna radiata</i>	
<b>2. Yield</b> a) Type of measurement area b) Area c) - d) Measurement area e) Total weight of produce and other plant material removed from measurement area f) Yield		<b>Measurement</b> * Field (ha) 2 * 1.0 ha - 1.0 ha * 3.5 t grain 0.35 kg/m <sup>2</sup> 3.50 t/ha 3.50 t/1 ha		<b>Estimate</b> * 1.0 ha - 1.0 ha * 1.0 t grain 0.10 kg/m <sup>2</sup> 1.00 t/ha 1.00 t/1 ha	

# 3 & 4. Nutrient removal

= yield x nutrient content

3. Crop nutrient content		<input type="checkbox"/> (Tick if there are measured values)	
4. Nutrient removal by crop			
N	E	5.25 g/m <sup>2</sup>	E 5.50 g/m <sup>2</sup>
N fixed by crop	E	0.00 g/m <sup>2</sup>	E -4.13 g/m <sup>2</sup>
P	E	0.88 g/m <sup>2</sup>	E 0.40 g/m <sup>2</sup>
K	E	0.88 g/m <sup>2</sup>	E 1.70 g/m <sup>2</sup>
Ca	E	0.18 g/m <sup>2</sup>	E 0.40 g/m <sup>2</sup>
Mg	E	0.35 g/m <sup>2</sup>	E 0.30 g/m <sup>2</sup>

M: Value based on measured crop nutrient content  
 E: Value estimated from published crop nutrient content  
 Both multiplied by *measured* yield of previous crop or *estimated* yield of next crop.

- Actual nutrient content if available
- Otherwise uses database of nutrient contents from literature
- Removal of P, K, Ca and Mg based on **previous crop**
  - Assumes retention of all crop residues
- N requirement of **next crop**
  - Assumes no residual N (unless leguminous)
  - Allowance for leguminous fixation

## Check against recommended thresholds

3. Soil nutrient status		<input checked="" type="checkbox"/> (Tick if there are measured values)		Status for next crop	
		Recently measured soil nutrient values			
4. Nutrient removal by crop		1	% 100		
N	E	10	g/m <sup>2</sup> /kg	E Low	5.50 g/m <sup>2</sup>
N fixed by crop	E	0.2	g/m <sup>2</sup> /kg	E Medium	-4.13 g/m <sup>2</sup>
P	E	1	g/m <sup>2</sup> /kg	E Medium	0.40 g/m <sup>2</sup>
K	E	0.2	g/m <sup>2</sup> /kg	E Medium	1.70 g/m <sup>2</sup>
Mg	E	0.15	g/m <sup>2</sup>	E	0.40 g/m <sup>2</sup>
Ca	E	0.35	g/m <sup>2</sup>	E Low	0.30 g/m <sup>2</sup>
Has fertilizer been applied regularly for the past 5 years?	<input type="checkbox"/>	<input checked="" type="checkbox"/> M: Value based on measured crop nutrient content <input type="checkbox"/> P: Value based on published crop nutrient content			
Soil pH		5.6		Ideal for next crop	
Both multiplied by <i>measured</i> yield of previous crop or <i>estimated</i> yield of next crop.					



# 5. Soil nutrient status

## Check against recommended thresholds

5. Soil nutrient status		<input checked="" type="checkbox"/> (Tick if there are measured values)	
		Recently measured soil nutrient values	Status for next crop
N		1 % 100 ▼	
P		10 mg/kg ▼	Low
K		0.2 cmol/kg ▼	Medium
Ca		1 cmol/kg ▼	Medium
Mg		0.2 cmol/kg ▼	Medium
Has fertilizer been applied regularly for the past 5 years?		* <input type="checkbox"/>	Low
Soil pH		* 5.6	Ideal for next crop

- Check soil nutrient content against recommended thresholds
  - Either use actual soil analysis
  - Or based on regular fertilizer use
- If soil nutrient levels < threshold: use fertility factor = 2
  - Builds up soil fertility to recommended levels

# 5. Soil nutrient status

## Check against recommended thresholds

<b>5. Soil nutrient status</b>	<input type="checkbox"/> (Tick if there are measured values)	
Has fertilizer been applied regularly for the past 5 years?	* <input type="checkbox"/>	Status for next crop Low
Soil pH	* <input type="text" value="5.6"/>	Ideal for next crop

- Check soil nutrient content against recommended thresholds
  - Either use actual soil analysis
  - Or based on regular fertilizer use
- If soil nutrient levels < threshold: use fertility factor = 2
  - Builds up soil fertility to recommended levels

# 6. Soil characteristics

## To modify fertilizer efficiencies

### 5.6 Soil characteristics

Soil Type/Subtype

Has fertilizer been applied regularly for the past 5 years?

Soil attributes

Soil topsoil texture

Soil waterlogging status

Does the soil fix P?

Does the soil leach easily?

Bulk density

☐ (Tick if there are measured values)

\* Brown or grey soil, Somewhat poorly drained

Status for next

\* ☐ Actual soil attributes

Low Default attributes for Soil Subtype

\* Clay 5.6

Identify for next crop

Waterlogging

Waterlogging

☐

☐

☐

☐

1.40 t/m<sup>3</sup>

1.40 t/m<sup>3</sup>

# 6. Soil characteristics

## To modify fertilizer efficiencies

**6. Soil characteristics**

Soil Type/Subtype

\* Brown or grey soils, Somewhat poorly drained

Brown or grey soils, Somewhat poorly drained

Soil attributes

Actual soil attributes

Default attributes for Soil Subtype

Topsoil texture

Clay

Clay

Soil waterlogging status

Waterlogging

Waterlogging

Does the soil fix P?

☐

☐

Does the soil leach easily?

☐

☐

Bulk density

1.40 t/m<sup>3</sup>

1.40 t/m<sup>3</sup>

- Waterlogging: decreases N efficiency
- Leaching: decreases N efficiency
- P fixation: decreases P efficiency

# 7. Nutrient requirements

= Nutrient removal x fertilizer efficiency x fertility factor

## 7.1 Soil characteristics for next crop

Soil Type/Subtype	Fertilizer efficiency	Multiplier for soil nutrient status	Actual soil attributes	Default attributes for Soil Subtype	kg/ha	kg/1 ha
N Soil attributes	40%	x 1	3.44	34.4	34.375	
P Topsoil texture	Clay 40%	x 2	4.38	Clay 43.8	43.75	
K Soil waterlogging status	Waterlogging 60%	x 2	2.92	Waterlogging 29.2	29.167	
Ca Does the soil fix P?	60%	x 2	0.58	5.8	5.833	
Mg Does the soil leach easily?	60%	x 2	1.17	11.7	11.667	
Bulk density	1.40 t/m <sup>3</sup>			1.40 t/m <sup>3</sup>		

# 7. Nutrient requirements

= Nutrient removal x fertilizer efficiency x fertility factor

## 7. Nutrient requirements for next crop

	Fertilizer efficiency	Multiplier for soil nutrient status	g/m <sup>2</sup>	kg/ha	kg/1 ha
N	40%	x 1	3.44	34.4	34.375
P	40%	x 2	4.38	43.8	43.75
K	60%	x 2	2.92	29.2	29.167
Ca	60%	x 2	0.58	5.8	5.833
Mg	60%	x 2	1.17	11.7	11.667

Nutrient requirement has two parts:

- Nutrient replacement
  - Nutrient removal of **previous crop** (P, K, Ca, Mg) and **next crop** (N)
  - Fertilizer efficiency – modified by soil characteristics
- Fertility build up
  - Use a 2x fertility factor where soil nutrient status is low



# 8. Manure application

## 8. Manure application

Water content of manure

\* 0.10 g/g oven dry manure

Default: 0.10 g/g oven dry manure

Nutrient content of manure

☐ (Tick if there are measured values)

N

g/m<sup>2</sup> kg/ha kg/1 ha

P

3.44 34.4 34.375

Amount to be applied (fresh weight)

40% x 2 4.38 43.8 43.75

Ca

60% x 2 0.03 0.29 29.27

Mg

60% x 2 0.58 5.8 5.833

Nutrient budget

Requirement for next crop Applied as manure Balance required

	g/m <sup>2</sup>		
N	3.44	0.75	2.69
P	4.38	0.24	4.14
K	1.46	1.46	-
Ca	0.29	0.79	-0.5
Mg	0.58	0.16	0.42

# 8. Manure application

**8. Manure application**  
Water content of manure  
*Nutrient content of manure*

\*

0.10

g/g oven dry manure

Default: 0.10 g/g oven dry manure

☐ (Tick if there are measured values)

Amount to be applied (fresh weight)

Calculate amount

kg/m<sup>2</sup>  
0.03

t/ha  
0.29

t/1 ha  
0.29

*Nutrient budget*

	Requirement for next crop	Applied as manure	Balance required
	g/m <sup>2</sup>		
N	3.44	0.75	2.69
P	4.38	0.24	4.14
K	1.46	1.46	-
Ca	0.29	0.79	-0.5
Mg	0.58	0.16	0.42

If available, manure can be used to meet part of the nutrient requirement

- Very little information on nutrient contents of manure
  - Currently uses chicken manure

# 9a. Fertilizer application

## Most suitable combination

### 9. Fertilizer application for next crop

Most suitable fertilizer combination

Nutrient content of manure

+ Urea

+ Superphosphate (triple)

Amount to be applied (fresh weight)

Cost  
Nutrient budget

N  
Nutrient budget

P

K N

Ca P

Mg K

\* Unit price 0.10 g/g oven dry manure

☐ (Tick if there are measured values)

\$0.28/kg

\$0.29/kg

\$0.25/kg

Calculate amount

g/m<sup>2</sup>

0.0

5.85

19.99

0.03

0.0

\$/m<sup>2</sup>

\$0.01

Requirement for  
next crop

Requirement after  
manure application

3.44

4.38

1.46

2.69

4.74

0.58

0.10 g/g oven dry manure

0.0

58.5

199.9

0.29

0.0

\$/ha

\$74.34

Applied as  
manure

g/m<sup>2</sup>

Applied as  
fertilizer

0.75

0.24

1.46

2.69

4.74

0.16

g/g oven dry manure

0.0

58.452

199.904

0.89

0.0

\$/1 ha

\$74.34

Balance  
required

2.69

4.14

-

-0.5

0.42

# 9a. Fertilizer application

## Most suitable combination

9. Fertilizer application for next crop				
a) Most suitable fertilizer combination		Unit price	g/m <sup>2</sup>	kg/ha
-		-	0.0	0.0
+ Urea	\$0.28/kg		5.85	58.5
+ Superphosphate (triple)	\$0.29/kg		19.99	199.9
+ Muriate of potash	\$0.25/kg		0.0	0.0
			kg/1 ha	
			0.0	0.0
			58.452	199.904
			0.0	0.0
			\$/m <sup>2</sup>	\$/ha
			\$0.01	\$74.34
			\$/1 ha	\$74.34
Nutrient budget			Requirement after manure application	Applied as fertilizer
			g/m <sup>2</sup>	Balance required
N			2.69	2.69
P			4.14	4.14
K			0.0	0.0

Calculates cheapest combination of fertilizers to meet (remaining) nutrient requirement

- Compound fertilizer to match requirement of one nutrient
- Urea, superphosphate and potash to match remaining nutrients

# 9b. Fertilizer application

## Alternative combinations

**9. Fertilizer application for next crop**

**b) Alternative fertilizer combination**

a) (Select fertilizers A to D in sequence)

**Most suitable fertilizer combination**

Fertilizer A: 12-12-17 \$0.28/kg

+ Urea \$0.28/kg

+ Fertilizer B: Urea \$0.28/kg

+ Superphosphate (triple) \$0.29/kg

+ Fertilizer C: Superphosphate (triple) \$0.29/kg

+ Muriate of potash \$0.25/kg

+ Fertilizer D: Muriate of potash \$0.25/kg

Cost \$0.01

Cost \$0.01

Nutrient budget

Nutrient budget

N

P

K

Reset

Calculate ABCD

Calculate BCD

Calculate CD

Calculate D

g/m<sup>2</sup>

kg/ha

kg/1 ha

20.67

2.08

15.98

0.0

\$0.01

\$0.01

Requirement after manure application

Requirement after manure application

Requirement after manure application

2.69

4.14

3.44

0.0

4.38

2.92

Applied as fertilizer

Applied as fertilizer

Applied as fertilizer

2.69

4.14

3.44

0.0

4.38

2.92

Balance

Balance

Balance

-

-

-

-

-

# 9b. Fertilizer application

## Alternative combinations

**b) Alternative fertilizer combination**  
(Select fertilizers A to D in sequence)

Fertilizer A:  ▼ Unit price \$0.28/kg

+ Fertilizer B:  ▼ Unit price \$0.28/kg

+ Fertilizer C:  ▼ Unit price \$0.29/kg

+ Fertilizer D:  ▼ Unit price \$0.25/kg

Cost \$0.01 \$/m<sup>2</sup> \$110.05 \$/ha \$110.05 \$/1 ha

**Nutrient budget**

	Requirement after manure application	Applied as fertilizer	Balance required
	g/m <sup>2</sup>		
N	3.44	3.44	-
P	4.38	4.38	-
K	2.92	2.92	-

Reset

Calculate ABCD

Calculate BCD

Calculate CD

Calculate D

	g/m <sup>2</sup>	kg/ha	kg/1 ha
Calculate ABCD	20.67	206.7	206.709
Calculate BCD	2.08	20.8	20.804
Calculate CD	15.98	159.8	159.825
Calculate D	0.0	0.0	0.0

Can also calculate alternative combinations



# Summary

## Simple nutrient balance calculator

- Intended as first step to better soil fertility management
  - By building awareness of nutrient balance
  - By encouraging better record keeping
- Is greatly improved by actual soil nutrient measurement
  - Demonstrates need for local soil analysis facilities
- Could also be improved by better fertilizer efficiency data
  - Helps to direct research efforts

# Thank you

## **CSIRO Agriculture and Food**

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