Department of Environment and Heritage Protection

REEF WATER QUALITY

Farming in Reef Catchments

The method for calculating the optimum amount of nitrogen and phosphorus to be applied to sugarcane properties regulated under the *Environmental Protection Act 1994*

Queensland Government

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Introduction

In October 2009, new reef protection measures were added to the *Environmental Protection Act 1994*. In part, these measures require that a person must not apply more than the 'optimum amount' of nitrogen and phosphorus when carrying out commercial sugarcane growing in the catchments of the Wet Tropics, Burdekin Dry Tropics and Mackay-Whitsunday.

The 'optimum amount' relates to the kilograms of nitrogen and phosphorus applied per hectare, kg/ha. In places, this document refers to a 'rate' rather than 'amount' which is the generally accepted term for applying fertiliser. The 'kg' refers to the actual amount of nitrogen or phosphorus (nutrient content) in the fertiliser product, not the fertiliser product application rate. The nutrient content of the applied commercial fertiliser product can be found on the label.

The method provided in this document is derived from procedures outlined in the *Six Easy Steps* program developed by BSES Limited (now Sugar Research Australia). The *Six Easy Steps* program is a complete nutrient management system, based on a site-specific approach to soil and nutrient management and is the accepted industry standard recognised in the Smartcane BMP program, available at **www.smartcane.com.au.**

The *Six Easy Steps* program aims to provide sugarcane growers with fertiliser rates that optimise productivity and profitability while minimising loss of nutrients through leaching, gaseous losses and run-off.

The optimum nutrient calculation method in this document focuses on nitrogen (N) and phosphorus (P), the two nutrients of environmental importance.

The results from soil testing must be used to determine the amount of fertiliser to apply. *The method for soil sampling and analysis for sugarcane properties regulated under the Environmental Protection Act 1994* provides guidance for soil testing and is also available on the Department of Environment and Heritage Protection website at **www.qld.gov.au/FarminginReefCatchments.**

It is important to note that records must be kept of activities relating to the application of fertilisers and chemicals on your sugarcane property. Record keeping forms and further information is also available from the Department of Environment and Heritage Protection website at **www.qld.gov.au/FarminginReefCatchments.**

How to calculate the rate of nitrogen fertiliser to apply?

The diagram below (Figure 1) outlines the method to calculate the rate of nitrogen fertiliser to apply. The rate only considers nitrogen sourced from fertiliser and mill mud. A modified approach is also described for calculating the nitrogen rate for ratoon crops established before 2010 that remain productive. The method requires the calculation of a baseline application rate, from which amounts are deducted based on the soil organic carbon content and mill mud applications.

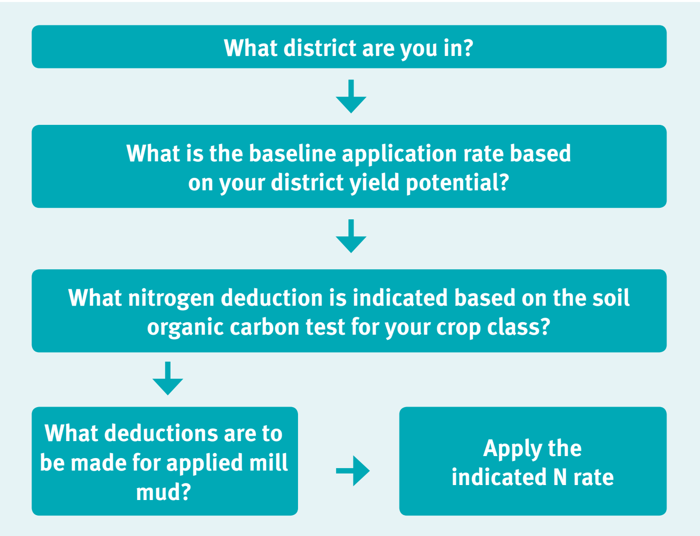


Figure 1: The process for determining the application rate of nitrogen on cane blocks.

Source: Schroeder 2009 unpublished.

Stage 1. Working out the baseline nitrogen application rate

The baseline application rate is the starting amount of nitrogen needed by the crop before deductions are made to account for the in-season mineralisation of available nitrogen from soil organic matter identified through soil testing. The baseline application rate is calculated by multiplying the district yield potential by the nitrogen utilisation index.

Step 1.1: What is the district yield potential?

The district yield potential represents the highest average yields of sugarcane obtained across a district over all soil types and is calculated by multiplying the estimated highest average annual district cane yield (tonnes cane/ha) by a factor of 1.2. For example, the highest average yield in the Tully district is 100 tonnes of cane to the hectare. This figure, multiplied by 1.2, gives a district yield potential of 120 tonnes of cane to the hectare.

How do I calculate my district yield potential?

Table 1 shows the yield potential for nine broad districts as defined by industry from sugar mill records. Identify the district your farm is located in from the left-hand column and find your district yield potential in the right-hand column. Use this figure for calculating the baseline nitrogen application rate.

Table 1: District yield potential for the nine districts defined by BSES Limited (now known as Sugar Research Australia)

District	District yield potential (tonnes of cane/ha) - 1.2 times the highest average yield
Mossman/Cairns	120
Innisfail/Johnstone	120
Tully	120
Herbert	120
Mareeba/Dimbulah	150
Burdekin	150 or 180*
Proserpine	130
Mackay	130
Plane Creek	120

Source: Schroeder, B.L., Wood, A.W., Panitz, J.H. (2007-2009), Nutrient management series, Australian Canegrower.

*The Burdekin district has two yield potentials (150 and 180 tonnes of cane/ha), recognising that some farms/blocks can attain yields above 150 tonnes of cane/ha. If verifiable yield records or other reasonable evidence from the past fifteen years show that your farm or block can produce yields higher than 150 tonnes of cane/ha, you may adopt the 180 tonnes of cane/ha yield potential figure to calculate your baseline application rate. Otherwise, you must use a district yield potential of 150 tonnes of cane/ha.

Step 1.2: What is the nitrogen utilisation index?

The nitrogen utilisation index is a figure derived from field experiments and modelling by the Cooperative Research Centre (CRC) for Sustainable Sugar to calculate the amount of nitrogen fertiliser required by plant and ratoon crops to produce a certain yield of millable cane. The index is 1.4kg of nitrogen applied for every tonne of cane up to a yield of 100 tonnes per hectare, plus 1.0kg of nitrogen for every tonne thereafter.

How do I calculate my baseline nitrogen application rate?

Table 2 shows the baseline amount of nitrogen to be applied in the nine different districts. These amounts were calculated by multiplying the district yield potential by the nitrogen utilisation index.

For example: A grower in Innisfail, where the district yield potential is 120 tonnes of cane per hectare would start with a baseline nitrogen application rate of 160kg of nitrogen per hectare. This is calculated by taking the first 100 tonnes of the district yield potential for Innisfail and multiplying it by the nitrogen utilisation index of 1.4—which equals 140 (100 x 1.4). The remaining 20 tonnes (the amount above the 100 tonne threshold as explained above) is then multiplied by 1.0 – which equals 20 (20 x 1.0). Add these two figures together (140 + 20) and the baseline application rate for nitrogen fertiliser in Innisfail is 160kg per hectare.

Table 2: District yield potential and the corresponding baseline N application rates

District	District yield potential (tonnes of cane/ha)	Baseline nitrogen application rate (for plant & ratoon crops)
Mossman/Cairns	120	160
Innisfail/Johnstone	120	160
Tully	120	160
Herbert	120	160
Mareeba/Dimbulah	150	190
Burdekin	150 or 180*	190 or 220*
Proserpine	130	170
Mackay	130	170
Plane Creek	120	160

Source: Schroeder, B.L., Wood, A.W., Panitz, J.H. (2007-2009), Nutrient management series, *Canegrowers magazine*.

*The Burdekin district has two yield potentials (150 and 180 tonnes of cane/ha), recognising that some farms/blocks can attain yields above 150 tonnes of cane/ha. If verifiable yield records or other reasonable evidence from the past fifteen years show that your farm or block can produce yields higher than 150 tonnes of cane/ha, you may adopt the 180 tonnes of cane/ha yield potential figure to calculate your baseline application rate. Otherwise, you must use a district yield potential of 150 tonnes of cane/ha.

What if my yield is higher than the district yield potential?

If a grower can demonstrate to the satisfaction of the Department of Environment and Heritage Protection (through verifiable yield records or other reasonable evidence from the past 15 years) that a farm or block can produce yields higher than the district yield potential, the baseline nitrogen application rate can be adjusted.

For example: If verified records or other reasonable evidence from up to fifteen years show that a block on a farm in the Johnstone district produced 130 tonnes of cane to the hectare, then the baseline N application rate can be increased to 170 kilograms of N per hectare. This adjustment is reached by applying the same calculation as provided previously i.e. (100 x 1.4) + (30 x 1.0) = 170. This figure is 10kg of nitrogen per hectare higher than the normal baseline rate applied in the Johnstone district shown in Table 2, reflecting the higher yield potential as verified by the farm records.

What if my yield is lower than the district yield potential?

If a farm or block produces lower yields than the district yield potential, the baseline nitrogen application rate could be reduced using the same approach. However you should first assess whether any constraints (i.e. soil compaction, soil waterlogging or nutrient deficiencies other than nitrogen or phosphorus) are preventing your crop reaching the district yield potential.

Consideration should also be given to reducing the application rate in older ratoon crops (fourth ratoon or older) or late cut cane, which may have a lower yield potential. In this case, use your property records to determine an appropriate yield potential and calculate the application rate using the method above.

Stage 2. Calculating the deductions from the baseline nitrogen application rate

This section shows how to calculate deductions from the baseline nitrogen application rate calculated in Stage 1.

Step 2.1: What is the soil nitrogen mineralisation index?

One source of available nitrogen is in-season mineralisation of nitrogen from soil organic matter. The quantity of nitrogen made available from organic matter is estimated by measuring the organic carbon level of the soil. Very broadly, soil organic matter is made up of crop residues, living soil microorganisms and stable, complex organic compounds termed 'humus'. Different soils contain different amounts of organic matter. All organic matter contains carbon which can be measured and is used as an indicator of organic matter content.

Soil organic matter breaks down into the inorganic forms of nitrogen, both of which are available to plants. This process is called mineralisation. However, the actual quantity of nitrogen supplied to the sugarcane crop varies according to the soil type and seasonal conditions.

The soil nitrogen mineralisation index was developed to help you adjust the **baseline nitrogen application rate** by taking into account the nitrogen mineralised from soil organic matter during the crop season. These adjustments are based on the organic carbon content of your soil (the soil nitrogen mineralisation index—OC%).

The soil nitrogen mineralisation index must be determined for each area that soil samples are taken in preparation for establishing plant cane, as different soil types may have different organic carbon contents—refer to the soil map prepared while completing the soil sampling methodology provided in *The method for soil sampling and analysis for sugarcane properties regulated under the Environmental Protection Act 1994.*

How do I adjust my baseline nitrogen application rate using the soil mineralisation index?

Once you have received the results of your soil test, you will know the organic carbon content of the soil, which will be presented as a percentage (%).

Plant cane

To determine what your nitrogen application rate is for plant cane crops established after a fallow refer to Table 3. These figures represent the regulated amount of nitrogen to apply recognising that a greater amount of nitrogen is mineralised in the soil during a fallow period of at least six months.

Table 3: Nitrogen application rates for plant cane after a fallow based on district yield potentials and the soil nitrogen mineralisation index.

Soil nitrogen mineralisation index	Organic carbon (%)	District yield potential (tonnes of cane/ha)			
		120[1]	130[2]	150[3]	180[4]
		N application rate for plant cane (kg N/ha)			
Very Low	<0.4	140	150	150	180
Low	0.4–0.8	130	140	140	170
Medium/Low	0.8–1.2	120	130	130	160
Medium	1.2–1.6	110	120	120	150
Medium/High	1.6–2.0	100	110	110	140
High	2.0–2.4	90	100	100	-
Very High	>2.4	80	90	90	-

1 Mossman / Cairns, Innisfail / Johnstone, Tully, Herbert, Plane Creek districts

2 Mackay and Proserpine districts

3 Burdekin, Mareeba / Dimbulah districts

4 Burdekin district - yield potential based on reasonable evidence

Source: Schroeder, B.L., Wood, A.W., Panitz, J.H. (2007-2009), Nutrient management series, *Canegrowers magazine*.

Ratoon and replant cane
Table 4 indicates the regulated amount of nitrogen to apply on ratoon and replant cane. Find the range of organic carbon percentage that matches your soil test result with the application rate under the district yield potential column identified earlier in Table 2. Note that the higher the organic carbon content, the greater the deduction from the baseline application rate.

Table 4: Nitrogen application rates for replant and ratoon cane based on district yield potentials and the soil nitrogen mineralisation index.

Soil nitrogen mineralisation index	Organic carbon (%)	District yield potential (tonnes of cane/ha)			
		120[1]	130[2]	150[3]	180[4]
		N application rate for ratoon and re-plant cane (kg N/ha)			
Very Low	<0.4	160	170	190	220
Low	0.4–0.8	150	160	180	210
Medium/Low	0.8–1.2	140	150	170	200
Medium	1.2–1.6	130	140	160	190
Medium/High	1.6–2.0	120	130	150	180
High	2.0–2.4	110	120	140	-
Very High	>2.4	100	110	130	-

1 Mossman/Cairns, Innisfail/Johnstone, Tully, Herbert, Plane Creek districts
2 Mackay and Proserpine districts
3 Burdekin, Mareeba/Dimbulah districts
4 Burdekin district—yield potential based on verifiable yield records

Source: Schroeder, B.L., Wood, A.W., Panitz, J.H. (2007-2009), Nutrient management series, C*anegrowers magazine*.

How do I adjust my baseline application rate for ratoon crops established before 2010 if I did not undertake soil testing prior to the plant crop?

The rate of fertiliser for ratoon crops already established at 1 January 2010 must also be calculated and recorded before fertilising. However, as it was not compulsory to take a soil test before fertilising these ratoon crops, a simplified method is used.

The application rate for nitrogen on ratoon crops already established at 1 January 2010 must not exceed the calculated baseline application rate for your district as outlined in Table 2. This amount can be reduced if the older ratoons produce lower yields and therefore require less nitrogen.

Note this method only applies to ratoon crops already established at 1 January 2010. Plant cane crops and subsequent ratoons established after this date must apply nitrogen at or below rates calculated using the full method as set out in Stage 1 and Stage 2 in this document.

Step 2.2: Nitrogen from mill by products

There are a number of mill by-products applied to sugarcane lands, including mill mud (fibre, soil and other milling process residuals), boiler ash (particulate material collected after bagasse and other material burnt at the mill) and mud-ash mixes (Schroeder 2008).

Substantial amounts of nitrogen, phosphorus and other nutrients are added to cane blocks through the application of mill by-products. However, the amount of nitrogen that blocks receive from mill by-products is affected by the following:

- Variability of the nitrogen content of the by-products due to the variable nature of the source of the material, i.e. mill mud is derived from different soil types within a district.
- Application rates of the by-products, as they range from around 50 to 300 wet tonnes per hectare.
- Variability of nutrient losses via nitrogen and phosphorus loss pathways.
- The ratio of the components of the mud/ash mix. This ratio can differ from load to load of the product.

Due to the variable nutrient content of mill mud and mill ash products, these mixtures will be treated as one product (mill mud). For the purpose of calculating the amount of nitrogen supplied by mill by-products, the lower documented value of their nitrogen content is used. This approach will be further refined in the future as techniques for quantifying and/or reducing the variability of the product are developed.

How do I calculate the deduction for nitrogen supplied from mill by-products?

Three rates of mill by-products are considered:

1. less than 100 wet tonnes/ha
2. 100–200 wet tonnes/ha
3. 200–300 wet tonnes/ha

Mill mud deductions from your nitrogen fertiliser application rate are only required in the season that mill mud is applied. To work out the deductions required from your nitrogen fertiliser application rate (Table 3 & 4) following the application of mill mud, refer to Table 5. These deductions reflect the low end of estimated nitrogen input from mill mud and were chosen to remove the uncertainty created by the variable nutrient content of mill by-products.

Note that deductions are voluntary where application rates are less than 100 wet tonnes per hectare and no deductions are required where mill ash alone is applied.

Table 5: Deductions from your nitrogen fertiliser application rate following the use of mill mud

Application rate (wet tonnes/ha)	Amount to be deducted from the N application rate in Table 4 (kg N/ha) in the plant or ratoon crop receiving mill mud
less than 100	Nil
100 – 200	40
200 – 300	60

Source: Adapted from Schroeder et al. (2009) unpublished.

Note that sources of nitrogen other than mill mud or fertiliser (such as legume crops grown during a fallow or irrigation water containing nitrate) can contribute additional nitrogen to your farm for crop uptake. To better match your nitrogen fertiliser rate to your crop nitrogen requirement, nitrate in irrigation water and nitrogen added by legume crops can be factored into your calculated nitrogen fertiliser application rate as further deductions from the baseline application rate. The *Six Easy Steps* program provides methodologies based on sound agronomic principles and extensive research to guide deductions to be made for nitrate in irrigation water and nitrogen supplied by legumes. Agronomic advice should be sought to determine appropriate deductions to be made for other nitrogen sources.

How to calculate the rate of phosphorus fertiliser to apply

Normally phosphorus (P) is applied to sugarcane through the application of fertilisers like di-ammonium phosphate (DAP) and blended fertilisers containing phosphorus as well as other nutrients. Other important sources that contain substantial amounts of phosphorus are mill by-products such as mill mud (Schroeder 2008).

This calculation method recognises sources of phosphorus from fertiliser products and mill mud, and requires that deductions be made for these inputs to calculate the rate of phosphorus fertiliser to apply. The method is based on the *Six Easy Steps* program which details the forms of phosphorus applied to sugarcane-producing soils, the fate of the applied phosphorus, a method for assessing the availability of phosphorus and management practices that aim to limit the risk of phosphorus losses from the farm (Schroeder 2008).

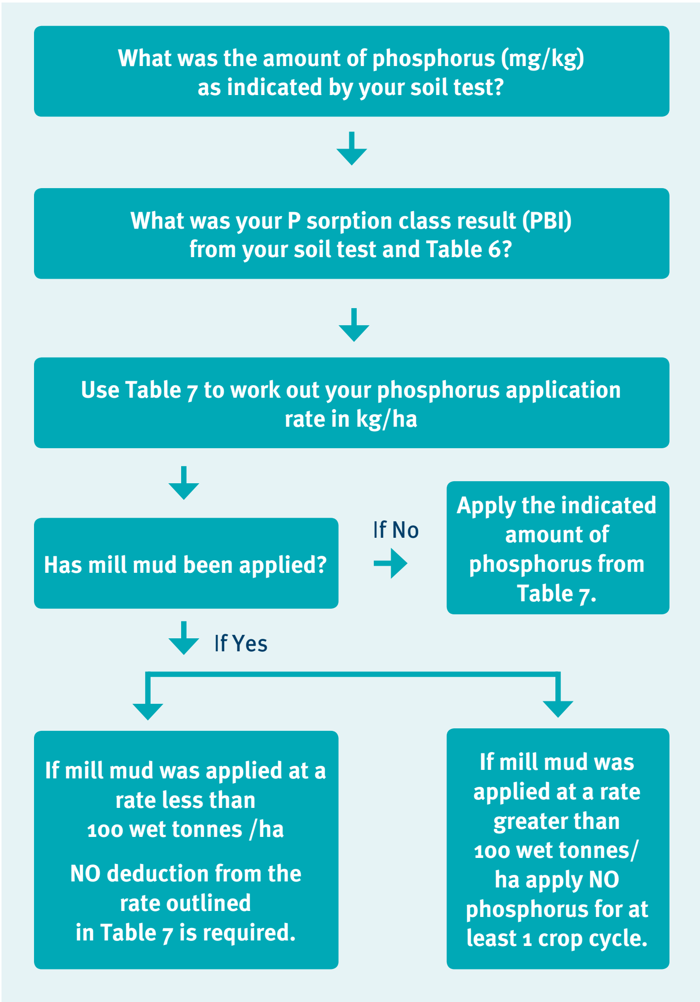


Figure 2: The process for determining the application rate of phosphorus on cane blocks.

Stage 1—How do I determine the phosphorus requirements of my soil?

The diagram presented in Figure 2 outlines the method to calculate the rate of phosphorus fertiliser to apply. The phosphorus requirement of the soil is determined using soil testing to show how much phosphorus is in the soil and how much of that phosphorus is available for use by the sugarcane crop. It is important to highlight that different soil types 'fix' phosphorus to different extents, making it unavailable to the crop. This is called 'sorption' and the higher the sorption capacity of a soil, the less phosphorus is available to the plant.

Some older sugarcane-producing soils do not require any additional phosphorus fertiliser due to their long history of phosphorus fertilisation. New land, on the other hand, may be deficient in available phosphorus.

Two different soil tests are used to calculate the phosphorus requirements of a soil for growing sugarcane:

1. The first measures extractable phosphorus (i.e. BSES P or Colwell P [Colwell P should be used for soil samples with a pH >7.5]), which provides an indication of the amount of phosphorus in the soil in mg/kg.

2. This value is then modified with a second test called the phosphorus buffer index (PBI) which is used to determine how much of the phosphorus is available for plant uptake, based on the soil type and sorption class. The higher the PBI value, the more phosphorus is 'fixed' by the soil, thereby lowering the amount available to the plant. Table 6 shows the soil phosphorus classes based on the PBI.

Table 6: Phosphorus (P) sorption classes based on the PBI

P buffer index (PBI)	P sorption class
<140	Low
141–280	Moderate
281–420	High
>420	Very high

Source: Schroeder et al. (2009 unpublished).

Recent research indicates that soils with very high PBIs require some phosphorus fertiliser at planting and for ratoon crops when BSES (acid) extractable phosphorus is greater than 50mg/kg.

Once you have your soil test results, you can calculate the amount of phosphorus to apply from Table 7.

Table 7: Phosphorus application rates based on extractable P (BSES acid method, or Colwell for soils with a pH above 7.5) and PBI

Phosphorus in soil test (mg/kg)	P sorption class	Phosphorus application (kg/ha)	
		Plant	Ratoon
>120	Low, moderate and high	Nil	Nil
	Very high	Nil	Nil
60–120	Low	Nil	Nil
	Moderate	Nil	Nil
	High	Nil	Nil
	Very high	30	20
50–60	Low	Nil	Nil
	Moderate	Nil	Nil
	High	Nil	Nil
	Very high	30	20
40–50	Low	20	Nil
	Moderate	20	5
	High	20	10
	Very high	30	20
30–40	Low	20	10
	Moderate	20	15
	High	20	20
	Very high	30	20
20–30	Low	20	10
	Moderate	20	20
	High and very high	30	25
10–20	Low	30	15
	Moderate	30	20
	High and very high	40	30
5–10	Low	30	20
	Moderate	40	30
	High and very high	50	40
<5	Low	40	20
	Moderate	60	30
	High and very high	80	40

Note that if this method determines that an application rate lower than 10kg P/ha is required for a plant crop, growers can either forego any application of phosphorus, apply the lowest amount that can be physically blended (10kg P/ha) or add the phosphorus requirements for 1 plant crop and 4 ratoon crops (based on the amounts indicated in Table 7) to aply the full crop cycle phosphorus amount to the plant crop.

For example: Soil tests for a block in the Burdekin undertaken prior to the establishment of plant cane gave a BSES P value of 45 mg/kg and a PBI of 160 (Moderate sorption class). The crop cycle phosphorus requirement is subsequently split across plant and ratoons: 20 (plant) +5 (1st ratoon) +5 (2nd ratoon) +5 (3rd ratoon) +5 (4th ratoon) = 40 kg of P/ha.

Stage 2—How do I calculate my phosphorus deduction after applying mill by-products?

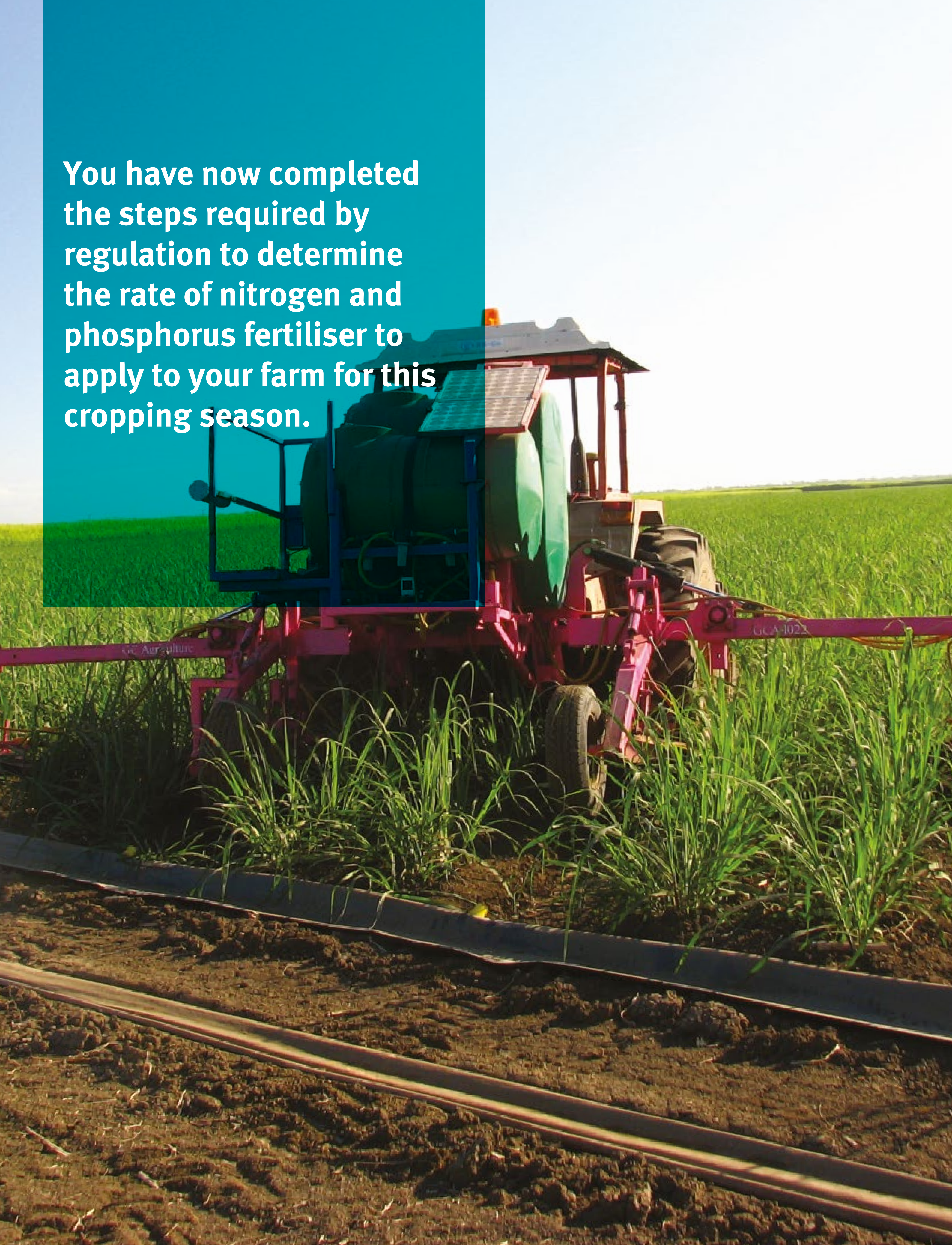
When soil tests indicate that phosphorus is required for blocks producing sugarcane, mill by-products (mill mud and mud/ash mixes) are considered as a source of phosphorus. As with nitrogen, the phosphorus application rate is affected by the amount of phosphorus applied as mill mud.

To calculate the deduction to be applied to the baseline rate of phosphorus application, refer to Table 8. This table indicates that due to the large amounts of available phosphorus in mill mud, no phosphorus fertiliser is required and no further mill mud can be applied for at least one crop cycle (plant and 4 ratoon crops) at application rates of 100–300 wet t/ha. Where application rates of less than 100 wet t/ha have been used, no deduction is required.

Table 8: Phosphorus application strategies following the use of mill by-products

Mill by-product	Application rate (wet t/ha)	Phosphorus application strategy
Mill mud	< 100	No deduction from the rate determined in Table 7
Mill mud	100–300	Nil P for at least one crop cycle

Source: Schroeder et al. (2009 unpublished).



You have now completed the steps required by regulation to determine the rate of nitrogen and phosphorus fertiliser to apply to your farm for this cropping season.

Acknowledgements

The efforts of the members of the consultation group comprising Queensland Government, industry and research organisations are recognised for their valuable contributions in the development of this document. Additionally, the significant contributions of the individuals who developed the *Six Easy Steps* program, upon which this method is based, are also acknowledged.

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