
Fertility Assessment and Mapping of Rice Areas under the Magat River Integrated Irrigation System in Isabela, Philippines

Dela, C.* , Josephine, D.¹, Margaret, C. A.², Ernesto, D. G.² and Fevie, R. A.¹

¹DA-Soils Laboratory, San Felipe, Ilagan City, Isabela, Philippines; ²DA Regional Field Office, Tuguegarao City, Cagayan, Philippines.

Dela, C., Josephine, D., Margaret, C. A., Ernesto, D. G. and Fevie, R. A. (2015). Fertility assessment and mapping of rice areas under the Magat River Integrated Irrigation System in Isabela, Philippines. *International Journal of Agricultural Technology* 11(2):581-594.

Abstract Soil is important in crop production. It holds water, microorganisms and essential nutrients needed by plants. In the rice areas irrigated by Magat River Integrated Irrigation System (MRIIS) where 2-3 croppings a year is possible, depletion of the native nutrients in the soil becomes a problem. The addition of nutrients, particularly NPK, in the form of inorganic fertilizer becomes a necessity. The immediate effect of inorganic fertilizer lure farmers to apply fertilizers indiscriminately. Hence commercial fertilizers account for approximately 26% of the total cost of rice production. Farmers would borrow against their projected earnings just to buy commercial fertilizers. The result in terms of yield, however, is not always satisfactory. There are times when the potential yield of rice is not attained despite heavy fertilizer application.

In view of this, soil and fertilizer management are given much attention. The fertility status of the soil must be known first through soil analysis in order to achieve precision in fertilizer application. This prevents wastage of resources and environmental pollution since excess fertilizer applied will only find their way eventually to bodies of water. In 2003 to 2005, massive soil sampling and analysis was done in the MRIIS area covering some 84,901.832 hectares. Results of analysis showed that of the total area covered, 74.8 % is low (0 to 2.0 %); 22.5 % is medium (2.1 to 3.0%); 2.7 % is high (3.1% above) in OM. For phosphorus and potassium, 13.6% and 24.4% is sufficient in P (above 20 ppm P) and K (above 60 ppm K) respectively. For the micronutrient zinc, 70.3 % is deficient (below 1.15 ppm Zn).

Using the soil analysis data, fertility maps for each municipality under the MRIIS area were generated. This will serve as ready reference for farmers to base their fertilizer application even if they did not subject their rice fields individually for soil testing. These maps also serve as guide for the DA management in decision making for the allocation of site specific interventions like biofertilizers, zinc sulfate and other soil enriching materials.

Every three years, these fertility maps are updated since the validity of soil analysis results is 3 years or 6 cropping seasons.

Keywords: Soil fertility, potential yield, fertility map

* **Corresponding author:** Dela, C.; **E-mail:**

Introduction

The Magat River Integrated Irrigation System is the biggest irrigation facility in the Philippines. With its inauguration in 1984, two croppings a year for rice is now possible within its service area. Yet despite the abundance of water, good seeds and technology for rice production, the average yield of rice in the region is low at 4.7 MT/ha for hybrid and 3.56 MT/ha for inbred, both of which are way down below their potential yields.

Generally, if plants do not perform according to expectations, one of the things to suspect is nutrient deficiency. Plants require at least 16 elements for optimal growth (Alejar and Sese, 1999). Majority of these elements come from the soil. Hence fertility assessment through soil analysis is an important tool in crop production. Soil analysis is a chemical method of estimating the nutrient-supplying power of a soil (Tisdale *et al.*, 1985). Knowing the available nutrient content of the soil enable farmers to apply the right kind and amount of fertilizer. Rational fertilizer use is one of the key factors in improving and increasing productivity of agricultural lands, particularly in the tropical region where nutrient deficiency is a limiting factor. It also prevent wastage of fertilizer material and subsequent environmental pollution. Cognizant of this, precision farming through proper fertilization became one of the advocacy of the Rice Program of Region 2 in the Philippines.

There are two soils laboratory in Region 2 – one in Cagayan and one in Isabela. The Soils Laboratory-Isabela covers Isabela and Quirino provinces. Unfortunately, with a total rice area of 160,229 hectares in Isabela and Quirino and approximately 74,000 farmers being, not all rice farmers can avail of soil analysis services. Nevertheless, the generation of fertility maps, even for the MARIIS service area only, will enable more rice farmers to enjoy the benefit of soil analysis. This project was undertaken to have a readily available and accessible reference material, guide and basis for rice fertilization. Other objectives include:

1. Development of farmers' awareness on the importance of soil sampling and analysis;
2. Assessment of the fertility status of rice areas under the MRIIS in the region;
3. Establishing a basis for DA management in allocating site specific yield-boosting interventions;
4. Increasing yield of rice; and.
5. Providing basis for fertilizer dealers in positioning fertilizer materials in the region.

The validity of soil test results is three years or 6 cropping seasons. Hence every after 3 years, updating of fertility maps is being done.

Materials and methods

Collection of mapping information

Base maps per municipality within the MRIIS service area in Isabela were secured from the National Irrigation Administration (NIA). These base maps show the location of irrigation Turn-Outs and Irrigators' Associations (IA).

Conduct of briefing and hands-on demo on proper soil sampling

Massive briefing on soil sampling was conducted from February to March 2003. Participants include farmers, Turn-Out Chairmen, Municipal Agriculturists and Agricultural Technicians.

Soil sample collection

Soil sampling was done by the trained farmers after harvest. The intent of this is for farmers to appreciate and value the importance of proper soil sampling and analysis. Included only in this project are municipalities covered by MRIIS in Isabela. The activity started in 2003. The second round was conducted in 2007 and the third round in 2011. Another round is slated for 2015, and so on. One composite soil sample was collected per Turn-Out (the smallest unit within the irrigation system) which could represent 2 - 50 hectares.

Soil analysis

Standard operational procedures for soil analyses were adopted from the Bureau of Soils and Water Management, the central soils laboratory in the Philippines. Organic matter, phosphorus, potassium, and zinc contents were analyzed using Walkley Black Method, Olsen's Method, Cold Sulfuric Extraction Method and DTPA method, respectively. Soil pH was also analyzed using pH meter.

Release and distribution of soil analysis results

Each farmer within the Turn-Out was given a copy of soil analysis result. Included therein are the recommended nutrient rate, the computed fertilizer material and the schedule of fertilizer application – all of which are easily understood by the farmers. They will use this as guide in fertilizer application pending the release of fertility maps.

Consolidation of data

Result of soil analyses were categorized into deficient, moderately deficient, slightly deficient and sufficient levels. Each level has its corresponding fertilizer recommendation in kilograms per hectare.

Fertility map preparation

Fertilizer recommendations per Turn-Out within the IA was plotted on a scale of 1:20,000.

Briefing on fertility map utilization

Municipal agriculturists, agricultural technicians and members of the IA were briefed on how to use and interpret fertility maps.

Fertility map distribution

All municipalities covered by the project was given a copy of their respective fertility maps for display at their Agriculture Office (located usually at the Municipal Hall). NIA was also given a copy of the NIA District Fertility Map. Other interested stakeholders are given upon request.

Results and discussion

As of 2003 the MRIIS has a total service area of 84,901.2 hectares found in municipalities of Isabela and Quirino (78,433 of which are in Isabela). Improvement of the facility in 2007 increased its coverage area in Isabela to 94,717 hectares. Farmers in the MRIIS area are organized into Irrigator's Associations (351 IA's). Each IA is subdivided into Turn-Outs (3693 T.O'S) according to Table 1.

Soil Sampling and Analysis

The precision of soil analysis results depend mainly on the collection of soil sample. Since approximately 1 kilogram of soil is collected to represent the whole sampling area which could be as large as 50 hectares, proper procedures should be strictly followed to obtain soil test results that precisely reflect the true fertility status of the soil. Hence proper soil sampling was emphasized during the briefings conducted.

Soil samples received at the laboratory were immediately recorded, labeled, air-dried and pulverized to pass at least 40 mesh before they are subjected for analysis. The three major elements N, P, and K were tested. For minor elements, only zinc was analyzed since it is considered by rice experts in the region to be the most crucial trace element to rice production.

After laboratory analysis, nutrient recommendations are given using the Table of Fertilizer Recommendations developed by the Bureau of Soils and Water Management. This table is a product of a nationwide calibration study conducted by the bureau in the 70's. Modification for recommendations for hybrid rice and corn has been made in the 90's. Fertilizer material requirements corresponding to each recommendation are then computed. Soil test results including all the pertinent data are then printed and reproduced to be given to all farmer members within the Turn-Out. This serves as basis for fertilizer application while the fertility maps are not yet available. Table 2 is an example of soil test result being released by the soils laboratories in the region.

Table 1. Magat River Integrated Irrigation System service area (in hectares).

| MUNICIPALITY | NO. OF IA'S | NO. OF T.O.'S | NO. OF FARMERS | SERVICE AREA, HA. (2003) | SERVICE AREA, HA. (2007-present) |
|---------------------|-------------|---------------|----------------|--------------------------|----------------------------------|
| <i>District II</i> | | | | | |
| Aurora | 7 | 58 | 1587 | 1,959.68 | 2,184.00 |
| Burgos | 14 | 123 | 2140 | 3,698.26 | 2,768.00 |
| Gamu | 6 | 46 | 579 | 835.98 | 3,040.00 |
| Roxas | 18 | 176 | 3712 | 4,829.91 | 5,503.40 |
| San Manuel | 17 | 135 | 3575 | 5,331.16 | 7,178.30 |
| <i>District III</i> | | | | | |
| Alicia | 46 | 496 | 8636 | 10,499.75 | 10,144.50 |
| Angadanan | 14 | 159 | 2247 | 2,208.88 | 2,959.50 |
| Cabatuan | 21 | 222 | 4948 | 5,198.88 | 5,085.00 |
| Cauayan | 37 | 426 | 7706 | 7,740.63 | 8,853.80 |
| Luna | 11 | 100 | 3032 | 2,425.44 | 2,389.60 |
| Reina Mercedes | 5 | 45 | 1397 | 1,103.12 | 1,210.50 |

| | | | | | |
|--------------------|-----|------|--------|-----------|-----------|
| San Mateo | 43 | 556 | 9314 | 9,401.60 | 10,440.70 |
| <i>District IV</i> | | | | | |
| Cordon | 15 | 131 | 3227 | 3,968.53 | 4,257.00 |
| Echague | 16 | 185 | 2705 | 1,269.77 | 2,925.80 |
| Ramon | 33 | 306 | 5839 | 7,996.10 | 8,991.50 |
| San Idisro | 13 | 176 | 2248 | 2,793.55 | 3,905.60 |
| Santiago | 35 | 353 | 7349 | 7,170.94 | 7,880.40 |
| Total | 351 | 3693 | 70,241 | 78,433.18 | 90,717.60 |

Table 3. Percentage of different levels of organic matter per municipality.

| Municipality | Nitrogen, ranges in % | | | | | | | | |
|---------------------|-------------------------------|--------------|-------------|--------------|--------------|-------------|--------------|--------------|-------------|
| | 2003 | | | 2007 | | | 2011 | | |
| | 0-2 % | 2.1-3.5 % | 3.6 % above | 0-2 % | 2.1-3.5 % | 3.6 % above | 0-2 % | 2.1-3.5 % | 3.6 % above |
| <i>District II</i> | | | | | | | | | |
| Aurora | 62.22 | 33.27 | 4.51 | 45.11 | 45.26 | 9.62 | 89.19 | 10.81 | |
| Burgos | 67.92 | 24.11 | 7.96 | 94.69 | 5.31 | | 95.72 | 4.28 | |
| Gamu | 87.14 | 12.57 | 0.29 | 97.11 | 2.89 | | 98.90 | 1.10 | |
| Roxas | 60.85 | 34.11 | 5.05 | 53.16 | 45.17 | 1.68 | 73.18 | 26.83 | |
| Sn Manuel | 65.83 | 30.24 | 3.93 | 100.00 | | | 71.39 | 28.61 | |
| <i>District III</i> | | | | | | | | | |
| Alicia | 79.98 | 19.18 | 0.84 | 99.21 | 0.79 | | 80.09 | 19.91 | |
| Angadanan | 94.80 | 5.20 | 0.00 | 91.70 | 8.30 | | 97.93 | 2.07 | |
| Cabatuan | 60.31 | 33.70 | 5.99 | 100.00 | | | 70.20 | 29.80 | |
| Cauayan | 84.06 | 14.97 | 0.97 | 98.41 | 1.59 | | 97.17 | 2.83 | |
| Luna | 72.00 | 26.83 | 1.17 | 96.09 | 3.91 | | 92.42 | 7.58 | |
| R. Mercedes | 96.61 | 3.39 | | 85.63 | 14.37 | | 96.65 | 3.36 | |
| San Mateo | 57.62 | 36.89 | 5.50 | 87.17 | 12.83 | | 77.84 | 21.74 | 0.43 |
| <i>District IV</i> | | | | | | | | | |
| Cordon | 85.16 | 14.84 | | 87.04 | 12.97 | | 90.63 | 9.40 | |
| Echague | 90.86 | 9.14 | | 91.64 | 8.36 | | 91.61 | 8.38 | |
| Ramon | 89.17 | 10.14 | 0.69 | 90.22 | 9.78 | | 94.12 | 5.87 | |
| San Isidro | 89.87 | 9.31 | 0.82 | 94.18 | 5.82 | | 94.44 | 5.56 | |
| Santiago | 87.27 | 12.23 | 0.50 | 63.51 | 35.05 | 1.44 | 95.35 | 4.65 | |
| Total | 76.12 | 21.37 | 2.52 | 89.31 | 10.30 | 0.40 | 86.62 | 13.33 | 0.43 |
| Rice variety | NUTRIENT REQUIREMENT, Kg N/Ha | | | | | | | | |
| Hybrid | 120 | 100 | 80 | 120 | 100 | 80 | 120 | 100 | 80 |
| Inbred | 100 | 80 | 60 | 100 | 80 | 60 | 100 | 80 | 60 |

The preceding table (Table 3) show the fertility status of the MRIIS area considered in this project in terms of organic matter. Of the total area, 76.12% is very low in organic matter in 2003, 89.31% in 2007 and 86.62% in 2011. At this level of soil OM, 120 kg N per hectare is recommended. This means that

10 years ago, larger rice area within the MRIIS has high nitrogen content compared to succeeding years.

For phosphorus, data presented in Table 4 show a larger area (69.06% or 62,595 hectares) sufficient with this element in 2007. These areas need only 7 kg P/ha as maintenance dose or none at all. In 2003, 33.08% (30,009 hectares) is sufficient while in 2011, the area sufficient in P dropped to 19.02 % (17,254 hectares) . Areas low in phosphorus (66.92% in 2007, 30.93% in 2007 and 80.98% in 2011) need either 60, 40 or 20 kg/ha P fertilizer depending on the level of deficiency.

Table 4. Percentage of different levels of phosphorus per municipality.

| Municipality | Phosphorus, ranges in ppm | | | | | | | | | | | | | | |
|---------------------|-------------------------------|--------------|--------------|--------------|--------------|-------------|--------------|--------------|--------------|--------------|-------------|--------------|--------------|--------------|-------------|
| | 2003 | | | | | 2007 | | | | | 2011 | | | | |
| | 0-5 | 6-10 | 11-20 | 21-50 | 51 & above | 0-5 | 6-10 | 11-20 | 21-50 | 51 & above | 0-2 | 3-10 | 11-30 | 31-50 | 51 & up |
| <i>District II</i> | | | | | | | | | | | | | | | |
| Aurora | 0.81 | 21.00 | 44.94 | 22.08 | 11.17 | | | 12.43 | 27.35 | 52.93 | | 6.04 | 45.04 | 31.55 | 17.37 |
| Burgos | 12.67 | 17.79 | 39.77 | 22.36 | 7.40 | | | 35.67 | 48.18 | 16.15 | 3.84 | 22.29 | 55.24 | 11.55 | 7.08 |
| Gamu | 8.24 | 22.49 | 42.31 | 3.77 | 23.19 | 20.76 | 22.81 | 8.25 | 28.80 | 19.38 | 0.00 | 57.90 | 34.60 | 6.74 | 0.76 |
| Roxas | 5.93 | 12.69 | 35.17 | 23.49 | 22.72 | 4.18 | 4.92 | 5.81 | 35.54 | 49.55 | 0.62 | 16.96 | 36.33 | 43.91 | 2.19 |
| Sn Manuel | 4.99 | 13.85 | 33.96 | 18.16 | 29.04 | | 20.48 | 9.34 | 27.75 | 42.42 | | 11.12 | 48.61 | 34.25 | 6.02 |
| <i>District III</i> | | | | | | | | | | | | | | | |
| Alicia | 5.29 | 19.65 | 55.25 | 14.34 | 5.48 | 0.02 | 4.16 | 8.28 | 49.54 | 38.00 | 2.59 | 26.53 | 53.61 | 5.64 | 11.62 |
| Angadanan | 7.65 | 19.45 | 30.90 | 37.18 | 4.82 | 1.85 | 7.25 | 15.87 | 21.70 | 53.33 | 4.95 | 36.63 | 57.98 | 0.48 | 0.00 |
| Cabatuan | 1.40 | 10.02 | 23.43 | 32.53 | 32.62 | 0.61 | 1.44 | 0.43 | 43.73 | 53.79 | 5.23 | 22.38 | 43.56 | 25.81 | 3.03 |
| Cauayan | 2.26 | 20.12 | 61.32 | 12.77 | 3.53 | 2.89 | 26.28 | 24.27 | 32.60 | 13.96 | 10.39 | 50.34 | 32.43 | 6.18 | 0.65 |
| Luna | 0.00 | 14.22 | 39.23 | 21.99 | 24.56 | | 3.41 | 3.20 | 24.29 | 69.10 | 11.70 | 34.29 | 39.13 | 9.82 | 5.06 |
| R. Mercedes | 0.00 | 44.18 | 39.45 | 6.58 | 9.79 | 3.81 | 14.96 | 38.06 | 26.59 | 16.58 | 5.76 | 40.42 | 48.72 | 4.88 | 0.20 |
| San Mateo | 1.01 | 5.17 | 45.87 | 34.66 | 13.28 | 11.72 | | 27.93 | 34.95 | 25.40 | 3.46 | 31.77 | 54.33 | 9.11 | 1.33 |
| <i>District IV</i> | | | | | | | | | | | | | | | |
| Cordon | 3.47 | 9.42 | 37.64 | 18.86 | 30.61 | 1.91 | 8.58 | 7.02 | 31.72 | 50.76 | 0.29 | 19.57 | 45.85 | 25.05 | 9.25 |
| Echague | 1.87 | 9.71 | 64.72 | 14.38 | 9.32 | 17.05 | 29.61 | 23.95 | 15.85 | 13.52 | 5.00 | 21.04 | 47.97 | 8.58 | 17.41 |
| Ramon | 14.94 | 32.45 | 39.81 | 4.87 | 7.93 | 5.02 | 11.32 | 21.59 | 38.61 | 23.47 | 3.31 | 35.00 | 48.03 | 9.21 | 4.44 |
| San Isidro | 2.86 | 17.40 | 48.55 | 20.86 | 10.34 | 4.87 | 11.75 | 9.17 | 34.75 | 39.46 | 5.32 | 37.33 | 50.50 | 5.83 | 1.01 |
| Santiago | 12.37 | 19.26 | 46.22 | 11.10 | 11.05 | 2.60 | 16.67 | 23.11 | 37.35 | 20.27 | 2.46 | 32.71 | 51.95 | 7.99 | 4.90 |
| Total | 5.73 | 17.16 | 44.03 | 19.08 | 14.00 | 4.40 | 10.71 | 15.82 | 35.33 | 33.73 | 3.81 | 30.07 | 47.10 | 14.12 | 4.90 |
| Rice variety | NUTRIENT REQUIREMENT, Kg P/ha | | | | | | | | | | | | | | |
| Hybrid & inbred | 60 | 40 | 20 | 7 | 0 | 60 | 40 | 20 | 7 | 0 | 60 | 40 | 20 | 7 | 0 |

In the case of potassium, the same trend was observed (Table 5). The largest area with sufficient levels of K was obtained in 2007, followed by 2003 and the least in 2011. Compared with phosphorus, potassium deficiency in the MRIIS area is more severe. For 2011, 85.89% of the total area or 77,917.35 hectares are very low in potassium requiring 60, 45 or 30 kilogram of K fertilizer.

Table 5. Percentage of different levels of potassium per municipality.

| Municipality | Potassium, ranges in ppm | | | | | | | | | | | | | |
|---------------------|-------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|--------------|
| | 2003 | | | | 2007 | | | | | 2011 | | | | |
| | 0-35 | 36-55 | 55-75 | 76 above | 0-35 | 36-55 | 55-75 | 76-100 | above 100 | 0-35 | 36-55 | 55-75 | 76-100 | above 100 |
| <i>District II</i> | | | | | | | | | | | | | | |
| Aurora | 0.05 | 5.82 | 32.68 | 61.44 | | 0.05 | 5.82 | 32.68 | 61.44 | 9.79 | 12.93 | 55.28 | 9.46 | 12.54 |
| Burgos | 28.31 | 24.67 | 27.35 | 19.67 | 8.08 | 20.23 | 24.67 | 27.35 | 19.67 | 44.70 | 11.83 | 31.73 | 2.64 | 9.10 |
| Gamu | 46.66 | 12.27 | 20.29 | 20.78 | 8.79 | 37.75 | 12.27 | 20.29 | 20.78 | 84.63 | 5.54 | 3.93 | 2.77 | 3.31 |
| Roxas | 25.24 | 14.36 | 18.07 | 42.32 | 10.11 | 15.14 | 14.36 | 18.07 | 42.32 | 22.56 | 26.09 | 14.90 | 5.41 | 31.03 |
| Sn Manuel | 10.56 | 15.71 | 18.92 | 54.81 | 3.01 | 7.55 | 15.71 | 18.92 | 54.81 | 5.61 | 12.60 | 38.69 | 14.45 | 28.64 |
| <i>District III</i> | | | | | | | | | | | | | | |
| Alicia | 66.73 | 22.64 | 6.08 | 4.55 | 24.14 | 42.59 | 22.64 | 6.08 | 4.55 | 69.55 | 7.81 | 7.11 | 2.77 | 12.76 |
| Angadanan | 66.75 | 21.21 | 2.85 | 9.18 | 44.38 | 22.38 | 21.22 | 2.85 | 9.18 | 69.44 | 22.06 | 5.08 | 2.10 | 1.38 |
| Cabatuan | 16.20 | 12.52 | 17.98 | 53.31 | 2.85 | 13.35 | 12.52 | 17.98 | 53.33 | 36.55 | 15.91 | 23.77 | 8.92 | 14.85 |
| Cauayan | 70.26 | 19.46 | 6.85 | 3.43 | 33.76 | 36.49 | 19.46 | 6.85 | 3.43 | 85.43 | 10.41 | 4.16 | 0.00 | 0.00 |
| Luna | 47.86 | 9.79 | 12.53 | 29.82 | 10.48 | 37.38 | 9.79 | 12.53 | 29.82 | 65.58 | 18.16 | 7.89 | 1.93 | 6.44 |
| R. Mercedes | 36.64 | 23.28 | 16.49 | 23.60 | 18.74 | 17.89 | 23.28 | 16.49 | 23.60 | 48.34 | 15.82 | 19.29 | 2.67 | 13.88 |
| San Mateo | 20.03 | 17.48 | 25.37 | 37.13 | 9.54 | 10.48 | 17.48 | 25.37 | 37.13 | 38.14 | 20.47 | 28.19 | 5.88 | 7.33 |
| <i>District IV</i> | | | | | | | | | | | | | | |
| Cordon | 13.35 | 14.61 | 32.39 | 39.65 | 1.35 | 12.00 | 14.61 | 32.39 | 39.65 | 45.17 | 23.37 | 22.01 | 1.50 | 7.96 |
| Echague | 61.43 | 20.21 | 8.50 | 9.87 | 27.36 | 34.07 | 20.21 | 8.50 | 9.87 | 57.63 | 10.11 | 17.11 | 3.00 | 12.16 |
| Ramon | 76.72 | 13.04 | 3.76 | 6.48 | 34.96 | 41.76 | 13.04 | 3.76 | 6.48 | 70.41 | 10.53 | 12.58 | 0.83 | 5.65 |
| San Isidro | 86.01 | 10.68 | 1.86 | 1.45 | 42.26 | 43.75 | 10.68 | 1.86 | 1.45 | 67.59 | 12.37 | 15.42 | 1.60 | 3.03 |
| Santiago | 57.71 | 18.35 | 13.84 | 10.10 | 28.57 | 29.14 | 18.35 | 13.84 | 10.10 | 87.08 | 9.30 | 0.00 | 0.34 | 3.27 |
| Total | 45.15 | 16.95 | 14.64 | 23.26 | 19.23 | 25.92 | 16.95 | 14.64 | 23.26 | 54.51 | 14.06 | 17.33 | 3.94 | 10.17 |
| Rice variety | NUTRIENT REQUIREMENT, Kg K/Ha | | | | | | | | | | | | | |
| Hybrid & inbred | 60 | 45 | 30 | 0 | 60 | 45 | 30 | 7 | 0 | 60 | 45 | 30 | 7 | 0 |

Zinc is the only trace element included during the first and second round of fertility assessment since we still do not have established or calibrated recommendation for the other trace elements. Table 6 present the percentage

of area showing different levels of zinc relative to the total area. In 2003, 72.19% or 56,621 hectares are Zn deficient.

Table 6. Percentage of different levels of zinc per municipality.

| Municipality | Zinc, ranges in ppm | | | | | | | | | | | |
|---------------------|--------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | 2003 | | | | 2007 | | | | 2011 | | | |
| | 0-0.4 | 0.5-0.8 | 0.81-1.15 | 1.16 up | 0-0.4 | 0.5-0.8 | 0.81-1.15 | 1.16 up | 0-0.4 | 0.5-0.8 | 0.81-1.15 | 1.16 up |
| <i>District II</i> | | | | | | | | | | | | |
| Aurora | 12.35 | 48.93 | 0.00 | 38.72 | 12.35 | 48.93 | 0.00 | 38.72 | 6.01 | 25.65 | 12.10 | 56.75 |
| Burgos | 17.48 | 53.02 | 2.36 | 27.15 | 17.48 | 53.02 | 2.36 | 27.15 | 6.40 | 18.30 | 23.38 | 54.93 |
| Gamu | 20.56 | 51.44 | 4.56 | 23.45 | 20.56 | 51.44 | 4.56 | 23.45 | 19.89 | 10.08 | 29.00 | 17.65 |
| Roxas | 19.45 | 47.40 | 0.00 | 33.14 | 19.45 | 47.41 | 0.00 | 33.14 | 9.42 | 34.74 | 31.27 | 27.16 |
| Sn Manuel | 14.97 | 32.19 | 0.95 | 50.93 | 14.97 | 33.15 | 0.95 | 50.93 | 14.66 | 32.63 | 14.42 | 48.67 |
| <i>District III</i> | | | | | | | | | | | | |
| Alicia | 21.88 | 36.86 | 19.57 | 21.69 | 21.88 | 36.86 | 19.57 | 21.69 | 16.13 | 20.36 | 23.93 | 33.90 |
| Angadanan | 9.65 | 23.94 | 18.85 | 47.56 | 9.65 | 23.94 | 18.85 | 47.56 | 9.25 | 20.35 | 14.36 | 42.82 |
| Cabatuan | 12.89 | 37.59 | 25.41 | 24.11 | 12.89 | 37.59 | 25.41 | 24.11 | 18.53 | 46.57 | 21.68 | 20.26 |
| Cauayan | 11.30 | 30.41 | 27.70 | 30.59 | 11.30 | 30.41 | 27.70 | 30.59 | 31.88 | 10.86 | 12.66 | 30.98 |
| Luna | 24.81 | 56.56 | 0.16 | 18.46 | 24.81 | 56.56 | 0.16 | 18.46 | 61.38 | 23.47 | 9.41 | 4.85 |
| R. Mercedes | 9.80 | 27.63 | 22.66 | 39.91 | 9.80 | 27.63 | 22.66 | 39.91 | 12.27 | 29.73 | 25.17 | 28.59 |
| San Mateo | 19.38 | 41.16 | 20.09 | 19.37 | 19.38 | 41.16 | 20.09 | 19.37 | 16.85 | 35.28 | 18.45 | 30.07 |
| <i>District IV</i> | | | | | | | | | | | | |
| Cordon | 23.76 | 43.66 | 0.48 | 31.72 | 23.76 | 43.66 | 0.48 | 32.10 | 13.51 | 24.50 | 13.88 | 46.12 |
| Echague | 10.30 | 52.42 | 0.00 | 37.28 | 10.30 | 52.42 | 0.00 | 37.28 | 0.00 | 5.68 | 13.21 | 82.70 |
| Ramon | 23.39 | 41.99 | 21.36 | 13.26 | 23.39 | 41.99 | 21.36 | 13.26 | 0.14 | 12.64 | 21.59 | 64.21 |
| San Isidro | 24.87 | 17.76 | 16.46 | 40.91 | 24.87 | 17.76 | 16.46 | 40.91 | 13.36 | 25.37 | 26.53 | 34.35 |
| Santiago | 19.38 | 33.21 | 20.28 | 27.13 | 19.38 | 33.21 | 20.28 | 27.13 | 25.52 | 24.38 | 16.20 | 32.28 |
| Total | 18.38 | 38.56 | 15.17 | 27.81 | 18.44 | 38.05 | 14.32 | 29.19 | 15.69 | 23.93 | 19.79 | 38.62 |
| Rice variety | NUTRIENT REQUIREMENT, Kg Zn/Ha | | | | | | | | | | | |
| Hybrid & inbred | 20 | 15 | 10 | 0 | 20 | 15 | 10 | 0 | 20 | 15 | 10 | 0 |

In an attempt to correct this deficiency, the management of the Department of Agriculture in Region 2 decided to procure zinc sulfate (17-21%) to be distributed in Zn deficient areas. The total distribution was 384,954 kilograms covering a total of 29,615 hectares (Table 7). Apparently, not all deficient areas were applied with zinc sulfate. Nevertheless, during the 2nd and 3rd round of fertility assessment, a continuous drop in Zn deficiency was observed - 70.81% in 2007 and 61.38% in 2011.

In 2011, other trace elements including copper, manganese and iron were also analyzed to define further the fertility status of the project area. Looking at Table 8, a very large area of the MRIIS (95.31% or 86,463 hectares) is now very low in copper. For manganese, 42.8% (38,827 hectares) is below ideal range which is 40 – 120 ppm Mn. Iron deficiency is not yet a problem in the MRIIS rice area. These results prompted the Soils Laboratory staff in the region to conduct calibration study for copper and manganese in 2012 to develop recommendation for these two elements. It is still an ongoing project.

Soil Fertility mapping

Results of soil analysis per Turn-out are consolidated and given the corresponding N, P and K fertilizer recommendation. These fertilizer recommendations are the ones plotted on a map. Figures 1 and 2 are an examples of fertility map being generated out of the soil analysis data. Each color on the map represents combination of NPK fertilizer recommendation.

Table 7. Zinc sulfate distribution in 2005 – 2006.

| Municipality | Zn deficient areas, Ha | Zinc Distribution, Kg | Area Served, Ha |
|---------------------|------------------------|-----------------------|-----------------|
| <i>District II</i> | | | |
| Aurora | 1,201 | 15,750 | 1,584 |
| Burgos | 2,694 | 17,850 | 1,266 |
| Gamu | 640 | 5,790 | 470 |
| Roxas | 3,229 | 31,650 | 3,165 |
| Sn Manuel | 2,565 | 21,744 | 1,354 |
| <i>District III</i> | | | |
| Alicia | 8,222 | 42,670 | 3,052 |
| Angadanan | 1,158 | 9,200 | 793 |
| Cabatuan | 3,946 | 19,785 | 1,552 |
| Cauayan | 5,373 | 43,590 | 2,906 |
| Luna | 1,978 | 5,725 | 438 |
| R. Mercedes | 663 | 6,650 | 476 |
| San Mateo | 7,581 | 25,000 | 1,983 |
| <i>District IV</i> | | | |
| Cordon | 2,695 | 24,800 | 1,731 |
| Echague | 796 | 21,130 | 1,679 |
| Ramon | 6,936 | 59,550 | 4,632 |
| San Isidro | 1,651 | 12,571 | 877 |
| Santiago | 5,226 | 21,500 | 1,658 |
| Total | 56,553 | 384,954 | 29,615 |

Table 8. Percentage of different levels of Cu, Mn and Fe per municipality (2011).

| Municipality | Copper, ranges in ppm | | | Manganese, ranges in ppm | | | | Iron, ranges in ppm | | | |
|---------------------|-----------------------|-------|----------|--------------------------|--------|---------|-----------|---------------------|-------|--------|-----------|
| | 0-17 | 18-50 | above 51 | 0-39 | 40-120 | 121-200 | above 200 | 0-25 | 26-50 | 51-300 | above 300 |
| <i>District II</i> | | | | | | | | | | | |
| Aurora | 92.04 | 7.96 | | 38.87 | 51.48 | 9.15 | 0.50 | 14.62 | 14.39 | 71.22 | |
| Burgos | 99.65 | 0.35 | | 31.01 | 44.92 | 21.63 | 2.45 | 9.99 | 22.04 | 67.42 | 0.63 |
| Gamu | 100.00 | 0.00 | | 17.81 | 62.78 | 19.41 | | 8.54 | 14.52 | 75.84 | 1.10 |
| Roxas | 77.70 | 22.30 | | 26.22 | 57.45 | 16.32 | | 3.22 | 27.16 | 69.62 | |
| Sn Manuel | 84.87 | 15.13 | | 42.00 | 55.76 | 2.23 | | 10.04 | 30.07 | 59.89 | |
| <i>District III</i> | | | | | | | | | | | |
| Alicia | 99.95 | 0.05 | | 41.87 | 47.53 | 10.59 | | 8.58 | 12.10 | 79.32 | |
| Angadanan | 99.41 | 0.59 | | 22.22 | 67.80 | 9.98 | | 9.81 | 40.88 | 49.55 | |
| Cabatuan | 99.27 | 0.73 | | 49.78 | 41.27 | 8.95 | | 4.73 | 14.87 | 80.51 | |
| Cauayan | 98.86 | 1.11 | | 60.40 | 31.88 | 7.71 | | 23.64 | 25.03 | 51.62 | |
| Luna | 100.00 | | | 75.98 | 22.10 | 1.93 | | 25.86 | 27.08 | 47.06 | |
| R. Mercedes | 100.00 | | | 17.99 | 76.84 | 5.16 | | 13.06 | 4.64 | 82.30 | |
| San Mateo | 98.52 | 1.48 | | 51.69 | 37.16 | 10.01 | 1.13 | 4.15 | 14.22 | 81.62 | 0.21 |
| <i>District IV</i> | | | | | | | | | | | |
| Cordon | 80.88 | 19.12 | | 17.72 | 54.83 | 27.46 | | 4.19 | 12.85 | 83.42 | |
| Echague | 100.00 | | | 35.04 | 51.51 | 13.47 | | 4.21 | 10.81 | 84.99 | |
| Ramon | 99.86 | 0.13 | | 59.46 | 30.54 | 8.67 | 0.14 | 14.18 | 21.62 | 64.22 | |
| San Isidro | 93.24 | 6.75 | | 31.00 | 43.45 | 25.08 | 0.47 | 12.05 | 23.69 | 64.83 | |
| Santiago | 98.05 | 1.95 | | 51.89 | 38.18 | 9.92 | | 10.29 | 17.21 | 72.85 | |
| Total | 95.31 | 4.68 | | 42.80 | 44.62 | 12.16 | | 10.46 | 20.26 | 69.66 | |

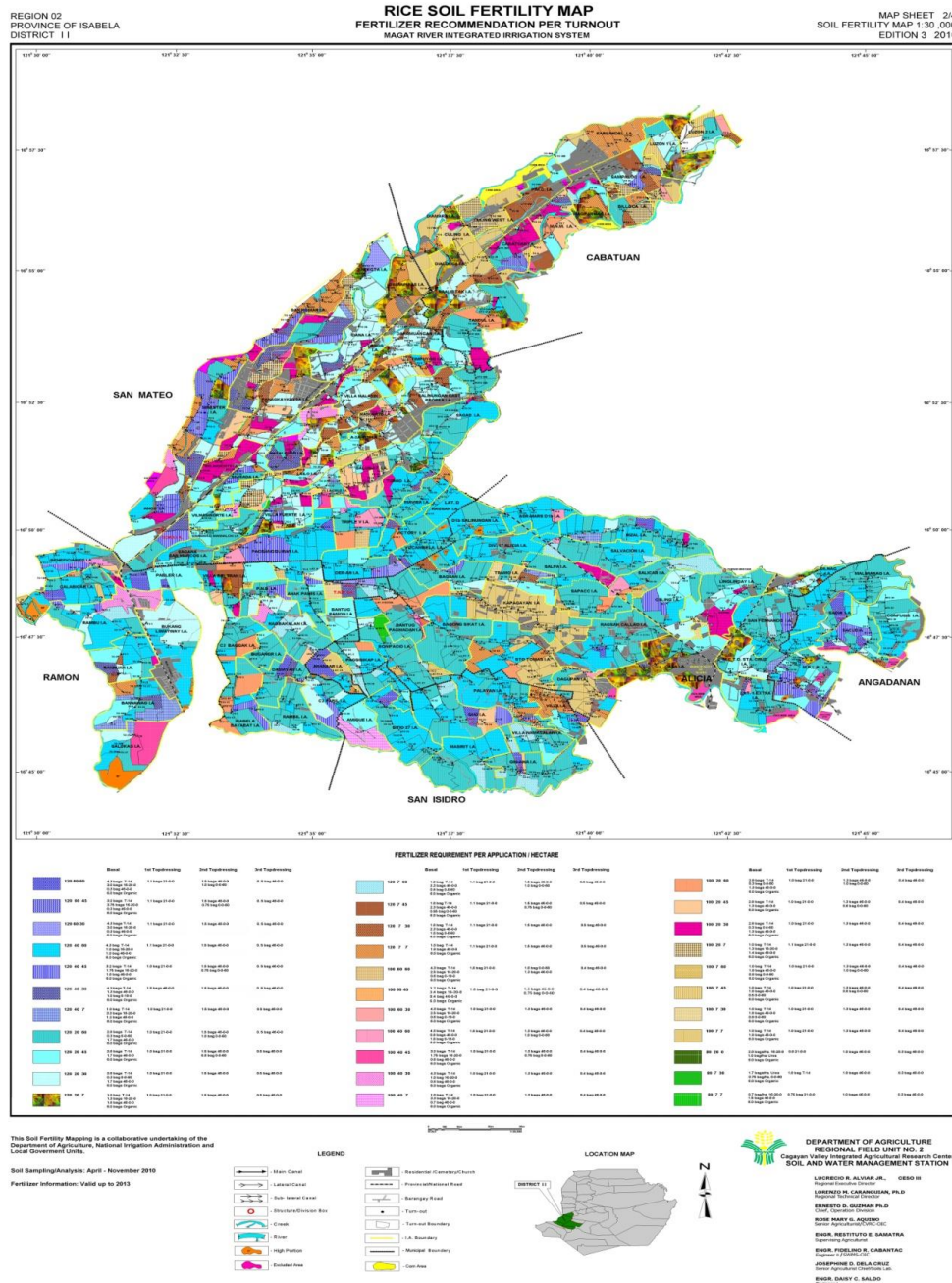


Figure 2. Sol fertility map of District II, version 2011.

Summary and conclusion

Rice areas covered by MRIIS is generally low in nitrogen measured as organic matter. With 120, 100 and 80 kg N/ha recommendation, approximately 9,000MT of N fertilizer is being applied in these rice areas every cropping season - granting that all farmers follow the fertilizer recommendation given by the Soils Laboratory. With 40 – 50% efficiency of N assimilation by rice crop, then some 4,500 MT nitrogen are either released in the atmosphere or leached underground causing environmental pollution.

Only phosphorus in 2007 yielded a minimal deficient area which is 30.93% of the total area. For the same year, the least potassium deficient area was also obtained, although the figure was still high at 62.1%. While the Department of Agriculture is advocating the use of soil analysis as a tool to increase rice production as it nurtures the soil and the environment, it is the farmers who determine the success of this endeavor. Hence their participation in this kind of project is very crucial and very much appreciated.

Recommendations

Close monitoring of changes in soil fertility status within the MRIIS area should be done and this calls for the continuation of this regular activity of the two soils laboratories in Region 2. Massive information campaign on the result of this activity should also be done to include not only farmers but other stakeholders like agricultural researchers, agricultural technicians, fertilizer dealers and the Local Government Units.

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