

# Rice Technology *Bulletin*

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## Minus-one element technique:

Nutrient deficiency test made easy



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# Foreword

The minus-one element technique offers a reliable, low-cost, and easy alternative technique for diagnosing nutrient limitation. Proper diagnosis of soil limiting nutrients will increase fertilizer use efficiency.

This technique benefits farmers and technicians especially those in the remote areas who barely have access to soil laboratories. Because the basis is the actual performance of the rice plants, the technique determines limiting nutrients that are not diagnosed in the soil chemical test. Elements such as zinc and sulfur, for example, may have sufficient levels based on the chemical analysis but the rice plants may still show deficiency symptoms. It is still recommended, however, that farmers subject the soil to chemical analysis every three to five years to quantify available nutrients.

The minus-one element technique was developed by researchers from PhilRice Los Baños. The initial tests were conducted in 1999 using soil samples from Tipas, San Juan, Batangas. At PhilRice Agusan, where nutrient deficiencies are often reported, several tests have already been conducted and results were made as bases in adjusting fertilizer applications.

We hope that this technique will help farmers use fertilizers more efficiently and will lead to higher profit and income.

  
**LEOCADIO S. SEBASTIAN**  
Executive Director

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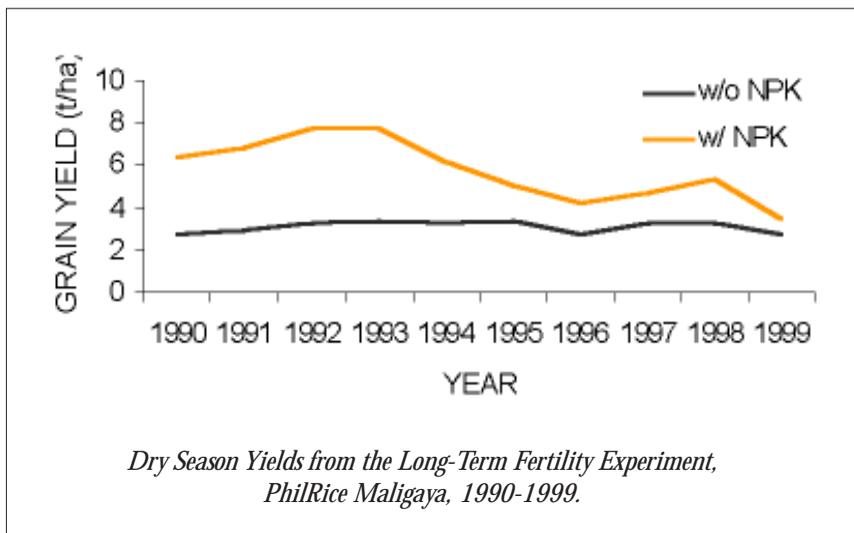
## How fertile are our paddy soils?

In 1999, PhilRice Los Baños researchers surveyed 22 provinces of the country to identify areas with multiple nutrient limitations. Out of 262 sites, only two had sufficient nutrient supply based on the normally accepted critical levels of essential soil nutrients. About 89% were multiple nutrient-deficient. Zn and S, which are not commonly included in fertilizer recommendations were deficient in 17% of the sites.

The study showed that rice areas are becoming multi-nutrient-deficient. Unless ameliorated, yields from these rice areas will remain dismally low.

This is supported by the long-term fertility experiment (LTFE) being conducted at PhilRice Maligaya. Without NPK, meaning the rice plants subsist only on the available nutrients in the soil, only an average yield of 3.06 t/ha for dry season (DS) was attained. On the other hand, yields in the plots applied with NPK yielded an average of 7.4 t/ha in DS.

These figures, which were derived from the 1990-1999 data of LTFE, show that ameliorating soil nutrients is important to increase and maximize yields. In farmers' fields, however, rice plants still show nutrient deficiency symptoms despite fertilizer application because other limiting nutrients are not properly diagnosed. It is therefore important to use a reliable method to determine the fertility status of the soil and increase fertilizer use efficiency.



# Minus-one element technique: nutrient deficiency test made easy



The technique is based on the principle that the rice plants will show reaction to limiting nutrients. Common indicators are reduced plant height and tiller count, delayed maturity, small panicles and manifestations of distinct discoloration such as yellowing.

The most common method is to take an air-dried sample of your paddy soil to the nearest Bureau of Soils and Water Management (BSWM) laboratory and wait for the results in about four to six weeks. This test, however, may not be very reliable for paddy soils because the analysis is based on a dried soil sample. Deficiency of some nutrients may not be diagnosed by chemical analysis, especially those which are highly sensitive to flooding or submergence such as P, Zn, and S. For example, Zn levels in the dry soil that is subjected to soil chemical analysis may be high but when the soil is flooded, as in the field, Zn may have been transformed into unavailable forms and therefore it becomes limiting.

The minus-one test is a reliable technique that determines nutrient deficiency in actual field conditions. You don't need a highly-equipped laboratory to do this simple experiment and you can conduct this near the field, or in your own backyard to closely monitor it for desired results.



It is best to conduct the minus-one element technique before land preparation so that you can adjust fertilizer application at the time of transplanting, assuming that land preparation takes about one month.

	CHEMICAL ANALYSIS	MINUS-ONE
1. Cost	• P525 (6 elements)	• P325
2. Duration	• 30-45 days	• 45 days after transplanting/sowing
3. Soil condition	• air-dried soil	• actual field condition
4. Person to perform test	• laboratory analyst	• farmers and extension workers
5. Test location	• soil laboratory	• near the field/backyard
6. Materials/facilities needed	• pH meter, UV-VIS, atomic absorption spectrophotometer, spectrophotometer glasswares, chemicals	• plastic pots, fertilizer formulations, rice seedlings or pre-germinated seeds

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# Problems addressed

- high cost of soil chemical test
- inaccessibility of test centers in remote areas
- lack of good facilities and trained personnel to conduct chemical test
- delay in chemical analysis results

# Cost

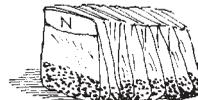
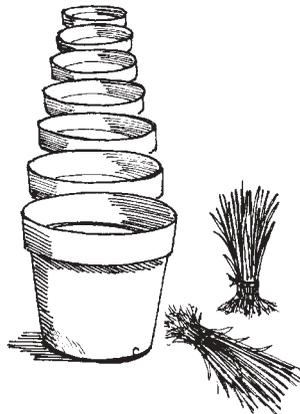
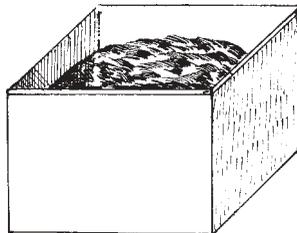
Seven plastic pots -- P125  
Fertilizer formulations -- P200

TOTAL -- P325

Currently, the fertilizer formulations are available at PhilRice Los Baños or contact (049) 536-3631 to 35 and look for Mr. Josue Descalsota. To save more, use recycled plastic containers or plastic bags. This will save about one third of the cost you pay for soil chemical analysis.

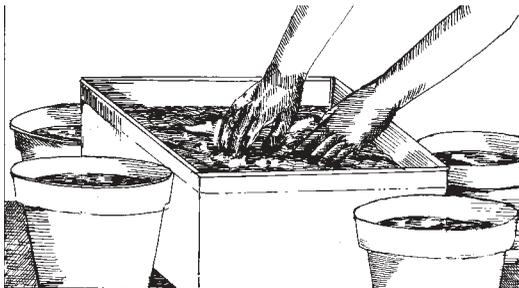
# Materials

- 7 plastic pots or any suitable container
- 28 kg fresh soil to be tested, preferably wet
- pre-weighed fertilizer formulation (available at PhilRice Los Baños)
- at least 28-35 rice seedlings (10-15 days old) or pre-germinated seeds



# Steps

- 1** Mix the soil sample thoroughly. Put 4kg of soil per pot. If the organic matter in the soil is still actively decomposing, keep the soil in the pots flooded for at least 2 weeks before transplanting or sowing.



- Collect your soil sample before land preparation to make sure that your sample is not affected by fertilizer application.
2. Collect the soil randomly at a depth of 20 cm. If the whole field has different fertility status as evidenced by crop stand, partition the field into uniform sampling units and test from each sampling unit separately.
3. Don't get your sample from abnormal locations such as carabao ponds or near piles of decomposing matter because these give erroneous results.

- 2** Before transplanting or sowing, mix the fertilizer formulations thoroughly with the soil in each pot. Label the pots: complete, -N, -P, -K, -Zn, -S, and -Cu.

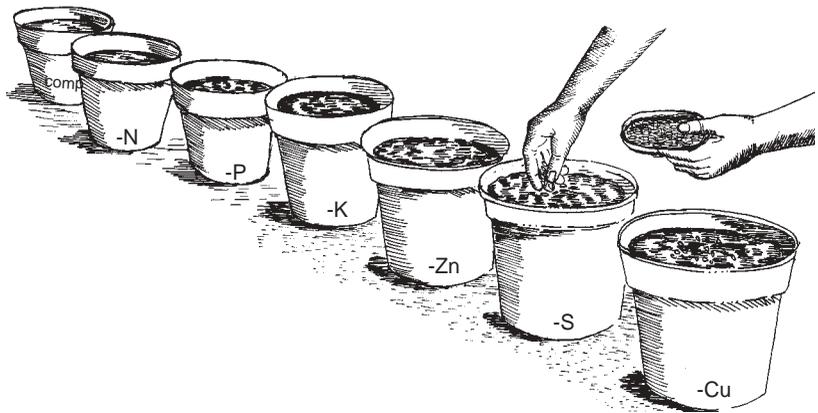
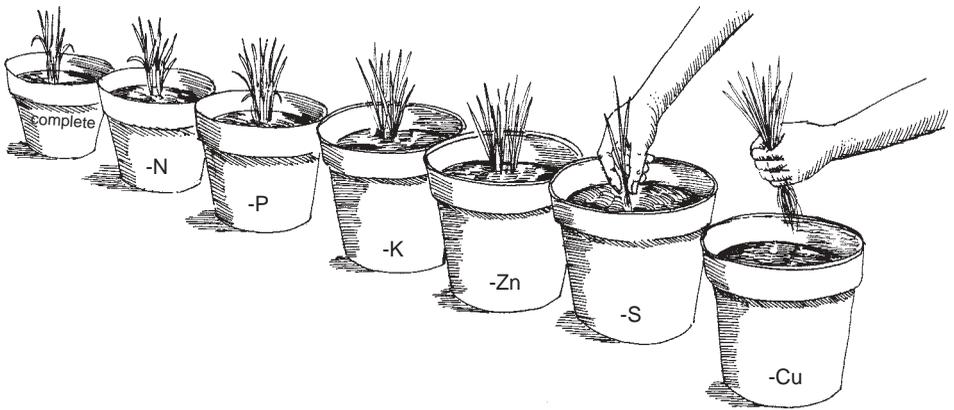
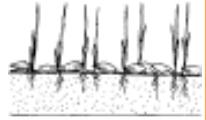
Make sure to wash your hands with water, after every after mixing of fertilizer formulations with soil samples in each pot, to avoid contamination. Cigarette butts, dust and other contaminants should also be avoided. Proper handling of fertilizer formulation packets is important.



**3** Transplant 4-5 seedlings per container. When using pre-germinated seeds, it is best to sow more seeds per pot to avoid replanting.

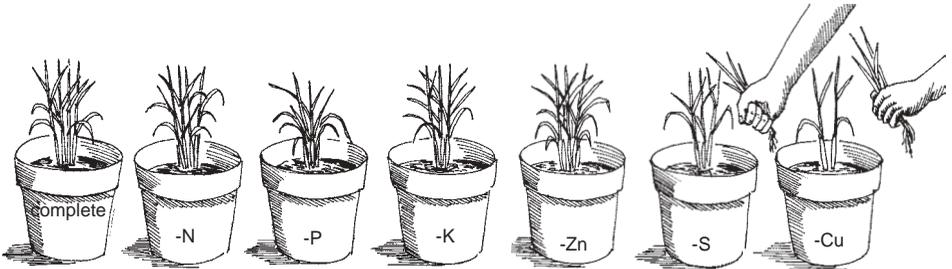


Keep the soil wet but without standing water until the seedlings have fully recovered from transplanting shock. Once water is introduced, see to it that the pots have standing water. It is more practical to use tap or irrigation water.

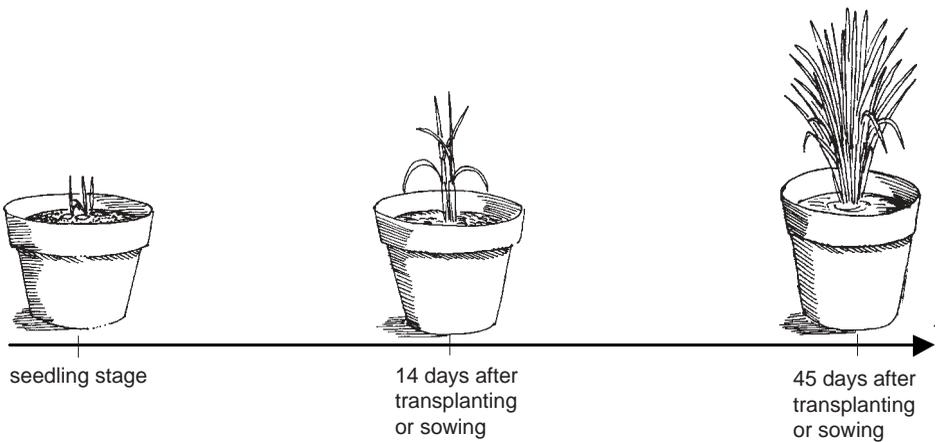




Retain only the two best growing plants per pot 7 days after transplanting or 7-10 days after sowing.

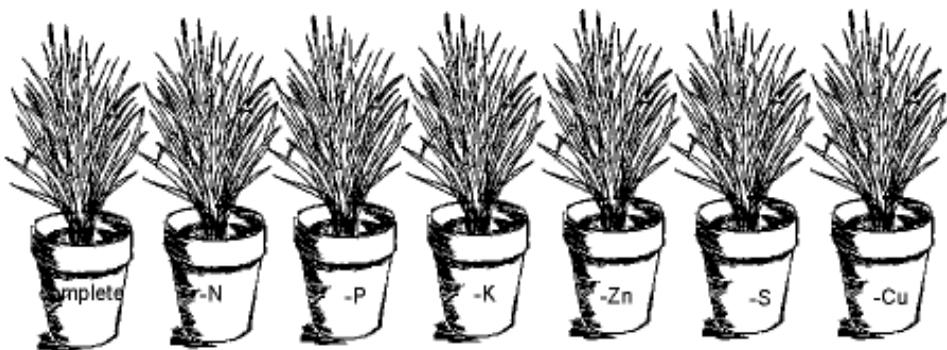


**4** Grow the plants up to 45 days after transplanting or sowing. Starting on the 14<sup>th</sup> day after planting, observe the growth of the rice plants.

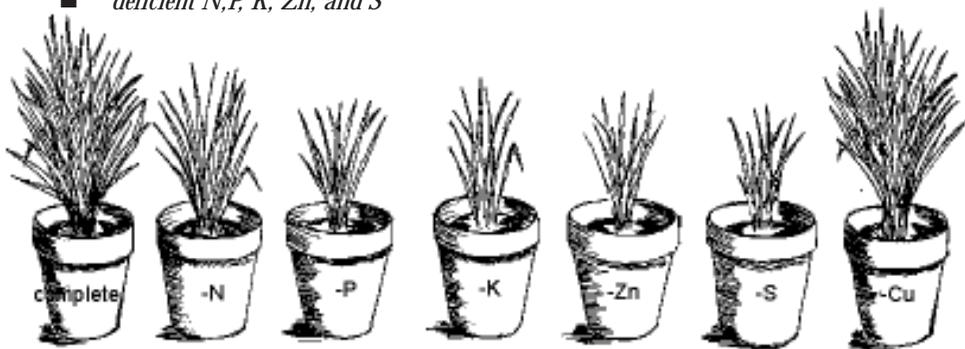


**5** After 45 days, compare the growth of the plants in each pot with that in the complete treatment that must be healthy. If the growth of the plants in all pots is as healthy as that in the complete treatment, then the soil has sufficient nutrients.

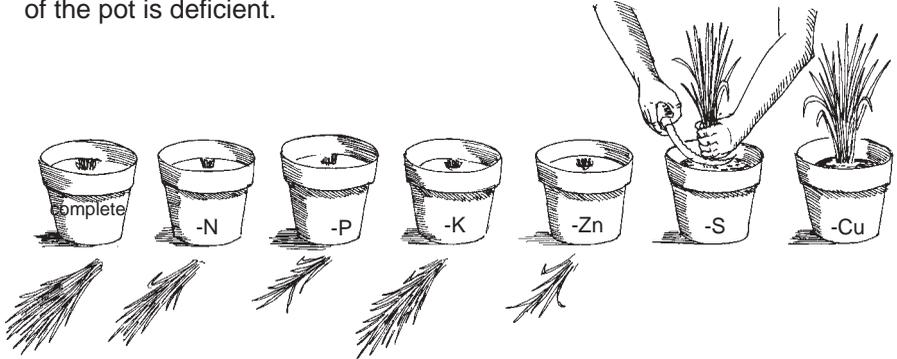
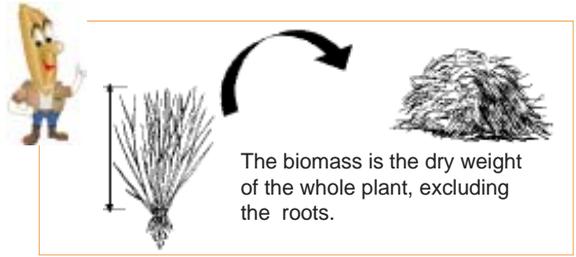
■ *fertile soil*



■ *deficient N,P, K, Zn, and S*



**6** Compare the biomass for each treatment with that of the complete. If the biomass of a treatment is less than 80% of that from the complete, the nutrient represented in the label of the pot is deficient.



**7** For deficiency symptoms, here's what you should do:

DEFICIENCY	RECOMMENDATION
N	- 20 kg urea (46-0-0) for wet season and 30 kg urea for dry season during basal application
N and P	- 3 bags 16-20-0; 2 bags 20-10-0 and 2 bags 0-18-0; 1 bag urea and 3.3 bags 0-18-0; 3 bags 17-17-17 and 2 bags 0-18-0 as sources of basal fertilizer
K	- 1 bag urea and 1 bag 0-0-16
S	- 2 bags ammonium sulfate in place of 1 bag urea for basal application
N, P and K	- 3 bags complete (14-14-14) or 4 bags 10-15-15/10-15-20/12-12-12 as basal fertilizer
P and S	- 3 bags 16-20-0 for basal application
K and S	- 3 bags ammonium sulfate and 1 bag 0-0-60 during basal application
N,P, K, and S	- 3 bags 16-20-0 and 1 bag 0-0-60 as basal
Zn	<ul style="list-style-type: none"> <li>● Foliar spray 2% zinc sulfate (<math>ZnSO_4</math>) solution (150-200L/ha) 10-15 days after transplanting. Repeat at least 2x at 1 week interval.</li> <li>● Dip seedlings in 2% zinc oxide (<math>ZnO</math>) suspension or <math>ZnSO_4</math> solution before transplanting.</li> <li>● Drain to aerate the field for 7-15 days during vegetative stage (when Zn deficiency is relatively mild)</li> <li>● Broadcast 10-25 kg <math>ZnSO_4</math>/ha 10-15 days after transplanting.</li> </ul> <p><i>Ranges of Deficiency / Amount of <math>ZnSO_4</math>:</i>  <i>mild - 5-10 kg; medium - 10-15 kg; severe - 15-40 kg</i></p>

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## SOME NUTRIENTS NEEDED BY RICE

### Functions and deficiency symptoms

Element	Function	Deficiency symptoms
Nitrogen	<ul style="list-style-type: none"> <li>• Gives green appearance to plant parts</li> <li>• Promotes rapid growth or increased height and tiller number</li> <li>• Increases size of leaves and grains, number of spikelets, and protein content in the grains</li> <li>• Stimulates root development</li> <li>• Promotes earlier flowering and ripening, particularly under cool climate</li> </ul>	<ul style="list-style-type: none"> <li>• Stunted plants with limited number of tillers</li> <li>• Narrow and short leaves which are erect and become yellowish green as they age (young leaves remain greener)</li> <li>• Old leaves become light straw colored and die</li> </ul>
Phosphorus	<ul style="list-style-type: none"> <li>• Encourages more active tillering, which enables rice plants to recover more rapidly and more completely after many adverse situations</li> <li>• Promotes good grain development and gives higher food values</li> </ul>	<ul style="list-style-type: none"> <li>• Stunted plants with limited number of tillers</li> <li>• Narrow and short leaves that are erect and dirty dark green</li> <li>• Young leaves remain healthier than older leaves, which turn brown and die</li> <li>• Reddish or purplish color may develop on leaves of varieties that tend to produce anthocyanin pigment</li> </ul>
Potassium	<ul style="list-style-type: none"> <li>• Favors tillering and increases the size and weight of the grains</li> <li>• Increases phosphorus response</li> <li>• Plays an important role in physiological processes in the plant including opening and closing of stomata and tolerance to unfavorable climatic conditions</li> <li>• Renders resistance to diseases such as blast and <i>Helminthosporium</i></li> </ul>	<ul style="list-style-type: none"> <li>• Stunted plants and tillering slightly reduced</li> <li>• Short, droopy, and dark green leaves</li> <li>• Yellowing at the interveins, on lower leaves, starting from the tip and eventually drying to a light brown color</li> <li>• Brown spots sometimes develop on dark green leaves</li> <li>• Irregular necrotic spots may develop on the panicles</li> <li>• Long, thin panicles form</li> <li>• Wilting when there is excessive imbalance with nitrogen (low K-N ratio in plant)</li> </ul>

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Element	Function	Deficiency symptoms
Zinc	<ul style="list-style-type: none"> <li>• Probable connection with the production of auxin, one of the best-known enzymes that regulate plant growth</li> <li>• Important in seedling development</li> </ul>	<ul style="list-style-type: none"> <li>• Midribs of younger leaves, especially the base, become chlorotic</li> <li>• Brown blotches and streaks in lower leaves appear, followed by stunted growth, although tillering may continue</li> <li>• Reduced size of the leaf blade but with the leaf sheath affected slightly</li> <li>• Uneven growth and delayed maturity in the field</li> </ul>
Sulfur	<ul style="list-style-type: none"> <li>• Involved in the formation of vitamins and synthesis of some hormones</li> <li>• Important in the functioning of many plant enzymes, enzyme activators and oxidation-reduction reactions</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to those of nitrogen deficiency, which makes it difficult to distinguish the two deficiencies by visual symptoms alone</li> <li>• Initially on leaf sheaths, which become yellowish, proceeding to leaf blades, with the whole plant chlorotic at the tillering stage</li> <li>• Reduced plant height and tiller number</li> <li>• Fewer panicles, shorter panicles, and reduce number of spikelets per panicle at maturity</li> </ul>
Iron	<ul style="list-style-type: none"> <li>• Related to the formation of the chlorophyll, but not a constituent of it</li> <li>• Required in protein synthesis</li> <li>• An inhibitor of the absorption of potassium by the rice plant</li> </ul>	<ul style="list-style-type: none"> <li>• Entire leaves become chlorotic and then whitish</li> <li>• The newly emerging leaf becomes chlorotic if iron supply is cut suddenly</li> </ul>
Copper	<ul style="list-style-type: none"> <li>• Required for lignin synthesis (cellular defense) and constituent of enzymes</li> <li>• Key role in photosynthesis, respiration, fertilization, and pollen formation</li> </ul>	<ul style="list-style-type: none"> <li>• New leaves do not unroll</li> <li>• Reduced tillering</li> <li>• Pollen viability reduced</li> <li>• Leaves develop chlorotic streaks followed by brown necrotic lesions on leaf tip</li> </ul>

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## Chemical symbols used

Nitrogen (N)	Sulfur (S)
Phosphorus (P)	Copper (Cu)
Potassium (K)	Zinc oxide (ZnO)
Zinc (Zn)	Zinc sulfate (ZnSO <sub>4</sub> )

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# PhilRice

The Philippine Rice Research Institute (PhilRice) is a government-owned and controlled corporation created through Executive Order 1061 approved on Nov. 5, 1985, which was amended by EO 60 dated Nov. 7, 1986 and EO 76 dated March 4, 2002 to help develop high-yielding technologies so that farmers can produce enough rice for all Filipinos. PhilRice accomplishes this mission through research, technology promotion, and policy advocacy, which are implemented through a network that includes 57 agencies and 95 seed centers strategically located nationwide.

Its interdisciplinary programs include the following: (1) direct-seeded and (2) transplanted irrigated lowland rice; (3) hybrid rice; (4) rice for adverse environments; (5) rice-based farming systems; (6) policy research and advocacy; and (7) technology promotion. With these programs, PhilRice aims to develop and promote technologies that are ecosystem-based, location- and problem-specific, and profitable to the Filipino farmers.

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Philippine Rice Research Institute



Sangguniyang trabaho para sa Pilipino



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