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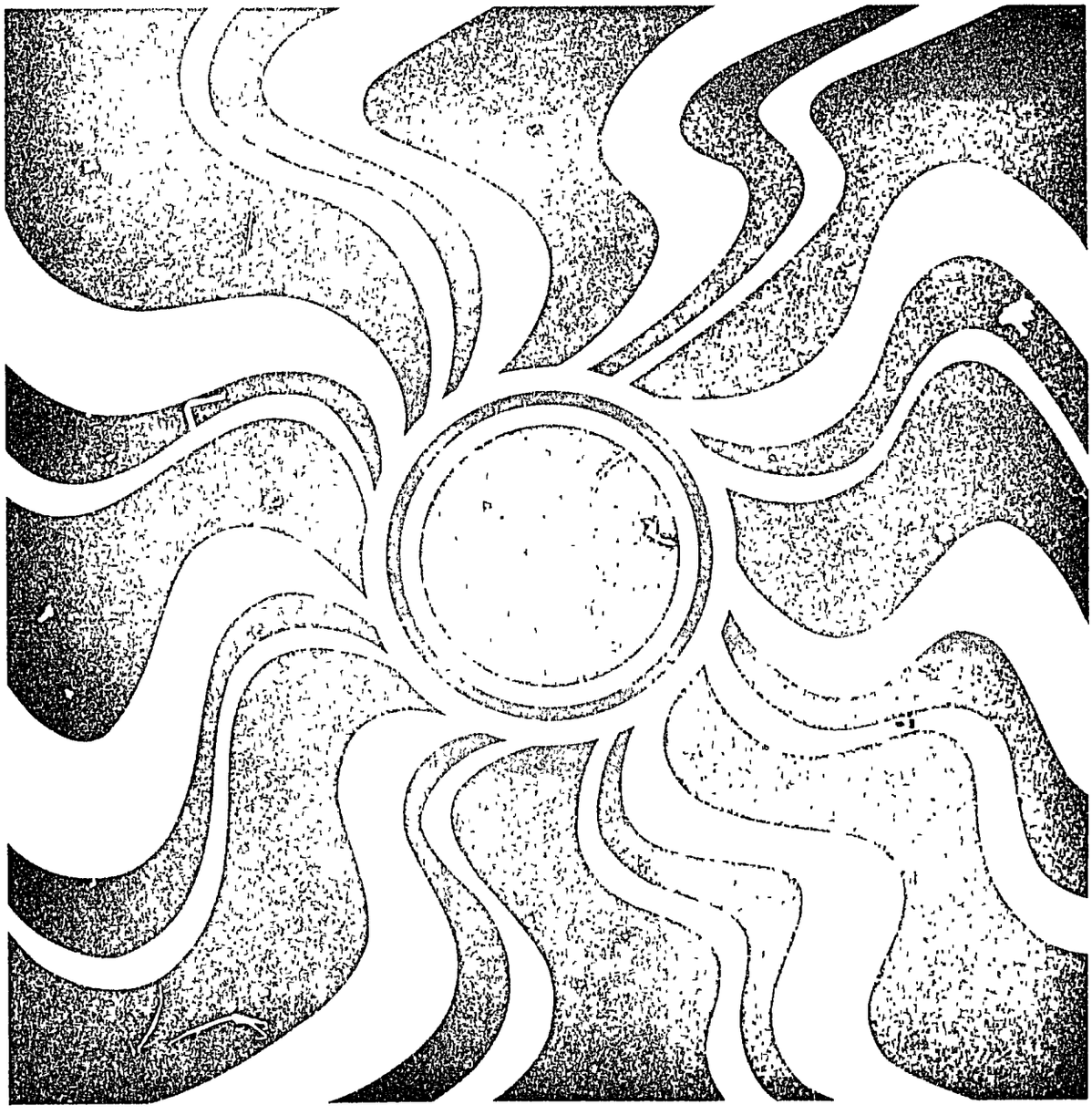

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FOREWORD

Nutrition of Rice is one of a series of bibliographies being prepared and supplemented at intervals of 2-3 years, at the request and with the financial support of the Agency for International Development. A basic goal is to make available the most recent literature published on selected crops, particularly in regions where library facilities are limited or absent.

This *1970-1972 Supplement* contains abstracts of many important articles written during those years and also articles that were inadvertently omitted in the original publication. In addition, under the section titled "Books and Reviews", attention is called to publications from international research centers that would be of particular interest to persons working in rice agronomy.

The bibliography itself is arranged into sections according to geographic regions suggested by the *Worldmark Encyclopedia of Nations*, 3rd ed. (Harper & Row, New York, 1967). Within sections, abstracts are arranged alphabetically by country in which the work was done or, if unknown, the country in which the work was published.

Nutrition of Rice would not have been possible without the cooperation and assistance of many individuals and organizations. Several institutions were particularly helpful in furnishing information and in permitting use of abstracts from their publications. They and their identifying notations are:

1. The Commonwealth Agricultural Bureaux (Publishers of *Soils & Fertilizers*, shown as SF, and *Field Crop Abstracts*, shown as FCA)
2. Chemical Abstracts Service (shown as CA)
3. Royal Tropical Institute, Amsterdam (shown as Trop. Abstr.)
4. Dissertation Abstracts International (shown as Diss. Abstr.)

Other abstracts were taken from TVA's *Fertilizer Abstracts* (shown as FA).

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AFRICA

GHANA

1 Effects of Phosphorus With Various Nitrogeneous Fertilizers on Upland Rice Yields. S. K. Takyi (Soil Res. Inst., Kwadaso, Kumasi, Ghana). *Ghana J. Agr. Sci. 4* (2), 195-6 (1971). *Soils Fert. 35*, 5444. Effectiveness of N fertilizers followed the order $(NH_4)_2SO_4$ > ASN > urea or CAN.

MADAGASCAR

2 Corrective Fertilizer Dressing and Maintenance of Soil Fertility. Experiments from 1964 to 1969. Part I: Rice. P. Roche and J. Celton. *Agron. Trop. (Paris) 26* (10), 1066-89 (1971)(Fr). *Soils Fert. 35*, 3490. Results of experiments on irrigated rice between 1964 and 1969 are reported. Except on Si-deficient soils, yields of 50-70 q/ha were possible, according to variety. Corrective dressings of P were required on hydromorphic soils. Residual effects from heavy P applications were still evident after 4-5 successive crops. No important K deficiency was observed during the first few years. According to variety, climate, soil, and amounts of P and K applied, N requirements varied between 60 and 150 kg/ha N.

3 Potassic Fertilization in Rice Fields. Report on Three Crop Season Experimentation at the Ivoloina Station (Tamatave). J. Velly (Inst. Rech. Agron. Trop., Paris, France). *Agron. Trop. (Paris) 27* (6-7), 655-66 (June-July 1972) (Fr). *FA 5*, 282. In the course of three crop season experimentation at the Ivoloina Station near Tamatave, Madagascar, the best maintenance application of K fertilizer on a moderately humic hydromorphic gley soil was determined. These trials were carried out on soils very low in K showing symptoms of serious deficiencies on all the plots. In order to establish these maintenance applications, increasing levels ranging from 0 to 300 kg of K_2O/ha were applied every season on rice. The yields increased rapidly between 0 and 60 kg of K_2O/ha and much more slowly at higher rates. Uptake of K by the crop increased to a rather small extent for the lowest levels of K but became very high with more than 180 kg of K_2O/ha, resulting in luxury consumption of K by rice. Straw reflected the different level of K nutrition the best. Less than 1% K_2O in the straw was associated with K deficiency. An application of 90 kg K_2O/ha for rice was recommended at this location.

SENEGAL

4 Increase in Dry Matter and Mineral Nutrition of Rice in a Clayey Soil at Richard-Toll (Senegal). D. Blondel (Cent. Nat. Rech. Agron., Inst. Rech. Agron. Trop., Bambey). *Agron. Trop. (Paris) 26* (6-7), 697-706 (1971) (Fr). *CA 76*, 58249. The timing of the N and P application to rice plants (IR8 variety) was an important yield factor. Plant dry wt. was plotted against 200 kg/ha N (as urea), 200 kg/ha N + 500 kg/ha P_2O_5 (as ammonium phosphate), 500 kg/ha P_2O_5 (as superphosphate), 200 kg/ha N (as urea) + 500 kg/ha P_2O_5 (as superphosphate). The primary growth-limiting factor was the N availability. Nitrogen was more readily available to the plant when applied as NH_4^+ rather than urea. High levels of N fertilizers increased paddy yields to 65.8 cwt/ha. An adequate supply of P was important in the first month of growth, but thereafter the soil usually contained sufficient P. Mobilization of K was greatly increased by N fertilizers.

SIERRA LEONE

5 Effects of Levels and Time of Nitrogen Application and Interaction Between Phosphorus and Nitrogen on Grain Yield of Rice Varieties Under Tidal Mangrove Swamp Cultivation in Sierra Leone. D. K. Das Gupta (Rice Res. Sta., Njala Univ. College, Rokupr). *Afr. Soils 16* (1), 59-67 (1971). *FA 5*, 1368. Two field experiments were carried out in the wet seasons of 1967 and 1968 in a mangrove swamp with two rice varieties (Faya and R.H.2) to study the effects of levels and time of N application and the interaction between P and N on the yield of grain. Nitrogen was applied as $(NH_4)_2SO_4$ at rates of 0, 30, 90, 150, and 210 lb N/acre. Significant increases in yield were obtained for 30 and 90 or more lb N/acre. The differences in grain yield among 90, 150, and 210 lb N were not significant. Three split dressings of N, in both varieties and irrespective of levels of applied N, caused significantly greater grain yield than all the N applied at transplanting. R.H.2 was superior in grain yield to Faya. Under mangrove swamp and present day rice cultivation, P at the rate of 30 lb P_2O_5/acre (167 lb single superphosphate) and in combination with N at the rate of 45 to 60 lb N/acre (220 to 293 lb ammonium sulfate) gave best net profit (le.26.44 to le.27.38/acre) from the application of fertilizer. Phosphorus fertilizer should be applied at the time of transplanting, while N fertilizer should be applied in three split dressings, for example, first about two weeks after transplanting when the plant is established in the field, secondly at the stage of maximum tillering, and thirdly at flower initiation stage. The bulk of N fertilizer should be applied at the first and second dressings. Heavy application of N at flower initiation stage should be avoided as it causes lodging and uneven ripening of panicles. Ammonium sulfate should be applied at the time when there is no standing water in the rice field but the field should be flooded by tidal water after fertilizer application.

6 Effects of Nitrogen Application on Nitrogen Content of Grains of Swamp Rice in Sierra Leone. D. K. Das Gupta (Rice Res. Sta., Njala Univ. College, Rokupr). *Exp. Agr. 8* (2), 155-60 (1972). *Soils Fert. 35*, 3495. The effects of 5 rates of N up to 210 lb N/acre applied in a single application at transplanting or in three split applications on the N nutrition of two swamp rice varieties were studied. Fertilizer N increased the N uptake and crude protein content of grains, though N recovery decreased with increasing N rate, but all three quantities varied with variety and all were larger with the split application treatment.

UNITED ARAB REPUBLIC

7 The Application of Isotopes and Radiation in Rice Cultivation. I. Fertilizer Placement Studies in Rice Cultivation. M. T. Eid *et al. Agr. Res. Rev. 46* (1), 59-76 (1968). *FA 2*, 1759. In Egypt, the effects of different placements of P on growth of rice were studied. Labeled superphosphate was used, and the treatments were: (1) broadcast on the surface with or without hoeing after application; (2) application at 10-20 cm depth in holes of 5 cm diameter, of which one was made in each plant hill; (3) applications at 10-20 cm depth in holes of

5 cm diameter, which were made in the middle of two plant rows; and (4) no P-application (control). Border rows of the plots were cut at intervals of 20, 40, 60, and 80 days, and the inside rows were harvested 60 days after transplanting. Highest dry matter yields and percentage of P in plants were obtained from superphosphate applied on the surface, with or without hoeing afterwards.

8 Application of Isotopes and Radiation in Rice Cultivation. II. Time and Rate of Phosphorus Application for Rice Using Isotope Technique. M T. Eid *et al* (Dep. Agr., Minist. Agr. Agrar. Reform.). *Agr. Res. Rev. 48* (6), 123-39 (1970) (Eng). *CA 77*, 150908 Phosphorus fertilizers labeled with ^{32}P were applied at a rate of 60 kg/ha in 1 or 2-3 split doses at various growth phases. Single applications at transplanting, or half way between transplanting and 2 weeks before primordial initiation, or split applications in 2 doses at the half-way growth phase and 2 weeks before primordial initiation was most effective. The P uptake by 5-week old seedlings was highest when the P fertilizer was applied in a single dose at the half way application time.

9 Application of Isotopes and Radiation in Rice Cultivation. III. Time and Rate of Nitrogen Application for Rice Using ^{15}Nitrogen. M. T. Eid *et al* (Dep. Agr., Minist. Agr. Agrar. Reform.). *Agr. Res. Rev. 48* (6), 140-64 (1970) (Eng). *CA 77*, 150907. The efficiency of fertilizer N and P utilization by rice as affected by time and rate of N application was studied. Nitrogen, 60 kg/ha, was applied in single and split doses at various growth phases; a control without N and a single rate of 120 kg N/ha applied at transplanting were added for comparison. A basic PK dressing was given at transplanting time. ^{15}N-labeled $(NH_4)_2SO_4$ was applied at transplanting, half way between transplanting and 2 weeks before primordial initiation (p.i.). The dry wt yield and total N content of plants measured at 3 and 5 weeks after the last N application did not show any significant difference between the various N timing treatments. Late N application in a single dose 2 weeks before p.i. caused a significant increase of N utilization. Timing of N fertilizer had little effect on fertilizer P uptake. On the basis of straw yield analysis, the most efficient time of N application was 2 weeks before p.i., however, no effect of N timing on grain yield was observed.

10 Rice Yield as Influenced by N-Fertilization in Nursery. Y. Y. Shalaby, T. El Kobbia, and M. A. Omar (Fac. Agr., Univ. Ain Shams, Cairo). *J. Soil Sci. U.A.R. 9*, 185-99 (1969) (Eng). *Soils Fert. 34*, 2512. In a nursery experiment, increasing the rate of application of $(NH_4)_2SO_4$ from 30 to 90 kg N/feddan increased the dry-matter yield and N content of the seedlings but decreased the ratio of root to shoot. Applying N 15 days after sowing increased the N content but decreased the growth and ratio of root to shoot as compared with N applied 10 days after sowing or at sowing. A field experiment showed that application of 60-90 kg N/feddan in the nursery 15 days before sowing and transplanting of 25 to 30-day-old seedlings is necessary for high yields.

NORTH AMERICA

UNITED STATES

11 Rice Yields Increased with Preplant Nitrogen and Ferric Sulfate. D. Adams. *Rice J. 74* (4), 15-7 (1971). *Trop. Abstr. 26* 3044. Many rice soils in Arkansas contain so much lime that the rice crop becomes chlorotic following first flooding, with a consequent reduction in yield. In five simple trials on such soils, plots received 34 kg N/ha in one of four forms, or 560 kg ferric sulfate/ha, or both immediately after sowing. The results were somewhat inconsistent: in two trials both N and Fe raised grain yields though chlorosis was not always alleviated, while two trials showed an effect of N only and one trial an effect of Fe only. A small positive N x Fe interaction was indicated.

12 Uptake of Soil and Fertilizer Nitrogen by Rice in Some Philippine Soils. F. E. Broadbent (Univ. Calif., Davis) and O. C. Reyes (IRRI, Los Banos, Philippines). *Soil Sci. 112* (3), 200-5 (1971). *FA 5*, 263. Isotopic ^{15}N was used to study the behavior of soil N in the presence of fertilizer N in flooded rice soils. A lateritic soil-pH 4.6, a volcanic montmorillonitic soil-pH 6.6, a calcareous montmorillonitic soil-pH 7.6, and a sandy loam-pH 4.8 were used in two pot experiments. In the first experiment with three of the soils, treatments were: control, 50 ppm N as tagged $(NH_4)_2SO_4$, and 100 ppm N as $(NH_4)_2SO_4$ plus chopped rice straw. Foliage from Peta, a tall leafy rice variety, was harvested 28, 57, and 90 days after planting; grain and straw were harvested 150 days after planting. The pots were flooded to 3 cm above the soil surface throughout the growth of the crop. The soil in each pot then was dried, mixed, rewetted, and planted to sorghum. Sorghum foliage was harvested 55 days (or 81 days for one soil) after planting. In the second experiment, tagged $(NH_4)_2SO_4$ was added to new samples of the above four soils at rates of 0, 50, 100, and 200 ppm at a depth of 10 cm. IR8 rice was transplanted into the pots and flooded to a 5-cm depth until harvest of the grain and straw 98 days later. The pots were then treated with more N (untagged) at the same rates as earlier. IR8 was again transplanted but the water level was allowed to fluctuate below the soil surface three times during the 96 days that elapsed prior to grain and straw harvest. In the first experiment 12-15% of the total N in the soils was taken up in 98 days; about 80% of the fertilizer N was taken up in the same time although uptake from the Luisiana clay was negligible for the first 30 days. The rice straw did not affect uptake of fertilizer N from the Luisiana clay and slowed uptake from the Maahas clay and Pila loam for about 90 days. The sorghum crop recovered an additional 1.5-3% of fertilizer N. In the second experiment grain yield did not respond to N fertilization on two soils but was linear up to 100 ppm and nonlinear up to 200 ppm N on the other two soils. About one-half the fertilizer N was in the grain and one-third in the straw. Availability of residual N was low and an accounting of fertilizer N could not be completed because enrichment of the

fertilizer was too low for ^{15}N to be measured in the soil. Four methods of measuring uptake of soil and fertilizer N are compared. These are difference, isotope, regression, and A-value.

13 Tailoring of Fertilizers for Rice. O. P. Engelstad, J. G. Getsinger, and P. J. Stangel (Tennessee Valley Authority, Muscle Shoals, Ala.). *Muscle Shoals, Ala.: Tennessee Valley Authority,* National Fertilizer Development Center; 56 pp. (1972) Bull. Y-52. *FA 6,* 474. Emphasis in this project, sponsored by the Agency for International Development, was placed on improving the efficiency of N fertilizers; determining suitable P sources for rice grown on acid soils; and determining suitable Zn sources, carriers, and methods of application. Thirty-two greenhouse tests and a large number of engineering tests were conducted at TVA. Field trials were conducted in India, the Philippines, Thailand, Ceylon, Peru, Brazil, and Colombia. Nitrification inhibitors were found to have little potential for reducing N losses from flooded soils whereas coated, soluble N sources have a real potential where flooding is delayed or intermittent. Basal applications of sulfur-coated urea (SCU) showed consistent yield increases over uncoated urea under such water management conditions. Basal applications of SCU frequently were better than top-dressed urea. The rate of N release from SCU within the range tested, had no consistent effect on yield. Economic calculations showed SCU to compete favorably where there were yield advantages. Rock phosphates of different geographic and geological origins vary in agronomic effectiveness Effectiveness is correlated with citrate solubility and some rocks approach triple superphosphate in effectiveness. Relative agronomic effectiveness and price ratios of competing P sources can be used in determining which source should be used on the acid soils in the rice-growing regions of Southeast Asia. Initial soil pH is most important in determining the effectiveness of rock. Most of the commonly known Zn sources are satisfactory for flooded rice. Early application and placement are most important. Marked varietal differences were found in relation to response to Zn.

14 Rice Response to Zinc in Flooded and Nonflooded Soil. P. M. Giordano and J. J. Mortvedt (National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala.). *Agron. J. 64* (4), 521-4 (1972). *CA 77,* 74171. Zinc deficiency in rice (*Oryza sativa*) was only recently diagnosed. Rice (variety Bluebelle) was grown in greenhouse pots on flooded and moist, limed Crowley soil (pH 7.5). Phosphorus, as concentrated superphosphate, was applied at rates of 20 and 200 ppm and Zn as $ZnSO_4$, was applied at rates of 1, 4, and 16 ppm. Dry matter production and P uptake of immature plants were doubled and uptake of Zn was 5-fold as high when the plants were grown on flooded rather than moist soil. The Zn concentration in the tissue decreased at the high P rate on moist but not on flooded soil. The percentage recovery of fertilizer Zn by the crop was greater from flooded than moist soil, especially at the high P rate. Mixed and surface applications of Zn were comparable for flooded rice, whereas middepth placement (8 cm below soil surface) was less effective. Both surface and middepth placements were less effective than mixing under nonflooded soil conditions. The mobility of Zn applied as $ZnSO_4$ was comparable in flooded and moist soil. DTPA extraction may not provide a reliable measure of Zn availability in flooded soils; differences in Zn uptake may be related to root distribution or some other physiological or morphological characteristic of rice roots growing in moist or flooded soil.

15 The Use of Zinc for Rice Grown on Alkaline Soils. B. A. Huey (Univ. Arkansas, Fayetteville). *Rice J. 74* (3), 10, 12-13 (1971). *FA 4,* 1231. Unreplicated demonstrations were established at ten locations in six rice-producing counties in Arkansas in 1970. The four treatments were 80 lb/acre of N as $(NH_4)_2SO_4$ or as urea with and without 10 lb/acre of Zn as $ZnSO_4$. Fertilizer was applied by hand on soils with a previous history of Zn deficiency. Where chlorosis occurred (5 of 10 locations), Zn gave a vegetative response as indicated by greener color and increased growth during the seedling stage. Without Zn, $(NH_4)_2SO_4$ applied preplant increased vegetative growth and greener color better than urea. At locations having severe injury, the response from the $(NH_4)_2SO_4$ treatment faded at 2 or 3 weeks from seedling emergence, whereas the urea treatment appeared to make chlorosis worse initially. Both N sources performed satisfactorily when Zn was added. Use of Zn tended to increase yields.

16 Response of Rice to Nitrogen and Calcium Nutrition. Prateep Krasaesindhu and J. L Sims (Dep. Agron., Univ. Kentucky, Lexington). *Soil Sci. Soc. Amer., Proc. 36* (3), 457-61 (1972). *CA 77,* 33439. The influence of N and Ca nutrition on growth and chemical composition of Nova 66 rice (*Oryza sativa*) was studied in the greenhouse Rice plants were grown in soil supplied with four levels each of N (0, 100, 200, and 300 ppm) and Ca (0, 400, 800, and 1200 ppm) fertilizer. The soil was submerged throughout the experiment Significant N-Ca interactions were obtained for both grain yield and straw wt. The yield increased as rate of N fertilizer increased, and increases were greatest when Ca levels increased simultaneously. In contrast, N increased the straw wt but the increases were lessened in the presence of Ca Total dry wt (grain + straw) was significantly increased by N but was only slightly affected by Ca. Thus Ca increased grain yield, decreased straw wt, and markedly increased the grain/straw ratio Nitrogen content (g/pot) and Ca concentration of grain were greatly enhanced by both N and Ca fertilization. Greatest contents were obtained at the highest levels of N and Ca In contrast, Ca lowered concentration of N in both grain and straw and N content (g/pot) of straw. Total N contents (straw + grain) were also slightly low in the presence of Ca. The reductions in N concentration and content increased with increasing Ca added. Evidence indicated that the effect of Ca may have been largely indirect through its effect on K accumulation. The inhibiting effect of Ca was overcome partially when N fertilizer level was increased.

17 Response of Rice Plants Grown in Four Potted Luzon Soils to Additions of Boron, Sulfur, and Zinc. R. G. Lockard (Univ. Kentucky, Lexington), J. C. Ballaux, and E. A. Liongson. *Philipp. Agr. 54* (3-4), 144 58 (1970). *FA 5,* 2107 Four potted soils, San Manuel silt loam (SM), San Fernando clay (SF), Bantog clay (B), and Presna (P) sandy loam, were treated with three nutrient elements, B, S, and Zn, at three levels in a 3^3 factorial design. Rice plants grown in all four soils to which B had been added (treatments B_1 and B_2) exhibited some symptoms of B toxicity. Plants in three soils, SF, SM, and B, to which no S was added (treatment S_0) showed symptoms of S deficiency. None of the rice plants exhibited recognizable symptoms of Zn deficiency. Data are presented on the full grain dry wt. The yields of plants in all four soils were significantly increased by the addition of S to the soil. The largest increase was on plants in SM silt loam, in which the yield was increased from 8.4 g/plant in treatment S_0 to 129.6 g/plant in treatments S_2. The smallest increase was on plants in P in which the yield was increased from 67.2

g/plant in treatment S_0 to 86.1 g/plant in treatment S_2 The application of B to the soil significantly increased the yield of plants only on P, in which the increase was significant between treatment B_0 and treatment B_1. Each increment in B application to the soil sharply reduced the yield of plants in SM silt loam. The application of Zn had no effect on the yield of plants in SM silt loam and P. However, treatment Zn_1 decreased the yield of plants in B and increased the yield of plants in SM compared to treatments Zn_0 and Zn_2. There was a significant interaction on the full grain wt between the S and B treatments and between the S and Zn treatments. The application of S to the soil resulted in the earlier and more rapid flowering of the plants. The greatest effect was on plants which showed marked yield responses to the addition of S to the soil.

18 Rice Fertilization as Related to Soil Type and Soil Test. F. J. Peterson *et al* (Louisiana State Univ., Baton Rouge). *Int. Symp. Soil Fert. Eval., Proc. New Delhi, Indian Society of Soil Science 1*, 445-54 (1971). *Soils Fert. 35*, 716. Field experiments were used as a basis for N fertilizer recommendations. Phosphorus and K field experiments were used to supplement soil test data. Nitrogen response curves were cubic on four soil types, quadratic on one and linear on one soil type. The coastal prairie soil types, which frequently have small amounts of extractable P, gave maximum yields with 50 lb P/acre. Potassium fertilizer produced yield increases only on two soil types which were low in extractable K.

19 Phosphorus Fertilization of Rice on the Grand Prairie of Arkansas. G. A. Place *et al* (Rice Branch Exp. Sta., Stuttgart, Ark.). *Ark. Agr. Exp. Sta. Bull.* 762; 31 pp. (1971). *Soils Fert. 35*, 734. In eight of nine field experiments P did not affect grain yield and in one P increased lodging and reduced grain yield. Better initial response was obtained with preplant than midseason P. In a greenhouse experiment, soil-incorporated P increased straw wt more than broadcast P did, but plant height, panicle number and panicle wt were not affected. When grassy weeds were controlled, P and K fertilizing did not increase rice grain yield. Phosphorus and K were more available when the soils were submerged.

20 Effects of Zinc and Other Elements on the Yield of Rice and Nutrient Content of Rice Plants. J. E. Sedberry, F. J. Peterson, and E. Wilson (Louisiana Agr. Exp. Sta., Baton Rouge). *Louisiana Agr. Exp. Sta. Bull.* 653; 8 pp. *Soils Fert. 34*, 5236 On a silt loam of pH about 7.0, Zn application over the period 1968-70 did not increase rice yields significantly, although plots receiving Zn gave consistently higher yields than the controls. After harvest in 1969 increases in soil Zn were detected at each rate of applied Zn. Relatively large increases (3.4 and 8.9 ppm) in the Zn content of the soil occurred following two annual applications of 12 and 24 lb/acre Zn. No adverse effects on the milling quality of rice were found. Although the differences obtained from various sources of Zn were not significant, yields were highest on plots receiving ZnO. Applications of $ZnCl_2$, $ZnSO_4$, and ZnO resulted in the largest increases in soil Zn. Application of Zn chelate gave the smallest increase in residual soil Zn. For rice exhibiting symptoms of Zn deficiency (bronzing), application of granular $ZnSO_4$ (36% Zn), powdered Zn chelate (14.2% Zn) or liquid Zn chelate (6% Zn) is recommended.

21 Performance of Long-Grain Rice Grown on Clay Soils as Related to Rate and Timing of Fertilizer Nitrogen. B. R. Wells (Univ. Ark., Fayetteville). *Ark. Agr. Exp. Sta. Rep. Ser.* 187; 12 pp. (1970). *Soils Fert. 34*, 3337. Nitrogen application increased rice yields at rates up to 80 lb/acre, but at 80-120 lb/acre a split application was necessary for further yield increases, 40 lb/acre being applied about 15 days after seedling emergence. When all of the N was applied at midseason, rates above 80 lb/acre were not effective for increasing yields. Increasing the rate of N also increased plant height and tended to delay heading, this delay was prevented by applying part of the N (40 lb/acre) at 15 days. Delaying midseason N until just after the start of rapid internode elongation increased grain yields and decreased plant height and days to heading.

22 Response of Starbonnet to Nitrogen Fertilization in Arkansas. B. R. Wells (Rice Branch Exp. Sta., Stuttgart, Ark.). *Rice J. 75* (4), 10-12 (1972). *FA 5*, 1190. Starbonnet is a short-strawed, high-yielding, long-grain rice variety released in 1967. By 1971 it was the leading U.S. variety, accounting for 24.57% of the rice acreage. To determine more precisely the N requirements, N fertilizer tests were conducted on a Crowley silt loam at the Rice Branch Experiment Station, a Perry clay at the Southeast Branch Experiment Station, a Perry clay at Fish Lake Farms in Jefferson County, and a Grubbs silt loam in Woodruff County. All tests were conducted under essentially disease- and lodging-free conditions. They showed that Starbonnet rice responded to N rates of 120 lb/acre or higher on both silt loam and clay soils having a long history of rice cultivation. Under intermittant flooding, considerably higher rates may be needed to maximize yields.

23 Rice Fertilization. B. R. Wells (Ark. Rice Branch Exp. Sta., Stuttgart) and Lyell Thompson (Ark. Agr. Res. Sta., Fayetteville). *Rice J. 74* (6), 38-9, 56 (1971). *FA 5*, 162. Rice fertilization research in Arkansas in 1970 was concerned mostly with problem soils and with N. The state now has a provisional Zn fertilizer recommendation for alkaline soils. No simple soil test can be used to predict Zn needs; past history, soil pH, and exchangeable Ca are used to predict needs but these are only about 60% successful. Time of N application tests for all but one variety showed no yield differences between preplant and topdress N. Sulfur-coated urea applied preplant to Starbonnet rice was superior, at 120 lb N/acre, to conventional urea applied either preplant or topdressed.

24 Differential Response of Rice Varieties to Timing of Mid-Season Nitrogen Applications. B. R. Wells and T. H. Johnston (Ark. Agr. Exp. Sta, Fayetteville). *Agron. J.*, 62, 608-12 (1970). *Soils Fert. 34*, 1710. Rice grown on silt loam (pH 6.3) was treated with $(NH_4)_2SO_4$ at 45 kg/ha N just before flooding (15 days after emergence) while the rest of the N to give total doses of 78-146 kg/ha was applied to drained soil at specified intervals in midseason. Maximum grain yields were associated with N applications at average median internode lengths of 21, 58.5, and 5 mm for Bluebelle, Nova 66, and Starbonnet variety, respectively; delaying midseason N applications until these stages of plant development resulted in less lodging (shorter plants) and increased grain yields.

25 Iron and Zinc Response of Chlorotic Rice Grown on Calcareous Soils. D. G. Westfall, W. B. Anderson, and R. J. Hodges (Texas A&M Univ., Beaumont). *Agron J.* 63, (5) 702-5 (1971). *Soils Fert. 35*, 1655. Soils where chlorosis of rice seedlings occurred were higher in pH and HCO_3 and Ca contents, and lower in Fe and Zn than adjacent soils where normal growth occurred. $FeSO_4$ alone or in combination with $ZnSO_4$ was the most effective in correcting chlorosis. The maximum yield increase of 2100 kg/ha was obtained with

100 kg/ha Fe. Organic sources of Fe and Zn were less effective.

26 Burning vs Incorporation of Rice Crop Residues. W. A. Williams, M. D. Morse, and J. E. Ruckman (Univ. Calif., Davis). *Agron. J. 64* (4), 467-8 (1972). *FA 5*, 1914. The effect of burning and incorporating rice (*Oryza sativa*) straw on grain production and the N economy of the crop was evaluated over a 5-yr period in a field planted annually to 'Colusa' rice. An additional variable was vetch (*Vicia benghalensis*) planted in the previous autumn for green manure. The rice crop was fertilized annually at rates of 0, 45, 90, 135 kg N/ha. The amounts of straw produced ranged from 33 to 85 q/ha (dry), and the N concentration was 0.42-0.59%, depending on the N and vetch treatments. Amounts of N incorporated in the straw or presumably volatilized by burning the straw ranged from 13 to 50 kg/ha, and N uptake measured in the grain-plus-straw ranged from 38 to 115 kg/ha, but burning caused no measurable decrease in the uptake of N. Highest yields were obtained from 135 N or 90 N plus vetch Vetch had a positive effect on yield equivalent to about 45 kg of fertilizer N/ha. Five-yr averages of yields of grain showed no measurable difference between burning and incorporation at any level of fertilizer or vetch N.

SOUTH AMERICA

ARGENTINA

27 Effects of Regulation of Depth of Irrigation Water and Fertilizer Applications on Rice Yields. A Galmarini. *Rev. Agron. Noroeste Argent. 7* (1-2), 167-86 (1970) (Span). *FA 5*, 494. In a trial with the Blue Rose rice variety, conducted in northeastern Argentina during 2 yr, PKSCaMg fertilizers were applied at sowing in the first yr; in both yr, 90 kg N/ha as urea was applied at sowing and 60 kg N/ha as Chilean nitrate at various intervals after sowing. Different irrigation methods gave rather inconsistent results; maximum yields were around 5 tons/ha. General conclusions were: submersion of the field with not more than 12 cm of water was desirable, but during the first few weeks the soil may be kept just saturated; draining the field during 10 days before topdressing was beneficial; the best time of topdressing with N was about 60 days after sowing.

BRAZIL

28 Optimum Levels of NPK Fertilizers for Upland Rice Cultivation in a "Cerrado" Soil in Patos de Minas, Brazil. R. Ferreira de Novais and B. V. Defelipo (Univ. Fed. Vicosa, Minas Gerais, Brazil). *Experientiae 11* (7), 281-96 (1971) (Port). *Trop. Abstr. 27*, 808. In an experiment conducted in the State of Minas Gerais upland rice was fertilized with N, P_2O_5 and K_2O at levels of 0, 40, or 80 kg/ha, all applied in the furrow. There was a highly significant response to P, a slight response to K, and a negative response to N applications. The most economic levels of P and K application were determined for a reasonable variation in price of fertilizers and the rice produced. As an average the most economic level of fertilizing was 55 kg of P_2O_5 and 15 kg of K_2O.

29 Effect of Different Nitrogen Fertilizers on the Productivity of Flooded Rice. Norberto Leite *et al* (Serv. Vale Paraiba, Dep. Aguas Energ. Eletr., Brazil). *Bragantia 29* (24), 263-72 (1970) (Port). *CA 77*, 87024. A study was made of the response of flooded rice crops to different kinds and doses of N fertilizers. The necessity was verified of separating experimental plots with a dike to avoid possible interference among treatments due to solubilization and movement of fertilizers tested. The fertilizers tested were castor bean meal, $(NH_4)_2SO_4$, and cal-nitro in three different levels. A constant amount of K and P was applied to all treatments. The rice variety used was Iguape-Agulha. There was a significant increase in rice production after application of N fertilizers. Castor bean meal was most effective in increasing the yield, followed by $(NH_4)_2SO_4$ and cal-nitro. The data show that dike construction is unnecessary since no interference of one treatment with another could be detected.

30 Effect of Nitrogen, Phosphorus, Lime and Micronutrients on Irrigated Rice in the Paraiba Valley. N. Leite, *et al* (Inst. Agronomico, Sao Paulo, Brazil). *Bragantia 29*, 273-85 (1970) (Port). *Soils Fert. 35*, 712. In 13 experiments on various sites in Sao Paulo including organic and clayey soils, N at 40 and 80 kg/ha greatly increased rice yield. Phosphorus increased yields to a lesser extent on six sites only. Liming and micronutrients had no effect.

31 Effects of Nitrogenous and Phosphorous Fertilization on Rice Cultivated in Flooded Soils. Norberto Leite, Hermano Gargantini, and L. S. Hungria (Serv. Vale Paraiba, Secr. Viacao e Obras Publicas, Brazil). *Bragantia 29* (11), 115-25 (1970) (Port.) *CA 77*, 113043. Fertilization of clay and organic lowland soils with N, P, and K resulted in a significant increase of rice yields.

32 Diagnosis and Prevention Treatment of Zinc Deficiency in Upland Rice, Cultivated in Soils with pH Below 7, in Sao Paulo State, Brazil. Derly Machado de Souza and Ruter Hiroce (Secao Cereais, Inst. Agron., Campinas, Brazil). *Bragantia 29* (9), 91-103 (1970) (Port). *CA 77*, 113042. Symptoms of Zn deficiency appeared in rice plants when the Zn content of the plant dry matter was <15 ppm. Application of 5 kg $ZnSO_4$/ha at the planting time was enough to avoid the deficiency.

33 Zinc Deficiency in Rice Crop. Derly Machado de Souza and Ruter Hiroce *Lavoura Arrozeiro 24* (261), 37-43 (1971) (Port). *FA 6*, 681. Zinc deficiency was observed in rice crops growing on soils with pH below 7 in Sao Paulo. Symptoms consisted of brown-coloring of the older leaves, except along the edges and the main vein, and leaves sometimes split along their length. Plants were affected in a very young stage and most of them died; surviving plants showed a delayed but normal development. Plant analysis revealed that the symptoms appear when plant Zn content was lower than 15 ppm. Other investigations showed that application of $ZnSO_4$ to the soil at planting time at a rate of 5 kg/ha corrected the deficiency.

34 Effect of the Trace Element Copper on Rice (*Oryza sativa*). A. M. Primavesi and A Primavesi (Univ Santa Maria, Brazil). *Agrochimica* 14, 490-5 (1970) (Ger) *Soils Fert. 34*, 2510 Application of $CuSO_4$ (50 mg/liter, 1 g/kg, 3 kg/ha) to paddy (late variety Agulha, hardy variety 707) increased grain yields by up to 65-80% and prevented brusone disease; the benefits appeared to be associated with the nutrient effect rather than fungicidal action of Cu

COLOMBIA

35 Effect of Four Nitrogen Levels on the Yield of the ICA10 Rice Variety. C. P Martinez and M. J. Rosero. *Arroz, Colombia 19* (198), 6-8, 12 (1970) (Span). *FA 4*, 1728. Field trials were run in Colombia to study the effect of different levels of N-fertilizer on grain yield of a directly sown new lowland rice variety (ICA10). The new variety was highly responsive to N-fertilizer The highest mean yield obtained was 8333 kg/ha, corresponding with a N rate of 150 kg/ha. For the soils of the Cauca valley it is recommended to use N-fertilizer at a rate of 150 kg N/ha in two equal split applications, 30 and 70 days after sowing. The last split application is to be reduced, if blast disease symptoms appear.

PERU

36 Timing of Nitrogen Applications for Rice Grown under Intermittent Flooding in the Coast of Peru. P. A. Sanchez and Mercedes de Calderon (Estacion Exp. Agropec. de Lambayeque). *Int. Symp Soil Fert Eval. Proc I.* pp 595-602 (1971). *FA 5*, 2073. Seven timings of N applications of 180 kg N/ha as urea were tested on three rice varieties of different growth duration and plant type, in transplanted and direct seeding systems in a subtropical desert environment under conditions of alternate flooding and drying Delaying basal or split applications until the panicle initiation stage increased grain yields by about 2000 kg/ha over applications at 0, 30, or 60 days after transplanting or direct seeding In general, yields increased as N applications were delayed. Yield increases were related to a 25% increase in the number of panicles/m^2, indicating that applications at the panicle initiation stage prevented the death of previously formed tillers In spite of a growing season range of 125 to 228 days, no varietal differences in their response to timing were observed Transplanting outyielded direct seeding due to suboptimal spacing of the latter. Under high N loss conditions caused by poor management, the optimum timing of N applications is substantially different from that recommended for constantly flooded situations.

ASIA

AUSTRALIA

37 Nitrogen Response of 'IR8' Rice at Coastal Plains Research Station in Northern Australia. J. J. Basinski and D. R. Airey (Commonw. Sci. and Ind Res. Organ., Div. Land Res., Canberra, Australia). *Aust. J. Exp. Agr. Anim. Husb. 10* (43), 176-82 (1970). *FA 4*, 484. An initial evaluation of the yield potential of IR8 rice was carried out in the 1968 dry season, in the form of a N trial. The mechanically harvested grain yields (oven dry) varied from 1700 kg/ha with no N to a calculated maximum of 7335 kg/ha with a N application of 216 ± 11.3 kg N/ha The highest rate of application (269 kg N/ha) caused a small but significant reduction in mechanically harvested yields. Hand-harvested quadrat yields were closely related to machine-harvested yields (r = 0.90), they were some 20% higher, and were not significantly reduced by the highest rate of N application. The yield response to N was mainly due to increased panicle numbers per unit area and secondarily to increased numbers of grains per panicle Mean individual grain wt was only slightly, though significantly, affected by the treatments The highest calculated yield was recorded with leaf area index (LAI) at flowering of 12.3 ± 1 05. With an increase in LAI to the highest value of 13 5 there was no significant decline in hand harvested yield Nitrogen uptake was linearly related to rates of N application throughout the range of treatments Apparent N recovery was 103% at flowering and 71% at maturity in all treatments

BANGLADESH

38 A Study on the Effects of Urea-N Applied in Splits on the Growth and Yield of Transplanted Aman Rice (Variety Dacca-31). M. Delwar Hossain *et al. Pak. J. Sci. Res. 21* (3-4), 67-72 (1969). *Trop. Abstr. 27*, 59. In E. Pakistan, fertilizer trials with July sown, transplanted, rainfed rice variety Dacca-31 on exhausted land showed that split applications of N increased yield responses significantly The highest grain and straw yield of 3650 and 4080 kg/ha, respectively, were obtained by 90 kg N/ha in four split applications at 20-day intervals as compared to 3230 and 3700 kg/ha, if N was given in one early dressing

39 A Comparative Study on the Performance of IR8 and Dharial Varieties of Rice, Grown by Different Methods of Planting under Different Combinations of Nitrogen Phosphorus and Potassium. A. L Mian and M. A. Ahsan. *Pak. J. Sci 21* (1-2), 30-5 (1969) *Trop Abstr. 26*, 53. Field experiments conducted in E Pakistan showed the superiority of the rice variety IR8 to the variety Dharial The broadcast crops produced significantly higher grain and straw yields compared with the transplanted crops By increasing the NPK fertilizer rates from 0 0:0 to 120:52.68 kg/ha, the yields of grain and straw of IR8 increased progressively. The highest grain yield of Dharial was obtained with a NPK rate of 60.26 34 kg/ha; at higher rates the yield declined gradually with increasing fertilizer amounts, though the yield of straw continued to increase. The variety IR8 outyielded the variety Dharial, both in grain and straw production.

BURMA

40 Evaluation of the Influence or Absence of Presence of Superphosphate in Nursery and Evaluation of the Most

Effective Time of Application of Superphosphate in the Transplanted Area in Rice Cultivation. Khin Win, Aung Khin, and Thein Maung (Agr. Res. Inst., Rangoon, Burma). *Union Burma J. Life Sci. 2*(1), 1-6 (1969). *FA 4*, 1573. Various rates of application of radioactive superphosphate in the nursery did not cause a significant difference in the uptake of phosphate fertilizer in transplanted plants. Single phosphate fertilizer application just before primordial initiation seems unsuitable in rice cultivation. No advantage was gained by split application of phosphate fertilizer in rice cultivation.

41 Effect of Nitrogen Sources and Methods of Application in Rice Cultivation. Khin Win and Thein Maung (Agr. Res. Inst., Insein, Burma). *Union Burma J. Life Sci. 2* (2), 147-55 (1969) (Eng). *CA 74*, 86936. Field tests were made to determine the efficiency of different N sources shallow-placed at transplanting and surface-applied at primordial initiation and the efficiency of P as affected by source and application method of N. Labeled N and P fertilizers were used to determine the source, whether from fertilizer or soil, of the assimilated nutrients. Fertilizer N utilization by plants indicated that $(NH_4)_2SO_4$ and urea were equally efficient and not influenced by the application time. The comparatively lower efficiency of NH_4NO_3 and $NaNO_3$ was improved by topdressing Utilization of fertilizer P was not influenced by either N source or application time. Urea is preferable to $(NH_4)_2SO_4$ because its high N content reduces transportation and storage costs. The hygroscopic and spontaneous combustible nature of NH_4NO_3 make it less desirable than urea.

CEYLON (SEE SRI LANKA)

INDIA

42 Efficiency of High Analysis Fertilizers in Comparison with Different Common Nitrogenous and Phosphatic Fertilizer Combinations. I. Response of Aman Paddy in Field Trial. Fertilizer Corp. of India Ltd. (Plann. Dev. Div., Fert. Corp. India Ltd., Sindri). *Technology 7* (2) (Spec. Issue), 109-13 (1970) (Eng). *CA 75*, 4763. The behavior and relative efficiencies of NH_4 polyphosphate and urea-NH_4 phosphate in relation to wet-land paddy were compared with those of $(NH_4)_2SO_4$-superphosphate, $(NH_4)_2SO_4$-NH_4NO_3-superphosphate, and urea-superphosphate. At equivalent dosages the two high analysis fertilizers are as suitable for rice as the conventional fertilizers.

43 Efficiency of Various Forms of Phosphate in Crop Plant Nutrition. Response of Aus Paddy, Aman Paddy, and Potato in Pot Cultures and Field Trials. Fertilizer Corp. of India Ltd. (Plann. Dev. Div., Fert. Corp. India Ltd., Sindri). *Technology 7* (2) (Spec. Issue), 24-33 (1970) (Eng). *CA 75*, 4736. Pot cultures and field trials were carried out to study the direct and residual effect of phosphates on Aus and Aman paddy varieties and on potatoes. Relative efficiencies of calcined phosphate, fused CaMg phosphate, thermal phosphate, rock phosphate, multiphosphate, and superphosphate fertilizers were compared. Citrate-soluble phosphates were equivalent to water-soluble forms in their effects on growth and development of the investigated plants.

44 Relative Efficiencies of Nitrophosphate and Other Nitrogenous and Phosphatic Fertilizer Combinations. I. Response of Aman Paddy, Potato, and Wheat in Field Trials. Fertilizer Corp. of India Ltd. (Plann. Dev. Div., Fert. Corp. India Ltd., Sindri). *Technology 7* (2) (Spec. Issue), 70-80 (1970) (Eng). *CA 75*, 4785. Nitrophosphate was tested in field experiments with Aman paddy, potatoes, and wheat in simple and complex trials in various districts of Assam and W. Bengal. Fertilizers applied were sulfonitric or carbonitric nitrophosphates (NPS or NPC), NH_4 phosphate sulfate (APS), superphosphate (SP), $(NH_4)_2SO_4$ (AS), NH_4NO_3 (AN), urea (U), NH_4 sulfate nitrate (ASN), and rock phosphate (RP) on paddy; NP, AS, SP, U, and K_2SO_4 on potatoes, and NPC, U, SP, KCl, and fertilizer mixture No. 4 on wheat. The fertilizers were applied in various combinations at rates of 0, 50, or 100 lb/acre N or P_2O_5 for paddy; 0, or 100 lb/acre N, P, or K for potatoes; and 0, 30, 60, and 80 lb N/acre, 0, 30, 40, and 45 lb P_2O_5/acre, and 0, 30, and 40 lb K_2O/acre for wheat. Data are presented for yields of wheat grain and potato tubers and for height, number of tillers, length of panicle, number of filled and unfilled grains, 1000 grain wt, N and P_2O_5 in straw and grain, and yield of straw and grain of rice. Tabulated data evidenced that both nitrophosphates can be used in India without risk of any deleterious effect.

45 Response of IR8 Paddy Strain to Fertilizers in Coimbatore District. D. S Aaron *et al. Madras Agr J. 58* (5), 379-84 (1971). *Trop. Abstr. 27*, 1323. Field trials were conducted in 31 holdings distributed over five community blocks in Coimbatore to study the effects of N, P, K alone or in combination on the rice variety IR8. Nitrogen was added at 60 or 120 kg/ha and P and K were added each at 30 or 60 kg/ha. The average rice grain yield varied with the blocks from 4600 to 6555 kg/ha. All the fertilizer treatments significantly increased the grain yield over the control. The average grain yields obtained varied from 5320 kg/ha (plots fertilized with 60 kg N/ha) to 6240 kg/ha (plots fertilized with 120, 30 and 30 kg/ha N, P, and K, respectively), as compared with 4675 kg/ha obtained from the control. Effects of the treatments on various yield components are discussed

46 Use of Indigenous Materials to Enhance the Efficiency of Fertilizer Nitrogen for Rice. S. N. Bains, Rajendra Prasad, and P. C. Bhatia (I.A.R.I , New Delhi, India). *Fert. News 16* (3), 30-2, 52 (1971). *FA 4*, 1563. A field study was run on a calcareous soil at the I.A.R.I. research farm at New Delhi during *kharif* 1970 to determine the effects of indigenous materials on inhibition of nitrification of urea and to evaluate several slow-release N fertilizers. The N was topdressed at a rate of 100 kg/ha about 40 days after a Java variety of rice was transplanted to the experimental plots. The 10 treatments included: no N, untreated urea at two rates - 100 and 200 kg N/ha; two S-coated ureas-with dissolution rates of 8 and 21.3% in 7 days; IBDU (isobutyldiurea); AM (2-amino-4-chloro-6-methylpyrimidine); crushed seeds from *neem* or the Margosa tree (*Azadirachta indica* Linn.) and coal tar were extracted with acetone and the extract used to treat urea; and urea coated with sulfathiazol. Effective tillers per hill, number of filled panicles, 1000-grain wt, straw yield, and grain yield were measured. The S-coated urea with the lower dissolution rate produced a significantly lower yield than untreated urea; whereas, the second S-coated urea and the sulfathiazol-coated urea produced the same yields. Urea treated with extracts from coal tar and from *neem* produced yields equivalent to those from twice as much untreated urea as did also AM fertilizer and IBDU.

47 Evaluation of ODDA and PEC Nitrophosphates for Rice

and Wheat. S. S. Bains, Rajendra Prasad, and M. L. Bhenida (Div. Agron., I.A.R.I., New Delhi, India). *Technology 7* (2) (Spec. Issue), 57-63 (1970) (Eng). *CA 75*, 4821. Experiments were conducted at 18 agronomic centers with rice and at 12 centers with wheat. Both rice and wheat in general gave the highest yield increase with superphosphate, followed by ODDA and PEC nitrophosphates PEC nitrophosphate, which contains all of its P in a citrate-soluble form, gave the lowest effect. The low response of rice to nitrophosphates could be partly associated with the nitrate-N in these fertilizers. In case of wheat, however, the response to ODDA nitrophosphate at two out of five centers (where a significant differential response to P sources was obtained) was not significantly different from that to superphosphate.

48 Effect of Inter-Row Spacing and Nitrogen Levels on Yield of Drilled Paddy. B. G Bathkal and D. H. Patil (Coll. Agr., Kolhapur, India). *Indian J. Agron. 15* (3), 288-92 (1970). *Soils Fert. 35*, 723 Different row spacings had no significant effects on grain and straw yields. Nitrogen increased the number of vegetative and productive tillers and the number of grains per panicle, the optimum rate being 150 kg/ha.

49 Foliar Spray of Urea for Yield Increase in Rice. U. P. Bhaskaran and R. De (I.A.R I., New Delhi, India). *Curr. Sci.* 20, 90-1 (1971). *Soils Fert 34*, 5239. Fifty to 200 kg/ha N were applied to rice, 80% as a basal dressing and 20% either topdressed or given as a foliar spray (as 3% urea). Up to 100 kg/ha, the highest yields resulted from the treatment that included the foliar spray and above 100 kg from the treatment that included topdressing.

50 Effect of Varying Level of Nitrogen, Phosphorus, and Potassium on Growth and Yield of Aman Rice at Haringhata. A. K. Bhattacharyya, N C. Banerjee, and P. Das Gupta (Agron. Dep. Univ. Kalyani, India). *Technology 7* (2) (Spec. Issue), 95-9 (1970) (Eng) *CA 75*, 4831. The response of Aman rice to N, P, and K applied as $(NH_4)_2SO_4$, single superphosphate, and muriate of potash was studied in 1965 and 1966. The nutrients were applied at three levels each. Nitrogen increased the number of tillers, but P and K had no effect, N and P increased the average height of the culm. In 1965 the crop showed no response in grain yield to N; but in 1966 there was a significant increase due to N, the response being quadratic in form. The optimum combination was 44.8 N and 67.2 P_2O_5 kg/ha, resulting in an increase of 11.02 qa/ha of grain over the control.

51 Effect of the Time of Application of Calcium Ammonium Nitrate on the Yield and Nitrogen Content of Rice. D. R. Bhumbla *et al* (Punjab Agr. Univ Ludhiana, India). *J. Res. Punjab Agr Univ. 8* 47-51 (1971). *Soils Fert. 35*, 1662. On sandy loam free from salinity and alkalinity hazards, moderate in organic C and available P but low in available N, 45 kg/ha N in the form of CAN was applied at transplanting or at 10, 20, 30, or 40 days after transplanting, or the application was split with one-half given 20 days after transplanting and the remainder 40 days after Yields were highest with a full application 20 days after transplanting. The N content of the plant 10 days after N application was significantly correlated with crop yield.

52 Efficacy of Urea Application in Rice Through Soil and Foliage. D. N. Borthakur and N. N. Kakoti (Assam Agr. Univ., Jorhat, India). *Assam Agrian 1*, 65-69 (1969). *Soils Fert. 34*, 2514. In a 3-year field trial, urea applied as a foliar spray or to the soil was as effective as $(NH_4)_2SO_4$. Safe urea concentrations to 40-, 60-, and 80-day-old plants were 3, 4, and 5% respectively for high-volume sprays and 6, 8, and 10% for low-volume sprays.

53 Progressive Changes in Potassium Availability at Different Stages of Paddy Growth. M. Chandrasekaran and D. Raj (Agr. Coll. & Res. Inst., Coimbatore, India). *Madras Agr. J. 57*, 315-19 (1970). *Soils Fert. 34*, 1707. In pot experiments on clay, loam and sandy-loam soils receiving K_2SO_4 at 30 lb/acre K_2O, application in three installments had a similar effect to application in two installments and was more effective than a single application at planting for increasing available K.

54 Effect of Fertilizer on the Protein Content of Rice. A. R. Chavan and N. G. Magar (Dep. Biochem. Inst. Sci., Bombay, India). *Curr. Sci. 40* (23), 642 (1971). *Soils Fert. 35*, 2570. The protein content of five rice varieties on upland and lowland sites was increased with application of $N_{80}P_{40}K_{40}$ as compared with $N_{40}P_{20}K_{20}$.

55 Effect of Molybdenum and Nitrogen Utilization in Rice. D. K. Das Gupta and G. S. Bera (Calcutta Univ., India). *Fert. News 17* (6), 89-90 (1972). *FA 5*, 2109. A field experiment conducted to study the effect of Mo (applied in the form of ammonium molybdate in spray at rates of 0.4 and 20 g/ha) on utilization of N (applied in the form of $(NH_4)_2SO_4$ at rates of 0, 100, 200, and 300 kg/ha) in two high-yielding varieties of rice; Jaya and IR8, in sandy loam soil reveals that in both the varieties yield increased almost linearly with the increase in the levels of either N or Mo and the response to higher rates was significantly greater in presence of Mo. The linear trend of the effects of both N and Mo indicates that the effects were largely additive.

56 Nitrogen Requirement of IR8 and Taichung Native 1 Rices in Tripura. N. Das Gupta, D. R. Roy, and L. M. Paul (Res. Farm, Arundhutinagar, Tripura, India). *Indian J. Agron. 15* (4), 322-24 (1971). *Soils Fert. 35*, 724. In field experiments on clayey soil, IR8 and Taichung rice varieties were fertilized with 0, 45, 95, and 135 kg/ha N applied one-half at transplanting and one-fourth 30 and 45 days after transplanting. The maximum yield of both varieties was given by 135 kg N. With IR8 all N increments gave significant yield increases but with Taichung the yield increases between 0 and 45 kg N and between 45 and 90 kg N were not significant. The variety IR8 gave higher yields than Taichung but the difference was not significant.

57 Response of Tall Indica Rice Varieties to Nitrogen Fertilization in Tripura. N. Das Gupta, D. R. Roy, and L. M. Paul (Res. Farm, Arundhutinagar, Tripura, India). *Indian J. Agron. 15* (4), 375-6 (1971). *Soils Fert. 35*, 725. The rice varieties Kaliboro and CB2 were grown in a clay loam soil during 2 *boro* seasons and fertilized with 0, 22.5, 45.0, and 67.5 kg/ha N. Nitrogen increased rice yields over the control and the highest yields were given by 45 kg N but these were not significantly greater than yields from 22.5 and 67.5 kg N.

58 A New Technique for Study of Nitrogen Balance Sheet and an Evaluation of Nitrophosphate Using ^{15}Nitrogen under Submerged Conditions of Growing Paddy. N. P. Datta, N. K. Banerjee, and D.M.V. Prasada Rao (I.A.R.I., New Delhi, India). *Int. Symp. Soil Fert. Eval. Proc. I.*, pp. 631-8 (1971).

FA 5, 2073. Denitrification loss of N from fertilizers is of considerable economic importance and, under adverse conditions, may account for significant losses of N from the soil. The main mechanisms of losses of N are known and are worked out. It was, however, far from easy to measure the gaseous losses quantitatively, particularly so under greenhouse or field conditions. Estimates of losses from denitrification have been obtained earlier by subtraction of recovered N from that applied. A technique of growing rice crop in greenhouse (applicable under field conditions as well) whereby it is possible to grow the crop under normal environmental conditions and at the same time collect data on gaseous (with a minimum dilution with air) and other losses for a balance sheet study is described. The technique permits growing of the rice crop under normal conditions without the facility of a growth chamber. The denitrification loss of N, under reduced conditions of growing paddy, from ^{15}N tagged ammonium sulfate, nitrophosphate (with high water solubility of P) and nitrophosphate (with low water solubility of P) was 24.1, 30.2, and 53.7%, respectively.

59 Relative Efficiency of Nitrogen Fertilizers for Rice. N. P. Datta *et al* (Div. Soil Sci. Agr. Chem., I.A.R.I., New Delhi, India). *Indian Soc. Soil Sci. Bull.* No. 8, 143-50 (1970) (Eng). *CA 75*, 47910. In collaboration with the International Atomic Energy Agency, $(NH_4)_2SO_4$, urea, NH_4NO_3, and $NaNO_3$ labeled with ^{15}N were tested for rice in Cuttack and Hyderabad. The results on uptake of N and grain yield suggested the superiority of basally applied $(NH_4)_2SO_4$ and urea. $NaNO_3$ was an inferior source of N, particularly in the heavy clays of Hyderabad. The efficiency of NH_4NO_3 was enhanced by applying as a topdressing, before primordial initiation as compared with basal application. Uptake of P was not affected by the form of N applied. There was, however, increased uptake of fertilizer P in treatments receiving N before primordial initiation.

60 Responses of High-Yielding Varieties of Rice (Taichung Native 1 and IR8) II. to Graded Doses of Phosphate. G. Dev *et al. J. Res. Punjab Agr. Univ. 7* (4), 449-53 (1970). *Soils Fert. 35*, 733. There was a significant linear response to 30-90 kg/ha P_2O_5; the efficiency of P_2O_5 fertilizing (response to each kg) depended on the initial P status of the soil and was lowest on soil with a high level of available P.

61 Efficiency of Four High-Yielding Varieties of Paddy for Absorption of Fertilizer Phosphorus. G. Dev *et al* (Dep. Soils, Punjab Agr. Univ., Ludhiana, India). *Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp.* pp. 369-76 (1970). *CA 77*, 47309. Dwarf varieties of rice are high-yielding and are suited to high fertility soil conditions. Pot experiments were done with four such rice varieties and various amounts of superphosphate-^{32}P. Phosphorus application increased the yield of dry matter. For utilization of fertilizer P, the efficiency of uptake decreased in the order culture-95, IR62288, Jaya, and IR8. The maximum absorption of P occurred at the tillering stage of growth.

62 Autoradiographic Study of ^{65}Zinc Availability to Rice Plants in Presence of Certain Amendments. P. R. Dikshit, D. Sharma, and Maharaj Singh (Uttar Pradesh Agr. Univ., Nainital, India). *Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp.*, pp. 329-38 (1970). *FA 6*, 310. Experiments were done in pots with the IR8 variety of rice to determine effects of soil applications of $MgCO_3$, $CaCO_3$, or straw. Each pot contained $^{65}ZnCl_2$. With no treatment but addition of 5 ppm ^{65}Zn, radioactivity was concentrated at root tips, nodes, and leaf bases. In leaves, the activity was more uniformly distributed. With 0.2% organic matter (straw) added, the concentration of ^{65}Zn in roots was higher but translocation to leaves and nodes was reduced. With $MgCO_3$ treatments, uptake of ^{65}Zn was very poor. Uptake of ^{65}Zn with $CaCO_3$ treatments was higher than with other treatments, and more ^{65}Zn was present in nodes and leaf bases. The distribution in leaf blades was uniform. Similar results were obtained with additions of different amounts of Zn. The decreased availability of Zn in $MgCO_3$ treatment may be due to precipitation of Zn in some unavailable form or to ion antagonistic effects. When Zn^{2+} is added to clay soils it may replace Mg^{2+} in clay minerals.

63 Effect of Heavy Doses of Nitrogenous Fertilizer on the Soil and Rhizosphere Microflora of Rice. V. S. Emmimath and G. Rangaswami (Univ. Agr. Sci., Bangalore, India). *Mysore J. Agr. Sci. 5* (1), 39-53 (1971). *FA 4*, 1926. The title studies were made with Taichung-65 variety rice grown under waterlogged conditions. Significant changes in the number and quality of bacteria, actinomycetes, and fungi under the influence of heavy doses of fertilizer application were observed. There was selective stimulation of bacteria and fungi in the rice rhizosphere during the early stages of plant growth whereas such an effect was more on actinomycetes at crop maturity. Fertilizer application decreased the Gram +ve and spore-forming bacteria. Certain characteristic changes in the genera of fungi, morphological grouping, and antagonistic activity of actinomycetes under the influence of heavy fertilizer dosage were also recorded. While the application of P and K increased the actinomycetes and *Azotobacter* populations in rice rhizosphere high, doses of N, applied to soil under waterlogged conditions, inhibited *Azotobacter* population, particularly during the early stages of crop growth.

64 Efficiency of Slow-Release Fertilizers for Rice (*Oryza sativa*). S. T. Gaikawad *et al* (Cent. Rice Res. Inst., Cuttack, India). *Indian J. Agr. Sci. 41* (5), 499-504 (1971). *CA 75*, 109348. In laboratory-incubation and pot-culture experiments the efficiency of ureaform fertilizers with U:F (urea:formaldehyde) ratios of 1.5, 2, and 3 and N-enriched coal was compared with that of $(NH_4)_2SO_4$ and urea. The pattern of release of N was similar in different soils. The percentage recovery of N from $(NH_4)_2SO_4$ and urea decreased gradually, followed by a decrease in the ureaform products. The efficiency of $(NH_4)_2SO_4$, urea, and ureaform with U:F 3 was comparable in grain yield and N uptake, while the efficiency of the other two urea-form products and N-enriched coal was inferior to that of the former; N-enriched coal was the least efficient. It was felt that the slow-release product with a higher U:F ratio may be advantageous in the cultivation of rice under adverse soil-water conditions where topdressing of N became difficult.

65 Physiological Significance of Boron in Rice (*Oryza sativa* variety IR8) Plants. O. K. Garg and B. Tiwari (Fac. Agr., Banaras Hindu Univ., Varanasi, India). *Labdev, Part B 9* (1), 20-3 (1971). *CA 76*, 33224. In general, the morphological changes in the B-deficient plants showed that the linear growth of both shoots and roots, the formation of leaves, and the tillering behavior were considerably reduced, the apical portions of the roots were stubby, tough and light brown in color, and that the leaves developed in most cases brownish scattered spots which gradually became dark brown in the distal region. The physiological changes observed at the various stages of growth indicated that there was invariably an increase in the

amount of the various sugars and a reduction in N and ascorbic acid content and catalase activity of leaves. Boron appears primarily to affect the carbohydrate-N status of the plants, and B is evidently linked with certain basic physiological reactions of the plants and its chief concern is the transport of carbohydrates from the leaves to maintain a proper C/N ratio and thereby regulates the various metabolic reactions at the cellular level.

66 Response of Rice to Topdressing with Phosphate and Potash in Kerala. C. M. George and C. Sreedharan (Agr. Coll., Vellayani, Kerala, India). *Agr. Res. J. Kerala 8* (2), 110-13 (1970). *Soils Fert. 35*, 3492. In 2 successive years the third crop-season rice growing in a sandy clay loam was fertilized with 50 kg/ha of P and K applied at planting, topdressed 2, 3, or 4 weeks after planting or one-third or two-thirds at planting and the remainder topdressed at 3 weeks. Application of all the P and K at planting gave significantly higher grain yields than topdressing or split applications.

67 Effect of Phosphatic Fertilizer Including Nitrophosphate on the Yield of Crop. S. K. Ghosh (Fert. Corp. India Ltd., Durgapur). *Technology 7* (2) (Spec. Issue), 106-8 (1970). *CA 75*, 4764. The direct and residual effects of superphosphate, basic slag, and bonemeal on Aman paddy were studied at Burdwan and Midnapur (W. Bengal). Nitrophosphate containing citrate-soluble PO_4^{3-} gave very good results and can be considered as an ideal fertilizer for the soils of this State.

68 Nutrient Status and Response of Rice and Wheat to Fertilizers in Different Soils. N. N. Goswami, S. R. Bapat, and V. N. Pathak (I.A.R.I., New Delhi, India). *Indian Farming 20* (11), 29-32 (1971). The results obtained with high-yielding varieties of rice and wheat show that good responses to P and K are obtained in coastal alluvial, red, and red and yellow soils in case of rice and in black, mixed red and black, and alluvial soils in case of wheat. Among the different major soil groups, alluvial soils are most responsive to N; coastal alluvial and red soils to P; and red, and red and yellow soils to K in the case of rice. Similarly, for wheat, alluvial soils are most responsive to N and mixed red and black soils to both P and K.

69 Studies on the Influence of Fertilizer Application on Yield, Tillering, and Grain Formation in IR8 Paddy. G. Halappa *et al* (Univ. Agr. Sci., Bangalore, India). *Mysore J. Agr. Sci. 4* (3), 306-12 (1970). *FA 4*, 1436. The treatments consisted of application of 120, 160, and 200 kg N/ha applied in two (at planting and at tillering) and three splits (at planting, at tillering, and at panicle initiation) along with P_2O_5 at 60 kg applied at planting and tillering stages over a common level of 40 kg of K_2O applied all at planting. Nitrogen at 160 kg level applied in three split applications along with 60 kg P_2O_5 applied in parts twice significantly increased the yields, the increase being of the order of 44% of grain and 44% of straw over the usual level (120 kg N/ha). Application of P in split doses was also found to be beneficial. The influence of level and timing of N and P was also pronounced on tillering and grain formation.

70 Effect of Biuret Content of Urea in Soil and Foliar Application on Dwarf Indica Rice. N. K. Jain, V. Singh, and H. P. Tripathi (Uttar Pradesh Inst. Agr. Sci., Kanpur, India). *J. Indian Soc. Soil Sci. 20* (2), 287-91 (1972). *CA 78*, 42172. The effect on rice of biuret contamination of urea fertilizer applied to the soil or as a foliar spray was studied. Biuret content of the urea varied from 0 to 1.5%. There was no significant reduction in yield from application to the soil, though there was some evidence of decreased yield at the highest levels of contamination. Biuret in the foliar spray application delayed ear emergence, reduced the numbers of ear-bearing tillers and the size of the ears, and decreased the yields of grain and straw.

71 Response of High-Yielding Dwarf Indica Rice to Different Sources and Levels of Phosphate Fertilizers. K. B. Khatua and B. N. Sahu. *Oryza 7* (1), 17-20 (1970). *FA 4*, 1810. Tests with Taichung Native 1 rice were run at Bhubaneswar for two seasons during 1966-67 with four sources of P fertilizer. These were ammonium phosphate (16-20-0), ordinary superphosphate, nitric phosphate (20-20-0), and rock phosphate (28% P_2O_5). Rates of the soluble P fertilizers were 40, 80, 120, and 160 kg P_2O_5/ha; rock phosphate was applied to supply 80, 160, 240, and 320 kg P_2O_5/ha. Rates of N and K_2O were 100 and 60 kg/ha, respectively. The maximum response of 273 (*kharif* season) and 467 (*rabi* season) kg/ha was obtained with 40 kg P_2O_5/ha with superphosphate and ammonium phosphate, respectively. There was no response to rock phosphate. In the acid, sandy latasol soil on which the test was conducted, nitric phosphate gave a better response than ammonium phosphate in the *kharif* season.

72 Zinc Deficiency in Rice in Andhra Pradesh. C. H. Krishnamoorthy *et al* (Agr. Res. Inst., Andhra Pradesh Agr. Univ., Rajendranagar Hyderabad, India). *Int. Symp. Soil Fert. Eval. Proc. I.*, 955-67 (1971). *Soils Fert. 35*, 736. Plants with Zn deficiency showed mid-rib bleaching. With excess Fe in the leaf, bronzing was observed. Ten ppm Zn in the third leaf was considered the critical level. Deficiency was cured by soil application of up to 100 kg/ha $ZnSO_4$ with responses up to 25% in some areas.

73 Response of High Fertility Strains of Rice (*Oryza sativa* L.) to Nitrogen. U. V. Krishnamraj and R. S. Rao (Agr. Coll., Bapatla, Andhra Pradesh, India). *Andhra Agr. J. 16* (1), 19-24 (1969). *Field Crop Abstr. 23*, 3390. Three high-yielding rice cultivars were given a basal dressing of 5 ton farmyard manure + 50 kg P_2O_5/ha and N at 0, 45, 90 and 135 kg/ha. Grain yields of cultivar Taichung Native 1 and IJ2410 increased linearly with increase in the rates of N, whereas yields of ADT27 responded to N rates up to 90 kg/ha; their highest yields were 6053, 5763 and 4373 kg/ha, respectively.

74 The Response of ADT27 Rice to Nitrogen and Spacing. R. Kulandaivelu and R. Kaliappan (Agr. Coll. Res. Inst., Coimbatore, India). *Madras Agr. J. 58* (8), 703-4 (1971). *Soils Fert. 35*, 3493. Maximum yields from N fertilizing (split application, one-half at planting and one-half 30 days after planting) were obtained with 60 kg/ha. The optimum rate was 78.5 kg/ha and above 120 kg/ha yields declined. No significant differences between spacings of 15 cm x 10 cm and 20 cm x 10 cm were observed.

75 A Note on the Effects of Heavy Nitrogen and Potassium Fertilization on the Cellulose and Lignin Contents of Rice Culm at Different Stages of Growth. K. K. Kundu and S. M. Sircar (Univ. Calcutta, India). *Potash Rev.*, 16/49, 4 pp. (1970). *Soils Fert. 34*, 1703. Nitrogen (30, 60, 90, and 120 lb/acre) decreased, and K (60, 120, and 180 lb/acre) increased, the cellulose and lignin content of the culm of two winter varieties of *indica* rice both at the tillering and milk stages of growth.

76 Influence of Magnesium Silicate, Sodium Silicate and Magnesium Carbonate on the Growth and Yield of Rice in the Kuttanad Soils of Kerala. K. R. Kurup and N N. Ramankutty (Reg. Rice Res. Sta., Moncompu, Kerala, India). *Agr. Res. J. Kerala* 8, 80-3 (1969). *Soils Fert. 34*, 2509. On alluvial clay of pH 4.5, application of Mg silicate or $MgCO_3$ did not affect the yield or tiller production of paddy, but Mg silicate at higher rates (50 kg/ha SiO_2) increased the straw yield. $MgCO_3$, and Mg silicate at lower rates, suppressed the height growth of the plants; this effect of $MgCO_3$ was nullified by the presence of Na silicate.

77 Response of Rice to Different Forms of Phosphatic Fertilizers and Lime in the Acid Soils of Kuttanad (Kerala State). K. R. Kurup and N. N. Ramankutty (Reg. Rice Res. Sta., Moncompu, Kerala, India). *Agr. Res. J. Kerala* 7, 97-9 (1969). *Soils Fert. 34*, 2515. On alluvial clay of pH 4.5. superphosphate, hyperphosphate and rock P (at 45 kg/ha P_2O_5) increased the grain yield significantly over control and bonemeal; superphosphate gave significantly greater straw yield than hyperphosphate or bonemeal. The forms of P were equally effective for increasing plant height. Lime had no effect on the plant characters studied whether applied individually or in conjunction with the different P forms.

78 Nitrogen Uptake by Rice as Affected by Varieties, Fertilizer Nitrogen and Nitrification Inhibitor Treatment. B A. Lakhdive and R. Prasad (I.A.R.I., New Delhi, India). *Agrochimica 15* (4-5), 377-83 (1971). *FA 5*, 2086. Nitrogen uptake by two rice cultivars was studied on sandy clay loam soil under frequent irrigations. Cultivars did not differ in N uptake when given N at rates up to 60 or 80 kg/ha, but at higher rates Taichung Native 1 took up significantly more N than NP 130. Sodium nitrate resulted in lower N uptake than $(NH_4)_2SO_4$. Treating $(NH_4)_2SO_4$ with N-serve or AM (2-amino-4-chloro-6-methylpyrimidine) delayed nitrification and increased N uptake by rice, compared with untreated $(NH_4)_2SO_4$. The two treated fertilizers increased N uptake to a greater extent in Taichung Native 1 than in NP 130.

79 Response of Taichung Native 1 Rice to Water-Management Practices and Nitrogen Fertilization in Dry Season. D. Lenka (Orissa Univ., Bhubaneswar, India). *Indian J. Agr. Sci. 41* (2), 166-72 (1971). *FA 5*, 113. At Bhubaneswar, Taichung Native 1 responded linearly up to 160 kg N/ha in the dry season. Continuous saturation of the field was as good as continuous submergence and a more efficient use of water. It is possible to economize water use and to increase crop yield by suitable water-management practices and fertilization. Alternate wetting and drying and high levels of N are conducive to higher yields. Deep percolation losses account for 29% of total water required in the field.

80 Method of Application of Urea on Rice. I. C. Mahapatra and A. R. Bedekar (Cent. Rice Res. Inst., Cuttack, Orissa, India). *Indian Soc. Soil Sci. Bull.*, No. 8, 151-4 (1970). *FA 4*, 2124. Two field tests were run at Cuttack to study the relative efficiency of foliar spray of urea and the most effective method of soil application of N on high yielding variety of rice (Taichung Native 1) and the compatibility of common insecticides, fungicides, and antibiotics. The results showed that basal soil + foliar application of urea (2% concentration) beginning from active tillering stage at 50 kg N/ha each was significantly superior to soil application of 150 kg N/ha as $(NH_4)_2SO_4$ or urea. The common pesticides such as folidol, endrin, coppesan, and streptocycline could be safely incorporated with urea solution to economize the cost of spray.

81 Effect of the Various Nitrogenous Fertilizers on the Uptake of Nitrogen and Phosphorus by Paddy Crop in Black Soil from Eastern Uttar Pradesh. S. G. Misra, S. K. Ojha, and Bharat Singh (Chem. Dep., Univ. Allahabad, India). *Madras Agr. J. 56* (6), 435-7 (1969). *CA 74*, 86921. The effect of N fertilizers on the uptake of N and P by rice from a black paddy soil was studied in greenhouse experiments. Three doses of N (40, 80, and 120 lb/acre) and four fertilizer forms [$(NH_4)_2SO_4$, NH_4Cl, $CaNH_4(NO_3)_3$, and urea] were applied. Uptake of N increased with increasing N rate. Increased N rates resulted in increased P uptake when N was applied in the form of $(NH_4)_2SO_4$ and $CaNH_4(NO_3)_3$. Best results with regard to N and P uptake by rice were with $CaNH_4(NO_3)_3$; there was no effect of NH_4Cl and urea on N uptake and P fertilizers did not affect P uptake by rice.

82 A Note on the Effect of Graded Levels of Nitrogen on High Yielding Varieties of Paddy in Typical Paddy Soils of Maharashtra. I. Effect on Yield of Dry Matter. A. V. Mohite and A. K. Shingte (Agr. Coll., Poona, India). *Indian J. Agron.* 15, 204-6 (1970). *Soils Fert. 34*, 5240. In pot experiments, the high-yielding rice varieties Taichung Native 1 and IR8 and the local variety Warangal-9 were grown in a neutral clay loam of medium fertility and an acid lateritic soil of low fertility and were fertilized with 0, 56, 113, 119, and 225 kg/ha N as $(NH_4)_2SO_4$. Increasing N levels significantly increased dry matter and grain yields. Both high-yielding varieties produced similar amounts of dry matter which were significantly greater than those from the local variety. Grain yield from IR8 was significantly greater than that from Taichung Native 1 which in turn was significantly greater than that from the local variety. Dry matter and grain yields were significantly higher in the neutral soil than in the lateritic soil.

83 Use of Basic Slag in the Management of Acid Soils and Increasing the Crop Production. M. R. Motsara and N. P. Datta (Div. Soil Sci. Agr. Chem., I.A.R.I., New Delhi, India). *Indian Soc. Soil Sci. Bull.* No. 8, 231-42 (1970). *CA 75*, 47913. In a field experiment at Palampur, Kangra district (soil pH 5.2) the crop yields in a rotation of paddy-wheat were significantly higher with the use of basic slag from Bhilai, Durgapur, and Tata Steel factories than with the equivalent amounts of P_2O_5 applied as superphosphate. The effect of the slags was as good as that of a combined application of superphosphate plus lime. The CaO content of basic slag treated crops was significantly higher than that with superphosphate. Basic slag considerably decreased the lime requirement of the soil, which became practically nil when applied at 2000 kg CaO (also supplying about 130 kg P_2O_5)/ha. Basic slag also improved soil fertility.

84 Zinc Deficiency in Rice Grown in the K. C. Canal Area of Andhra Pradesh. C. K. Murthy, J Venkateswarlu, and M.G.R. Reddy (Andhra Pradesh Agr. Univ., Hyderabad, India). *Andhra Agr. J. 16* (6), 199-201 (1969) *CA 74*, 99004. Zinc deficiency caused bleaching of the midrib in the basal portion of young paddy leaves, attended in some cases with the appearance of dark brown necrotic spots in the affected leaves. This was confirmed in field trials and by leaf analysis. Application of 50 kg $ZnSO_4$/ha to the soil corrected the deficiency. Foliar application, especially in the young stage of plant growth, was not effective even though no leaf injury was observed up to a concentration of 0.4% $ZnSO_4$. The disorder symptoms could be a result of Fe toxicity superimposed on Zn

deficiency.

85 Effect of Depth of Placement of Nitrogen on Fertilizer Nitrogen Uptake by Rice. K. S. Murty (Cent. Rice Res. Inst., Cuttack, India). *Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp.* 347-55 (1970). *CA 77*, 47307. Pot experiments were done with seedlings of the Norin 29 variety of rice on alluvial soil, with $(NH_4)_2SO_4$ labeled with ^{15}N placed at different depths in the soil. At the tillering stage of plant growth, the fixed N uptake was 6-fold higher for $(NH_4)_2SO_4$ placed at a depth of 10 cm than at 20 cm. The percentage of N in the plants was the same for both treatments. At the booting stage of growth, the differences in the two modes of treatment were not so marked. With $(NH_4)_2SO_4$ placed at a depth of 20 cm, tillering was poor and the eventual yields were low. Young tillers of rice can better absorb fixed N from shallow placements.

86 Response of Rice to Phosphate Manuring in a Waterlogged Lateritic Sandy Loam of Kerala. R. R. Nair and P. N. Pisharody (Cent. Rice Res. Sta., Pattambi, Kerala, India). *Agr. Res. J. Kerala 8* (1), 6-13 (1970). *FA 5*, 1008. The results of six field experiments conducted under waterlogged conditions over a period of 35 yr show that response of rice to P manuring was not significant. Neither the form in which the P was applied nor varying the rate of N and K with which P was applied had any effect in influencing rice yields. The P present in the soil is sufficient for rice.

87 Studies on Placement of Superphosphate to Rice and Millets in the Tamil Nadu Soils, Using Radioisotope Techniques. C. P. Natarajan (Radioisotop. Div., Agr. Coll. Res. Inst., Coimbatore, India). *Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp.*, 309-20 (1970). *CA 77*, 47301. In field experiments with Co 25 rice and superphosphate-^{32}P (*I*) plus $(NH_4)_2SO_4$ growth was better when the mixture was placed in rows at a depth of 5 cm and 7.5 cm away from the plant rows. In pot experiments with short-duration rice Co 29 on three soils, surface application of *I* gave better results than placement at 5 or 10 cm depth, but differences for dry matter and grain yield at 37 days were not significant. The results of applying *I* varied with the nature of the soil involved.

88 Relative Efficiency of Different Rice Varieties to Take up Soil and Fertilizer Phosphorus. A. M. Oza, S. Wakhaloo, and S. V. Subbiah (Nucl. Res. Lab., I.A.R.I., New Delhi, India). *Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp.*, 377-85 (1970). *CA 77*, 47310. Pot growth was determined for three varieties of rice under different soil moisture conditions, with superphosphate-^{32}P or $H_3{}^{32}PO_4$. Final varietal differences in dry matter were not significant. The P content was 1.67-2.55 mg/g plant material. Uptake of P declined in the order Jaya, Padma, and BC6. Compared with water-saturated soil conditions, P uptake was higher under waterlogged conditions. Differen in P uptake depended more upon the form of soil moisture than upon the rice variety tested.

89 Leaching Loss of Nitrogen in Submerged Rice Cultivation. H. K. Pande and N. K. Adak (Dep. Agr. Eng., Indian Inst. Techn., Kharagpur, India). *Exp. Agr.* 7 (4), 329-36 (1971). *CA 76*, 2892. In general, the rice yield on alluvial soil under all treatments was higher than the yield on lateritic soil. Nitrogen was lost through leaching as NH_4^+ nitrogen and NO_3^- nitrogen, even after application of the NH_4 form under puddle conditions in the reduced soil zone. Grain yield, total dry matter, and N content in the plants were influenced by the amount of N retained in the soil after the leaching loss in each corresponding treatment. Under saturation the percentage loss was greater under NO_3^- nitrogen and under submergence with NH_4^+ nitrogen and the loss was accelerated when all the N was applied at one time. Three split applications at the active vegetative, reproductive, and ripening stages helped to give maximum responses in both soils.

90 Effects of Depth of Submergence, Fertilization and Cultivation on Water Requirement and Yield of Rice. H. K. Pande and B. N. Mittra (Indian Inst. Techn., Kharagpur, India). *Exp. Agr.*, 7, 241-8 (1971). *Soils Fert. 34*, 5235. Under three levels of submergence (0, 5, and 10 cm depths) water requirements were maximal at 10 cm. With medium and high levels of NPK fertilizers, both *Aus* (April/July) and *Aman* (July/December) crops had higher water requirements than under low levels of fertilization. Compacted soil compared well with puddled soil but water requirement was higher with shallow puddling. Transpiration, evaporation, and percolation losses all increased with the level of submergence, but only transpiration was affected by varying the levels of fertilization.

91 Tillering Behavior and Grain Yield of Lowland Rice in Relation to Nitrogen Fertilization. H. K. Pande and N. N. Narkhede (Indian Inst. Techn., Agr. Dep., Kharagpur, India). *Riso 21* (1), 59-66 (1972) (Eng). *Soils Fert. 35*, 3494. In pot experiments, Taichung 65 rice variety was fertilized with 0, 30, 60, and 90 kg/ha N as $(NH_4)_2SO_4$ applied on the surface or 6 cm below the surface at transplanting, half at transplanting and half at tillering or half at transplanting, one-fourth at tillering and one-fourth at the flag leaf stage. Tillering increased with increasing N rates and was higher when the N was applied in two installments than when it was applied in one or three. Yields also increased with increasing N but the application of N in three installments gave higher yields than single or two applications. The application of N at 6 cm depth gave a greater rate of tiller emergence for a longer period and greater grain yields than surface application.

92 Response of Lowland Rice to Split Application of Nitrogenous Fertilizer. H. K. Pande and V. P. Singh (Dep. Agr. Eng., Kharagpur, India). *Indian J. Agr. 15* (3), 285-7 (1970). *Soils Fert. 35*, 728. In pot and field experiments, split applications of N were more efficient than single dressings. Best results were obtained when the split applications were made at the transplanting or active tillering stage, the neck-node differentiation, reduction division, and heading stages.

93 The Uptake of Nutrients in Relation to Growth of India Rice (*Oryza sativa* L.). S. Patnaik and C. T. Abichandani (Cent. Rice Res. Inst., Cuttack, Orissa, India). *Riso 19* (1), 17-35 (1970). *FA 4*, 1056. Dry matter production, content, and uptake of N, P, S, K, Ca, Fe, and Mn in relation to growth of six indica rice varieties were studied under solution culture and field tests. There was a rapid increase in N, P, and S content in the plant after transplanting followed by a decrease to low values during or after the reproductive growth period. Phosphorus and Mn content in plant in the solution culture followed the same pattern as that for N, whereas in the field test, there was a gradual decrease from transplanting to harvest; the concentration of Ca and Mg in the solution culture experiment remained at a constant high level from the maximum tiller number stage while in the field test, the plants had a uniform content of these two nutrients throughout the

growth period; S had a tendency to increase from transplanting to maturity in solution culture and decrease in the field test. Nitrogen, P, and S were absorbed from transplanting to flowering. Potassium was absorbed from transplanting up to the dough stage. In the early varieties, the absorption of the four nutrients was continuous while in the medium and late ones, there was an absorption lag during the vegetative lag period. Calcium, Mg, Fe, and Mn absorption was delayed and increased during the reproductive growth period.

94 Nutrient Availability and Response of Rice to Nitrogen-Phosphorous Fertilizers. S. Patnaik *et al* (Cent. Rice Res. Inst., Cuttack, India). *Phosphorus Agr. 25* (58), 22-35 (1971). *CA 76*, 152534. Pot and field experiments were conducted to study the effect of different NP fertilizers [$(NH_4)_2SO_4$, urea, $CaNH_4(NO_3)_3$, superphosphate, NH_4 phosphate, nitrophosphate] on grain yield, uptake of N and P by the plant, and on nutrient losses in percolating water. Application of NH_4^+ containing fertilizers resulted in higher availability and lower loss of N and P as compared to nitrates and nitrophosphate. However, nitrophosphate proved as efficient as NH_4 phosphate or as $(NH_4)_2SO_4$/urea plus superphosphate.

95 Response of Rice IR8 to Different Sources of Nitrogen. B. Prasad and S. C. Shukla (Bihar Agr. Coll., Sabour, India). *Madras Agr. J. 57*, 519-22 (1970). *Soils Fert. 34*, 2513. On moderately fertile loam of pH 6.9, ammonium sulfate nitrate, $(NH_4)_2SO_4$ and urea were equally effective in a kharif (autumn) season characterized by moderate rainfall; in the following kharif season, however, characterized by heavy rainfall after transplanting, urea was less effective than the other forms.

96 Studies on Method of Nitrogen Application in Relation to Frequency of Irrigation for Rice. K. Rajagopolan, K. M. Balasubramaniam, and P. Narayanaswamy (Agr. Coll. Res. Inst., Coimbatore, India). *Madras Agr. J. 58* (8), 683-7 (1971). *Soils Fert. 35*, 2577. Over three seasons during 1969-70, a medium-textured clay loam soil of pH 8.2 received 120 kg/ha N as a basal dressing or split applications of 30 + 50 + 40 kg N at planting, tillering, and panicle initiation, respectively. Split application gave an average yield increase of 449 kg/ha over basal application. Reflooding on alternate days gave similar yields to reflooding once in 3 days after N application and these were superior to reflooding intervals of 5 and 7 days.

97 Influence of Nitrogen Levels on Nitrogen Fractions and Nitrate Reductase Activity in Rice. T. Ramanujam and J. S. Rao (Reg. Cent., I.A.R.I., Coimbatore, India). *Madras Agr. J. 58* (5), 358-62 (1971). *CA 76*, 2895. Application of graded levels of N (30 to 180 kg N/ha) to the high fertility ADT 27 strain of rice led to approximately a 2-fold increase in total N, protein N, nonprotein N, and nitrate N in the leaves by the tillering stage. No significant increase in nitrate N, ammonia N, or amide N occurred. By the flowering stage, all N fractions showed significant increases. By the harvesting stage, the N in the straw (after all treatments) had decreased equal to that in the control, but in the grain, total N showed gradual increases in relation to the increased supply of N. The activity of nitrate reductase was not changed significantly by any of the treatments.

98 Influence of N supply on Growth Factors of Rice (*Oryza sativa* L.). T. Ramanujam and J. S. Rao. *Madras Agr. J. 58* (3), 239-44 (1971). *Trop. Abstr. 27*, 1834. A study was conducted to assess the response of the rice variety ADT 27 to different levels of N. The shoot height indicated a positive relationship with N levels, whereas the root length showed a negative trend. The number of tillers per hill, shoot wt, root wt and shoot/root ratio were evidently influenced by N levels. Among the yield components studied, the number of panicles per hill and length of panicle were increased by higher levels of N, but the filled grain percentage did not change beyond 60 kg N/ha. A quadratic response in grain yield to increased levels of N was observed up to the level of 90 kg N/ha. At this level a maximum yield of 4850 kg/ha was recorded, compared to 3200 kg/ha for the control.

99 Response of ADT 27 Rice (*Oryza sativa*) to Nitrogen Fertilization. P. K. Rangiah (Agr. Coll. Res. Inst., Madurai, India). *Madras Agr. J. 59* (5), 297-8 (1972). *Soils Fert. 35*, 5445. Rice responded parabolically to applied N, the maximum economic rate being 90 kg/ha.

100 Effect of Nitrogen Levels on the Net Assimilation Rate, Growth Rate and Yield of ADT 27 Rice. J. S. Rao and T. Ramanujam (Dep. Agr. Bot., Agr. Coll. Res. Inst., Coimbatore, India). *Madras Agr. J. 58* (12), 899-900 (1971). *CA 77*, 60733. A field trial was run on ADT 27 rice with N at 0, 30, 60, 90, 120, 150, and 180 kg/ha and with 50, 45, and 30 kg/ha of green leaf manure, P_2O_5, and K_2O. Net assimilation rate (NAR) and relative growth rate (RGR) were determined at three stages: between transplanting and tillering (*A*), tillering and flowering (*B*), and flowering and harvesting (*C*). NAR increased with applied N at *A* and *B* but decreased at *C*. At all levels of N, maximum NAR occurred at *A* indicating maximum utilization of N in the first 30 to 60 days. Similar trends occurred in RGR with the increase in rate being more pronounced at *A* and with *C* showing an increase at high N. Straw yield increased with N over the entire range from 4625 for the control to 9650 kg/ha for 180 kg/ha N. Grain yield increased from 3200 to a maximum of 4850 kg/ha at 90 kg/ha N. Higher N levels did not significantly affect the grain yield.

101 Nitrogen, Phosphorus, and Potash Uptake by ADT 27 Rice. A. K. Sadanandan, M. Guruswamy, and A. N. Sivappah (Agr. Coll. Res. Inst., Coimbatore, India). *Madras Agr. J. 56* (4), 188-94 (1969). *CA 74*, 86919. Absorption studies of N, P, and K were carried on with ADT 27 rice. Uptake of N increased with increased N application. The nutrients percent in soils decreased with growth while their uptake increased. Maximum utilization of N occurred during the tillering and flowering phases. Utilization of P did not improve when fertilization above 30 lb P_2O_5/acre was applied. The uptake pattern for P closely followed N, but at a lower level. The percentage content and uptake of K significantly increased with higher dose of K fertilization. The maximum K uptake was observed at the flowering phase. The yield data revealed that 60 lb N, 45 lb P_2O_5, and 45 lb K_2O was the best among the treatments tested to augment yield.

102 Role of Silicate in the Uptake of Nutrients by Rice Plants in the Laterite Soils of Kerala. A. K. Sadanandan and E. J. Verghese (Agr. Coll., Vellayani, Kerala, India). *Agr. Res. J. Kerala 7*, 91-6 (1969). *Soils Fert. 34*, 2507. In pot experiments ion lateritic soil of pH 4.5 containing 1.34% organic C, 4.35% acid-soluble SiO_2, and traces of water-soluble SiO_2, application of Si, particularly in the form of CaMg silicate, promoted the N and P uptake by straw and grain. Sodium silicate promoted K uptake. Calcium, Mg, and Si uptakes were increased by Si application. The strength of straw increased as a result of the increased number of silicated cells and increased

Si content of the stalk.

103 Efficiency of Different Phosphatic Fertilizers on Acidic Soil of Western Mysore State. T. Sadasivaiah and T. S. Rao (Univ. Agr. Sci., Bangalore, India). *Indian Soc. Soil Sci. Bull.*, No. 8, 243-7 (1970). *CA 75*, 47912. A pot-culture experiment was conducted for 2 years on paddy rice with the acidic soil of Mangalore to test the usefulness of superphosphate, rock phosphate, basic slag, and steamed bonemeal. In the first year, 1966-67, the differences in yield of grain due to the application of different phosphatic fertilizers was not statistically significant. In the second year, 1967-68, the yield obtained with basic slag was significantly higher than with other treatments. Soil analysis after harvest did not show any change in N content but the available P was somewhat reduced. It was suggested that relatively insoluble phosphatic fertilizers be used on the Western Coast of Mysore state and the use of superphosphate be gradually discouraged.

104 Efficiency of Phosphatic Fertilizers on Paddy. B. N. Sahu, K. B. Khatua, and K. N. Rout (Coll. Agr., Bhubaneswar, India). *Technology 7* (2) (Spec Issue), 52-7 (1970). *CA 75*, 4820. Experiments were conducted for 3 years with different sources, levels, and methods of application of phosphatic fertilizers at the Agronomy Farr at Bhubaneshwar. The response to P_2O_5 was comparatively lower than to that of N. Among the different phosphatic fertilizers, superphosphate gave better results than ODDA (obtained from ODDA Smeltwerke, Norway) and PEC (developed by M/s Potasse et Engrais Chimique, France) nitrophosphates; among the nitrophosphates, PEC seemed to perform better than ODDA. The optimum doses appeared to be 53.8 kg N and 47.0 kg P_2O_5/ha for a nonsensitive, short duration tall indica variety of rice. PEC nitrophosphate gave a better residual effect than either SSP or ODDA nitrophosphate.

105 Soil Fertility Investigation under Continuous Application of Ammonium Sulfate Alone and in Combination with the Organic Manures in the Bhubaneswar Long-Term Fertility Trial. B. N. Sahu and B. C. Nayak (Orissa Univ. Agr. Techn., Bhubaneswar, India). *Int. Symp. Soil Fert. Eval. Proc. I.*, pp. 873-9 (1971). *FA 5*, 2073. Investigation was carried out on a sandy loam lateritic soil of Bhubaneswar, Orissa, for 10 yr to study the effect of continuous application of ammonium sulfate (AS) and organic manures such as farmyard manure (FYM), greenmanure, and groundnut cake singly as well as in combination on the yield of lowland rice and on the physicochemical properties of soil. Results indicate that inorganic N was more effective in increasing rice yield than organic N. Tall indica rice gave response to N up to 45 kg N/ha beyond which there was a fall in the yield. The best combination for high yield of indica rice was 45 kg N/ha as inorganic fertilizer with a basal dressing of FYM to supply 45 kg N/ha. Analysis of soil samples collected at the beginning and end of the trial show that continuous use of AS has no deleterious effect on soil pH. Organic C and N declined by 12.7 and 27%, respectively, in unmanured plot; whereas, organic C, total N, available P, and K were comparatively more in the soils under organic manure treatments than inorganic fertilizer treatments. Of the organic manures, FYM treatment showed more increase in organic C, total N, available P and K, and C.E.C. than greenmanure and groundnut cake treatments.

106 Water Requirement and Response of Lowland Rice to Nitrogen and Phosphate at Different Soil Moisture Regime. B. N. Sahu and S. P. Raut (Orissa Univ. Agr. Tech., Bhubaneswar, India). *Indian J. Agron. 14* (1), 46-55 (1969). *Soils Fert. 35*, 719. Cumulative water-use on sandy loam soil of pH 4.9 increased with increasing soil moisture. From transplanting to harvest, the total consumptive use of water under submergence, at field capacity and at 75% available moisture was 1560, 812, and 200 mm, respectively. Consumptive use during the vegetative, reproductive, and milky stages was 1.2 cm, 1.5 cm, and 0.60 cm/day and dropped to 0.60 cm during the dough and yellow-ripe stage of the grain under 15 cm submergence. Water requirements were highest during the reproductive phase. Fertilizers enhanced the total water requirement but increased water-use efficiency.

107 Soil Amendments to Prevent and Correct Iron Chlorosis in Upland Rice Nurseries. N. P. Saxena, M. J. Rao, and H. Sakai (All-India Coordinated Rice Imp. Proj. Hyderabad, India). *Int. Symp. Soil Fert. Eval. Proc. I*, pp. 797-804 (1971). *FA 5*, 2073. Experiments were conducted to study and control Fe chlorosis in upland nurseries, both in field and pot culture with adequate nutrient supply. Taichung Native 1, a variety susceptible to Fe chlorosis, was used for the studies. The pH of the soil and irrigation water was very high (7.8-8.4) and soluble Fe very low. Chlorosis was either due to the immobility of Fe because of the high pH of the soil and/or the low content of soluble Fe. Treatments were designed to increase the mobility of Fe by decreasing the soil pH and increasing the Fe^{2+} by soil reduction or supplementation by Fe-chelate. Application of concentrated H_2SO_4 brought down the soil pH to 5.0 and proved to be very effective in preventing chlorosis and in growing healthy green seedlings. The excess of salts liberated was washed out with sprinkling irrigation but the water being alkaline it raised the pH of the soil again and thus reduced the residual effect. Being alkaline in reaction, the soil was reduced very easily after incorporation of fresh organic material under flooded conditions. This treatment liberated abundant amount of ferrous Fe. Drying of the soil drastically decreased the liberated Fe but still enough ferrous Fe existed to grow healthy green seedlings. This method of preventing chlorosis was very cheap and effective. When once chlorosis appeared on the growing seedlings, repeated sprays of dilute Fe chelate did not prove very effective and resulted in nonuniform recovery. Application of a concentrated solution of Fe chelate around the root zone of the affected seedlings maintained continuous supply of available Fe and made the chlorotic seedlings uniformly green within 3-4 days and was the only effective means of correcting chlorotic seedlings.

108 Effects of Zinc Nutritional Levels on Uptake, Translocation, and Metabolism of ^{32}Phosphorus in Rice. D. Sharma and V. S. Rathore (Coll. Basic Sci., Uttar Pradesh Agr. Univ., Pantnagar, India). *Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp.*, 103-16 (1970). *CA 77*, 47314. Surface-sterilized rice seeds (*Oryza sativa*, variety IR8) were germinated. After 2 weeks, the seeds were detached and the seedlings grown on half-strength Hoaglund's solution with roots completely submerged. Zinc was supplied at 0.0, 0.05, 0.5, or 5 ppm. With 0.0 or 0.05 ppm Zn, growth was reduced and the leaves became chlorotic and necrotic. With no added Zn^{2+}, the fresh wt of the seedlings was <20% of those grown on 0.5 ppm Zn. Zinc deficiency also reduced root growth. When Zn deficiency became pronounced, the highest ^{32}P uptake was in plants grown at 0.5 ppm Zn. In the absence of Zn, the uptake was only 27% of that with 0.5 ppm Zn. The highest Zn concentration was slightly phytotoxic and also decreased ^{32}P uptake. With 0.0 and 0.05 ppm Zn, there was increased translocation of ^{32}P to the shoots. In Zn deficiency,

there were lower rates of nucleotide synthesis and ^{32}P incorporation into lipids and nucleic acids.

109 Effect of Varying Water-Management Practices on the Growth, Yield and Nitrogen Uptake by High-Yielding Rice Varieties. J. E. Shinde and V. K. Srivastava (I.A.R.I., New Delhi, India). *Indian J. Agr. Sci. 42* (1), 57-62 (1972). *Soils Fert. 35*, 5432. In pot experiments using two varieties in a sandy loam soil the effects of continuous waterlogged or upland conditions or various durations of both and of 10 or 100 kg N/ha were studied. The effects of the water treatments were not significant at the low N level. The highest grain yield and N uptake occurred when waterlogging continued from transplanting to flowering or to maximum tillering, depending on variety. Upland conditions imposed during any growth stage except ripening reduced the grain yield, but to a different extent between varieties.

110 Response of High-Yielding Paddy Varieties to Foliar Application of Nitrogen under Conditions of Inadequate Irrigations. M. P. Singh, R. M. Upadhyay, and S. D. Dhiman. *Kanpur, India: Uttar Pradesh Inst. Agr. Sci. Proc. Symp. Recent Advan. Crop Prod.*, pp. 201-5 (1970). *Soils Fert. 35*, 2575. Two-year trials showed that the optimum N rate was 100 kg N/ha, 40 kg N as a soil dressing plus three foliar sprays between tillering and flower initiation.

111 Response of Wheat and Paddy to Different Levels of P and K in Relation to an Optimum Level of N under Different Agro-Climatic Conditions. M. P. Singh *et al. Kanpur, India: Uttar Pradesh Inst. Agr. Sci. Proc. Symp. Recent Advan. Crop Prod.*, pp. 195-200 (1970). *Soils Fert. 35*, 2512. Recommended fertilizer rates for wheat are 120 kg N/ha and 30 or 90 kg P_2O_5/ha (depending upon locality) and for rice 60 or 120 kg N/ha (depending upon variety) and 30 or 60 kg P_2O_5/ha (depending upon locality and variety).

112 A Note on Relative Efficiency of Nitrogenous Fertilizers for Rice. R. S. Singh (Orissa Univ. Agr. Tech., Bhubaneswar, India). *Indian J. Agron. 15* (4), 373-4 (1970). *Soils Fert. 35*, 727. In a two-year field experiment on a sandy loam soil (pH 4.5), T-1242 rice variety was fertilized with 33.6 kg/ha N as $(NH_4)_2SO_4$, NH_4Cl, factomfos (16% N:20% P_2O_5), CAN, urea and nitrophosphate (20% N:20% P_2O_5) applied one-half at transplanting and one-fourth 1 month after transplanting. All N sources significantly increased grain yields over the control. Factomfos gave the highest grain yield but it was not significantly greater than yields from other sources in the first year and only significantly greater than yields from NH_4Cl and nitrophosphate in the second year. Urea also gave significantly higher yields than nitrophosphate in the second year.

113 Effect of Soil Moisture Conditions and Potassium Application on the Chemical Composition of the Leaf of Rice Plant at Different Stages of Growth and Development. Sant Singh and K. K. Singh (Fac. Agr., Banaras Hindu Univ., Varanasi, India). *Proc. Nat. Acad. Sci., India, Sect. A 40* (3), 289-95 (1970). *CA 76*, 152570. Rice plants were grown in pots, with varying K and moisture content, and the leaves were analyzed at different growth stages. With few exceptions concentration of all nutrients decreased with plant age. Low soil moisture reduced N in early stages but later increased it. Variation in P was not appreciable. Depleted soil water increased leaf K in the first period but the trend was later entirely reversed. Normal irrigation increased it most. Low soil moisture caused an accumulation of Si. The effect on Ca and Mg was indefinite, but Ca was greatly reduced in wilting leaves. In general the application of K did not affect the accumulation of other nutrients, although split application appeared slightly to increase N, P, and K contents in low-moisture plants. Concentrations of Si, Ca, and Mg were not affected. In general split application of K and low soil moisture favored accumulation of N and Si, especially during late growth stages.

114 Trends in Nitrogen Uptake in Paddy Grain. A. N. Sivappah *et al* (Reg. Arecanut Res. Sta. Peechi, India). *Madras Agr. J.* 56, 713-17 (1969). *Soils Fert. 33*, 4872. The response in N content of the grain to applied N was quadratic in CO 25 and linear in ADT 27.

115 Effect of Micronutrients on Paddy in a Red Loam Soil of Kerala. C. Sreedharan and C. M. George (Div. Agron., Agr. Coll., Vellayani, India). *Agr. Res. J. Kerala 7* (2), 61-6 (1969). *CA 75*, 87567. The effect of various combinations of B, Cu, Mo, Mn, and Zn together with a basic application of NPK fertilizer and green manure on paddy in red loam soil was studied. Copper increased both grain and straw yields. Manganese and B increased the straw yield. Probably the availability of applied Mn was increased by fertilizers such as $(NH_4)_2SO_4$, superphosphate, KCl, and green manure. Molybdenum and Zn, either alone or combined, did not influence the straw yield. Probably there was sufficient available Zn in the soil. Combined application of all the micronutrients did not influence grain and straw production.

116 Recent Soil, Fertilizer, and Physiological Studies with ^{32}Phosphorus on High-Yielding Varieties of Paddy. B. V. Subbiah and J. C. Katyal (I.A.R.I., New Delhi, India). *Isotopes Radiat. Invest. Fert. Water Use Eff. Countries Asia Far East*, pp. 61-81 (1970). *CA 76*, 33214. Studies were carried out on the applicability of the ^{32}P plant injection technique for paddy, comparison of the results of root activity obtained by the placement of ^{32}P in different soil zones and root distribution pattern by ^{32}P plant injection technique, the root distribution pattern of some of the high-yielding dwarf paddy varieties as compared to local ones, and effect of N fertilization on the rooting pattern of a dwarf variety. ^{32}Phosphorus plant injection technique was applicable for paddy for evaluation of root distribution and injecting ^{32}P into the plant with sucrose resulted in increased transport of the activity from the stem to the roots. The root activity data by ^{32}P placement (in capsules) gave statistically reproducible results which are highly correlated with the root distribution pattern obtained by ^{32}P plant injection technique. The high-yielding dwarf varieties (viz., IR8 and Taichung Native 1) had more intensity of root distribution in lower depths as compared to local tall variety (viz., NP130). Effect of increasing levels of N fertilization resulted in a greater intensity of root distribution in lower depths.

117 Nitrogen Response of Dwarf and Tall Rice Varieties. H. ten Have (All-India Coordinated Rice Imp. Proj., Hyderabad, India). *Fert. News 17* (6), 31-5 (1972). *FA 5*, 133. Results from many coordinated N-variety and uniform variety trials during 1966 to 1970 revealed that at many stations the optimum N level for a variety like IR8 was around 150 kg/ha during a kharif season. At locations with large seasonal differences for N response, the optimum level was higher during a rabi season and exceeded sometimes 200 kg N/ha. The main reasons for a low N response are mentioned and the importance of good crop management practices for enhancing N efficiency are stressed. Large differences in grain yield were

observed between dwarf and tall varieties. These differences increased with higher levels of N and were usually much higher during a rabi than during a kharif season. Distinct seasonal differences for N response were found at most locations.

118 Nitrogen Response of Rice as Influenced by Varietal and Seasonal Differences. H. ten Have (All-India Coordinated Rice Imp. Proj., Hyderabad, Andhra Pradesh, India). *Fert. News 16* (5), 28-35 (1971). *FA 4*, 2117. Field tests on the N response of dwarf and tall *indica* varieties of rice at several stations over eight seasons showed that the dwarf varieties always exhibited a much better grain yield response to N than the tall varieties. At the 0 N level, the dwarf yielded more than the tall varieties and these differences were more pronounced during the *rabi* season. The main reason for differences in yield between IR8 and the tall varieties was a much higher panicle wt for IR8. Grain to straw ratios were higher in a *rabi* season and were likewise more favorable for the dwarf types. These ratios decreased with more N and this decline was more during a *kharif* season. With N levels from 0 to 150 kg/ha the dwarf varieties generally yielded slightly less straw during a *kharif* season than the tall varieties. Weather conditions (rainfall) during a *rabi* and *kharif* season were closely associated with the N response of these varietal groups. At five locations (Burdwan, Cuttack, Bhubaneswar, Rajendranagar, and Maruteru) the crop response to N was strikingly better during a *rabi* season. At Coimbatore and Patna, seasonal differences for N response were almost absent. Weather conditions and N response were much more favorable at Coimbatore than at Patna.

119 Optimum Times of Nitrogen Application for Transplanted Rice. H. ten Have (All-India Coordinated Rice Imp. Proj., Rajendranagar, Hyderabad, India). *Fert. News 16* (2), 9-19 (1971). *FA 4*. 1032. Coordinated trials with dwarf *indica* varieties during six seasons have shown that split applications of N yielded better results than when all N was applied at planting. Two topdressings of N (at tillering and panicle initiation) usually performed better than a single topdressing. As an average over three *kharif* seasons the yield advantage of 100 kg N/ha as a split application over the 100% basal dressing averaged about 200 kg/ha. For three *rabi* seasons this difference amounted to approximately 300-400 kg/ha. Results indicated that *ponlai* varieties (like Tainan 3 and Taichung 65) responded less favorably to split applications than dwarf *indicas*. Early N applications at planting and, to a lesser extent, at tillering were very effective in increasing the number of panicles per unit area, whereas later N dressing increased grain yield more by producing heavier panicles. These trends were also reflected in the grain-to-straw ratios. Late and high rates of N application increased the protein content of the grain. Incidence of bacterial leaf blight was associated with times and rates of N application during the *kharif* season. Main factors to be taken into consideration for determining the proper rates and times of N application, such as soil type, variety, cultural practices, methods of application, and season are discussed.

120 Effect of Nitrogen and Spacing on Bacterial Leaf Blight of Rice. H. ten Have and H. E. Kauffman (All-India Coordinated Rice Imp. Proj., Rajendranagar, Andhra Pradesh, India). *Indian Farming 21* (10), 8-13 (1972). *FA 5*, 1184. Bacterial leaf blight caused by *Xanthomonas oryzae* has become serious in India since the introduction of the dwarf, N-responsive rice varieties. Chemical control is not effective in the tropics and, until resistant varieties can be developed, reduction in infection will depend upon careful manipulation of agronomic practices. Experiments were conducted to determine the effect of N and spacing on leaf blight severity. When climatic conditions favored build-up of the disease, rate of N and level of infection were closely related. Yield response to N was very poor. In a comparison of urea, ammonium sulfate, and calcium ammonium nitrate as N sources, yields were 30% lower and blight incidence over 65% lower with the latter; N status of the plant seemed to explain this observation. Similarly, methods of fertilizer application that resulted in the greatest uptake of N were positively related to high incidence of disease. No consistent trend was observed between time of N application and level of infection. The higher N content of plants spaced widely in the row makes these plants more susceptible to leaf blight; highest grain yields were obtained with close spacing in the row.

121 A Note on Effect of Time of N Application on Lodging in Paddy. P. S. Tomar and G. S. Shekhawat (Sub. Reg. Agr. Res. Sta., Jetstar, Rajasthan, India). *Madras Agr. J. 57*, pp. 344-46 (1970). *Soils Fert. 34*, 1709. A triple-split application of $(NH_4)_2SO_4$ at the time of transplanting, 1 month after transplanting, and at flower initiation prevented any substantial reduction in yield due to lodging.

122 Changes in Nutrient Content of Soils Caused by Growing Wheat and Rice in Rotation under Pot-Culture Conditions. M. Velayutham, K. B. Shome, and B. Ramamoorthy (Div. Soil Sci. Agr. Chem., Indian Agr. Res. Inst., New Delhi, India). *Proc. Nat. Acad. Sci., India, Sect. A 40* (3), 313-20 (1970). *CA 76*, 152573. A pot-culture study was made of the relative changes in distribution of N, P, and K forms and available nutrients in alluvial soils caused by growing wheat and rice in rotation. No change occurred in status of exchangeable NH_4^+ or NO_3^- and fixed NH_4. Amino-N, Fe, and P decreased after wheat but increased after rice. Phosphorus, as determined by saloid method, followed the reverse trend. Phosphorus, as determined by Olsen method, decreased after wheat growth, but that determined by Bray method increased. A reverse trend occurred after rice. Occluded forms of P did not change. Fixed K decreased after wheat but increased after rice. Rice and (to a lesser degree) wheat caused a decrease in available Cu but an increase in available Zn and Mn. Results demonstrate that wheat and rice grown in rotation play a complementary role in making better utilization of the available forms of the soil major and minor nutrients, offsetting some of the relative depletions and accumulations caused by growing crops in rotation.

IRAQ

123 Fertilization Studies on Rice Crop in Diwania. A. Al-Fakhry. *Mesopotamia Agriculture*, 4, pp. 11-17 (1969). *Trop. Abstr. 26*, 1391. In Iraq, rice experiments were conducted with 200 kg N, 200 kg of each N and P, and 200 kg of each N, P, and K applied/ha. Nitrogen, NP, and NPK gave a yield increase of 40.6, 64.3, and 71.2%, respectively. However, the ratio of net profitable return to the cost of fertilizer was highest for the NP treatment, viz. 2.62:1 as compared to 2.38:1 for NPK, and 2.32:1 for N.

JAPAN

124 Studies on the Change of the Respiratory System in Roots in Relation to the Growth of Plants. IV. Relation

Between the Respiration and the Uptake of Salts (Ammoniacal Nitrogen, Nitrate Nitrogen and Phosphorus) by the Nodal Roots of Cereal Crops with the Aging of the Plant. K. Barat, *et al* (Tokyo Univ., Japan). *Soil Sci. Plant Nutr. (Tokyo)* 15, 222-5 (1969). *Soils Fert. 34*, 4186. In rice roots grown under normal conditions, maximum amounts of N accumulated just after the panicle-formation stage when increased respiration resulted in increased NH_4 uptake. Subsequently, NH_4 uptake decreased with decreasing oxygen uptake. After the ear-heading stage total N uptake again increased, mainly as a result of NO_3 uptake corresponding to the beginning of grain formation when a large number of lateral roots appeared around the last nodal roots. Phosphorus accumulation was similar to that of N up to the ear-heading stage.

125 Protein Content in Rice Grain. II. Effects of Fertilization Conditions on Protein Content and Protein Production in Paddy Grain. Kazuo Honjyo (Fac. Agr., Iwate Univ., Morioka, Japan). *Nippon Sakumotsu Gakkai Kiji 40* (2), 190-6 (1971) (Japan). *CA 76*, 45099 Rice plants were grown at a density of 50, 80, and 110-40 hills/33 m^3. The basal dressing of fertilizer was 0.56, 0.75, and 0.94-1.13 kg N/acre. The amounts of P and K were normal. Topdressings of 0.05-0.25 g N/hill were applied before or after the heading stage. The more N fertilizer applied and the wider the spacing between plants, the higher the protein content in the grain. Ultimately, the protein content depended on N supply per hill; protein production tended to increase at higher levels of N fertilizer in any planting density, but it was hardly influenced by planting density at each N level. The most effective topdressing of N fertilizer, on protein production is the heading stage. Prior to this stage the N effect was minimal. After this stage the effective period lasted for a long time but the effect decreased gradually. Topdressing of 0.25 g/hill at the heading stage increased the protein content by 38% compared with nontopdressing. Protein production was the highest in the complete NPK plot.

126 Principles of Yield Determination of Rice and Plant Studies of Their Use. 93. Effects of Different Temperature Conditions and Fertilization Conditions During a Nursery Period on Various Characteristics of Rice Seedlings. Takafumi Hoshino, Seizo Matsushima, and Toyoo Tomita (Natl. Inst. Agr. Sci., Konosu, Japan). *Nippon Sakumotsu Gakkai Kiji 40* (2), 197-202 (1971) (Japan). *CA 76*, 45100. The study was designed to have 6 temperatures (2 air temperatures and 3 water temperatures) with 6 fertilizer applications (3 levels of fertilizer at 2 soil depths). Rice seedlings were planted in these 36 treatments for 30 days. The plant age (expressed by the number of leaves on the main stem) was much influenced by the water temperature; the higher the temperature, the older the plant. It was also influenced slightly by the amount of N. The plant height, the wt of the top dry matter and root dry matter, and the ratio of top dry matter to the plant height all increased with increasing amounts of N as well as increasing concentrations of N in the soil at low air and water temperatures. At high temperatures high N levels decreased seedling growth. The N content of rice seedlings was influenced more by the fertilizing than by temperature; it almost paralleled the amount of N applied. The carbohydrate content in rice seedlings was high at both the highest and the lowest temperature. It decreased with increasing amounts of N applied.

127 Effect of the Application of Wollastonite on the Growth of Rice Plant. Iawo Isai *et al* (Fac. Agr. Gifu Univ., Japan). *Gifu Daigaku Nogakubu Kenkyu Hokoku*, 26, 85-91 (1968) (Japan). *FA 4*, 559. Mined wollastonite fertilizer compared favorably with silicate slag fertilizer since the Si and Ca were absorbed and utilized easily by rice.

128 Chemical Quality of Rice Kernels. II. Effect of Nitrogen Topdressing on Protein Content. Katsumi Kataoka (Tamagawa Univ., Machida, Japan). *Tamagawa Daigaku Nogakubu Kenkyu Hokoku*, 10, 87-91 (1970) (Japan). *CA 76*, 13131. Kernel wt of rice grains increased as the date of total leaf cutting of rice plant after heading became later. Protein contents in rice grains were high when the leaves were cut during heading and 28 days after heading. Protein and starch accumulation in rice grains continued for at least 28 days after heading. The highest kernel wt and protein content in rice grains were found when N topdressing was applied from 7 days before heading to 7 days after heading.

129 Effect of Nitrate Nitrogen Fertilizer on the Rice Plant. Nobuo Kosuge (Hokuriku Natl. Agr. Exp. Sta., Takada, Japan). *Hokuriku Nogyo Shikenjo Hokoku* 14, 13-61 (1972) (Japan). *CA 77*, 60668. Topdressing of rice plants with nitrate-N was studied. Soil-applied nitrate-N increased the oxidation-reduction potential and decreased Fe^{2+} accumulation in the soil. Compound NO_3^- containing fertilizer gave a higher yield than that of the check (NH_4 fertilizer). Topdressed at a rate twice as much as ammonium-N, NO_3^- was reduced in the plant body and transported mainly to the ears. Absorption of topdressed NO_3^- was less than that of NH_4^+. Coated nitrate-N, given at the same dose as ammonium-N increased the yield. On plots treated with nitrate-N, more P and K were transported to the ears at maturing and more Ca and Mg and less Mn were absorbed by the plant than on plots given ammonium-N. Transportation of P was related to that of glucose; P in ears at harvest was significantly correlated with the yield (r = 0.62). The Mg content of the plant was also significantly correlated at earing time with the grain yield (r = 0.72). At earing and maturing, more reduced sugars were accumulated by the plants on the NO_3^- than on the NH_4 plots. The same was observed with regard to the basic amino acids: arginine, tryptophan, and histidine. On the NO_3^- plots, the plants developed more roots and they had a high oxidative power for Fe^{2+} or α-naphthylamine, and catalase and peroxidase were very active in the roots and leaf blades of rice plants.

130 Soil-Plant Nutrition Studies on Tropical Rice. I. Studies on Varietal Differences in Absorbing Phosphorus from Soil Low in Available Phosphorus. Takeo Koyama (Nat. Inst. Agr. Sci., Japan) and Chittana Chammek (Rice Dep., Min. Agr., Thailand). *Soil Sci. Plant Nutr., (Tokyo) 17* (3), 115-26 (1971) (Eng). *FA 5*, 295. Crop varieties growing under identical environmental conditions could differ in their P content either because one variety had a lower physiological need for P or the other variety had a stronger ability to absorb P from the soil. Two local Thai varieties of rice, Muey Nawng 62M and Dawk Mali 3, were transplanted into an acidic (pH_{KCl} 3.6) paddy clay low in available P. Fertilizers were surface applied 1 day before transplanting using 37.5 kg/ha each of N and K_2O with an additional 37.5 kg N/ha topdressed and 0, 25, 50, 75, or 150 kg P_2O_5/ha. Sources were $(NH_4)_2SO_4$, K_2SO_4, and superphosphate. Plant samples were collected three times during the growing season and at harvest and analyzed for N, P, K, Fe and Si. When heavy rates of P fertilizer were used (50 kg P_2O_5/ha or more), there was no significant difference between the two varieties in straw

and grain yields. When P supply was low (0 or 25 kg P_2O_5/ha), Muey Nawng 62M yielded much less grain than Dawk Mali 3. At the 0 level, Muey Nawng 62M showed severe symptoms of P deficiency and had a P_2O_5 concentration of 0.11% at the tillering stage. Dawk Mali 3 did not show P deficiency symptoms at the 0 level of P and contained 0.18% P_2O_5 at the tillering stage. It was concluded that the Dawk Mali 3 variety was a stronger feeder on soil P and therefore yielded better in soils low in available P than the Muey Nawng 62M variety.

131 Coated Fertilizer for the Controlled Release of Nutrient. K. Kurihara. *Japan. Agr. Res. Quart. 5* (3), 21-5 (1970). *FA 5*, 803. Pot trials with irrigated rice showed that a single dressing of coated fertilizers with a standardized differential solution rate of 60-90% in 2 weeks yielded 5-10% more grain and tillers compared to one application of uncoated fertilizer. Coated fertilizers allow controlled release of nutrients to crop roots, advantages include reduction of nutrient loss, lower fixation rates, and better nutrient recovery. Drawbacks relate to production processes. Dissolution rates >90% or <60% gave results inferior to those of uncoated fertilizers. In dry rice cultivation coated compounds with a release rate of 40-80% were similarly effective if applied in the presence of 200-300 kg P_2O_5/ha.

132 Manurial Effect of Nitrate Nitrogen on Rice Plant Growth. Syozi Kusaka, *et al* (Prefect. Agr. Exp. Sta., Hyogo, Japan). *Hyogo Kenritsu Nogyo Shikenjo Kenkyu Hokoku*, 17, 33-6 (1970) (Japan). *CA 76*, 24046. By field and lysimeter experiments, the leaching of nitrate N from the soils was examined in reference to the effect of added nitrate N. The effect was not generally seen except for elongating ears, where it caused lower yields. Applied N was leached more from gravelly soils. From yellowish brown soil N was more slowly leached than from other soils caused by slow percolation of water. In gley soils with the same amount of percolating water, N was denitrified.

133 Supply of Solid Fertilizers in Portions to the Irrigating Water for Paddy Fields. Kozo Kutsuna and Akira Uemori (Prefect. Agr. Exp. Sta., Toyama, Japan). *Nippon Dojo-Hiryogaku Zasshi 42* (12), 471-5 (1969) (Japan). *CA 76*, 125784. Supplying portions of solid fertilizers to irrigation water was compared with supplying fertilizer solutions. A special mechanical device supplied fertilizer drops to the water regularly. By the use of the device solid $(NH_4)_2SO_4$, urea, KCl, K_2SO_4, and NK fertilizers could be introduced to the water regularly and continuously for 7 hr. Ammonium sulfate and KCl, dropped into the irrigating water, were dissolved by shaking. Irrigation water supplied regularly with $(NH_4)_2SO_4$ and KCl was used for paddy dressing at earing.

134 Role of the Root System of Rice in Relation to the Physiological and Morphological Characteristics of Aerial Parts. V. Effects of Rate and Placement of Fertilizer on the Characteristics of Root and Aerial Parts. J. H. Lee and Y. Ota (Nat. Inst. Agr. Sci., Konosu, Saitama, Japan). *Nippon Sakumotsu Gakkai Kiji 40* (2), 217-22 (1971) (Japan). *Soils Fert. 35*, 730. Increased basal application of N resulted in greatly retarded development and elongation of new roots immediately after transplanting and excessive numbers of tillers at the time of peak tillering. However, an optimum amount of basal N applied deeply or distributed in all soil layers resulted in increases in root activity, chlorophyll content, percentage of productive tillers and grain yields.

135 Effect of Nitrogen Topdressing on the Yield of *japonica* and *indica* Rice. K. Nagato, N. Yamada, and F. M. Chaudhry (Nagoya Univ., Japan). *Nippon Sakumotsu Gakkai Kiji 40* (2), 170-7 (1971) (Japan). *Soils Fert. 35*, 732. Yields of *japonica* varieties were increased by additional N application in the form of a topdressing; this resulted from increased number of panicles per plant; the yield per panicle, except in two varieties, was not increased so that yield quality was maintained. In *indica* varieties, the carbohydrate content in the plant at heading was lower and the number of spikelets per panicle greater than in *japonica* varieties, hence the competition for carbohydrates between kernels was great; this condition was accentuated by N topdressing.

136 Changes in Uptake Capacities of Phosphorus and Calcium During Callus Induction in Rice. T. Nishi (Univ. Kyoto, Japan). *Physiol. Plant 23*, 561 3 (1970). *Soils Fert. 33*, 4871. Phosphorus uptake decreased and Ca uptake increased during callus induction in rice.

137 Effect of Silicon on Phosphorus Metabolism on Rice Plants. T. Nishihara *et al* (Kagoshima Univ., Japan). *Kagoshima Daigaku Nogakubu Gakujutsu Hokoku 20*, 85-102 (1970) (Japan). *Soils Fert. 34*, 1705. Plant height, number of spikelets per ear, 1000-grain wt percentage of fully ripened grains, and wt of mature grains were reduced in Si-deficient plants. Silicon deficiency did not affect the number of tillers and ears at low P levels but decreased them at high P levels. Total P contents at the maximum tillering stage were lower in Si-deficient plants but at the mature stage, they were about equal in the presence or absence of Si. The rate of P distribution to the ear was higher in Si-supplied plants at moderate and high levels of P supply.

138 Effect of Deficiency or Excess of Calcium, Potassium and Magnesium on the Translocation of C-Photosynthates in Paddy Rice. The Role of Calcium in the Translocation of Photosynthates. I. II. Y. Ohta *et al* (Tokyo Educ. Univ., Japan). *Nippon Dojo-Hiryogaku Zasshi Tokyo 40*, 192-203 (1969) (Japan). *Soils Fert. 34*, 4260. In solution cultures, photosynthesis and translocation of assimilated ^{14}C were reduced more severely by Ca deficiency than by Mg or K deficiency. Plant respiration was also decreased by Ca deficiency.

139 Physiological Studies on the Effects of Silicic Acid upon Rice Plants. II. Effects of Various Amounts of Silicic Acid Supply on Growth. 13. Effects of Silicic Acid on the Formation of Organs and Tissues of Rice Plants. Y. Okamoto (Wakayama Univ., Japan). *Nippon Sakumotsu Gakkai Kiji 39*, 139-43, 151-5 (1970) (Japan). *Soils Fert. 34*, 1706. In culture solutions the optimum SiO_2 concentration for growth of rice plants was 50-100 ppm. Supplying Si increased plant height, numbers of leaves and stems, leaf size, number of panicles, grain size, number of vascular bundles in the culm, rate of protoplasmic translocation in the root hairs and thickness of the lowest elongated internode. There was little or no difference in growth between plants containing 0.2 and 0.0025% SiO_2. Chaff was lighter in color in plants containing 0.06% SiO_2.

140 Effects of Topdressing with a Phosphate Contained in Two Phosphorus-Potassium Fertilizers (Multiphosphate, Superphosphate) on Rice Plants. Masahiro Ookuma, Takeo Manabe, and Susumu Ando (Kagawa Agr. Exp. Sta., Takamatsu,

Japan). *Kagawa-Ken Nogyoshikenjo Kenkyu Hokoku*, 21, 43-7 (1971) (Japan). *CA 76*, 139451. The yield of rice grains decreased by 10% after topdressing with a superphosphate type PK fertilizer when no Ca silicate was applied. It increased by 7-10% after topdressing with a multiphosphate type PK fertilizer and application of Ca silicate. In the latter case, the P_2O_5/SiO_2 ratio in the leaves was high, indicating a high metabolic activity in the leaves.

141 Nitrogen Metabolism in Crop Plants. VII. The Nitrogenous Compounds in the Bleeding Sap and Various Organs of the Crop Plants. Takashi Oritani and Ryuzi Yoshida. *Nippon Sakumotsu Gakkai Kiji 39* (3), 355-62 (1970) (Japan). *CA 74*, 52554. The analytical results for paddy rice plants were reported. The N level in the bleeding sap increased until the early spikelet initiation stage, but decreased rapidly afterwards. The major amino acids in the bleeding sap were asparagine, alanine, and glutamine and their levels increased significantly, when N fertilizers were applied at the early spikelet initiation stage. The content of these amino acids in the leaf sheaths and culms also increased in accord with the N supply level. Diagnosis of nitrogenous nutrition in rice might be carried out by determining the amino acid level in the bleeding sap

142 Effect of Improvement of Nutrient Supply on the Rice Yield on Heavy Clay Paddy Fields. K. Seino *et al* (Hokuriku Agr. Exp. Sta., Takada, Niigata, Japan). *Hokuriku Nogyo Shikenjo Hokoku* 11, 25-80 (1970) (Japan). *Soils Fert. 34*, 2508. The growth of upland rice seedlings was improved by application of silicate materials (containing various minor elements + Ca) in conjunction with Mg. Yields of brown rice over a 9-year period were increased by an average of 9%. This treatment, together with deep plowing to 30 cm and drainage during the period from determination of the bearing tillers to ear formation, increased yields by about 17%.

143 Form and Behavior of Zinc in Reclaimed Saline Paddy Soils on Which Zinc Deficiency in Rice Plants Occurred. Koji Shiratori, Takeshi Suzuki, and Hiroshi Miyoshi (Prefect. Agr. Exp. Sta., Chiba, Japan). *Nippon Dojo-Hiryogaku Zasshi 43* (8), 291-6 (1972) (Japan). *CA 77*, 150869. The Zn content in paddy soils (*A*), suffering from Zn deficiency and sulfide accumulation, was compared with that of normal soils (*B*). Total Zn in *A* was similar to that in *B*. Weak acid-soluble Zn occurred more in *A* than in *B*. Exchangeable Zn occurred less in *A* than in *B*, more clearly not in air-dried soils. More organic Zn was found in *A* than in *B* soils, suggesting that Zn is rigidly chelated with soil organic matter. *A* had much Zn in oxidative and soluble form; reductive and soluble Zn was coprecipitated, in the soils probably, with free Fe. It is concluded that Zn deficiency in the paddy soil is caused not by the lack of total Zn but by the accumulation of difficultly available organic or oxidative Zn forms.

144 The Fate of Fertilizer Nitrogen Applied to Paddy Fields and its Absorption by the Rice Plant. II. The Fate of Basal Nitrogen in the Paddy Field. S. Shoji *et al* (Fac. Agr., Tohoku Univ., Sendai, Japan). *Nippon Sakumotsu Gakkai Kiji 40* (3), 281-6 (1971) (Japan). *Soils Fert. 35*, 1658. Rice plants were treated with 60-70 or 150 kg N/ha as ^{15}N enriched $(NH_4)_2SO_4$. Soil NH_4-N increased more in the high N treated plots, but in both treatments decreased gradually until there was little left by the end of June. Uptake of fertilizer N was 22-27% and that left in the soil after harvest was 18-21%. The formation of soil NH_4-N had maxima at the beginning of June and late July/early August.

145 Iron Nutrition of Rice Plants. IV. Excess Iron Absorption of the Plant by Nutritional Status. Toshiaki Tadano (Hokkaido Univ., Sapporo, Japan). *Nippon Dojo-Hiryogaku Zasshi 41* (12), 498-501 (1970) (Japan). *CA 75*, 47933. Plants were cultured in solution containing low N, P, K, Ca, Mg, and Mn. When the Fe concentration in the solution was >50 ppm, Fe uptake by the rice plant was inhibited This inhibition was lessened most by low K in the medium, somewhat by low Ca, Mg, P, or Mn, but not by low N. The migration of Fe to the top from the root was promoted strongly by low Mg or Mn, and moderately by low K or Ca. The absorption of Fe by rice plants from solutions of high concentration was lessened by the presence of phosphate ($\leq$10 ppm).

146 Effect of Fertilizing on the Protein Content in High-Yield Rice. H. Taira (Minist. Agr. For., Koto-ku, Tokyo, Japan). *Nippon Sakumotsu Gakkai Kiji 39*, 200-3 (1970) (Japan). *Soils Fert. 34*, 1704. In farmers' fields, the protein content of the grain was not increased by basal or topdressing of N at the young panicle formation stage, but was increased by N topdressing after heading. Phosphorus and K fertilizing did not affect the protein content.

147 Soil Improvement of Plots for Rice Plant Culture. Hiromi Ueta and Masao Arita (Prefect. Agr. Exp. Sta , Tottori, Japan). *Chugoku Nogyo Kenkyu* 40, 10-11 (1970) (Japan). *CA 73*, 55075. Plots were different in mechanical texture and internal drainage The main procedure for improvement involved applying soil conditioners with proposed fertilizers (such as Ca silicate, fused phosphate, open hearth slags, and bentonite), with or without draining. In general the procedures almost always caused the plot soil to increase its available P, sometimes its available Si, with an increase of Ca or Mg. By draining the plot, soil was made free from gleying; by drying the paddy soil in summer, the soil was brought to a suitable hardness for plant growth. Yield from each plot was generally increased.

148 The Fate of Fertilizer Nitrogen Applied to Paddy Fields and its Absorption by the Rice Plant. I. Absorption of Basal Nitrogen by the Rice Plant. G. Wada, S. Shoji, and J. Takahashi (Fac. Agr , Tohoku Univ., Sendai, Japan). *Nippon Sakumotsu Gakki Kiji 40* (3), 275-80 (1971) (Japan). *Soils Fert. 35*, 1659. Rice plants, transplanted in early or late May, were treated with 60-70 or 150 kg N/ha as ^{15}N enriched $(NH_4)_2SO_4$. Uptake of fertilizer N increased until the middle of June, after which soil N only was taken up. The ratio of fertilizer N to total N in the plant tissue was highest soon after transplanting and at plant maturity was about one-third and one-seventh on the high- and low-N treated plots, respectively. The recovery of fertilizer N was 22-27%. Uptake of soil N was greater from N-fertilized plots than from those without applied N.

149 The Fate of Fertilizer Nitrogen Applied to Paddy Fields and its Absorption by the Rice Plant. III. Fate of Topdressed Nitrogen in the Soil and its Absorption by the Rice Plant. G. Wada *et al. Nippon Sakumotsu Gakki Kiji 40* (3), 287-93 (1971) (Japan). *Soils Fert. 35*, 1660 The fate of topdressed ^{15}N-enriched $(NH_4)_2SO_4$ applied to rice at 25 and 30 kg N/ha was investigated. NH_4-N persisted longer in the plowed layer when applied during the early growth of the rice. After harvesting, 3-10% of the fertilizer N remained in the plowed layer. Nitrogen recoveries were higher from plots to which N

had been applied at the panicle-formation stage. The rate of N absorption was greater on the plots dressed latest with N. Uptake of soil N was greater from N fertilized plots than from those without applied N

150 Nutriophysiological Studies of Crops Grown in a Sand Dune Soil. IV. The Effects of Nitrogen Topdressed at the Time of Maximum Tillering Stage on the Growth of Upland Rice. M Yamanouchi and S Sawada *Sand Dune Res 14* (2), 22-31 (1968) (Japan) *FA 5*, 262. In a trial at Tottori University, upland rice was grown in Wagner pots in virgin sand-dune soil and supplied with 0 3, 0 6, or 0.9 g N/pot in order to obtain 40, 50, and 55 tillers, respectively, at maximum tillering. At maximum tillering pots were again topdressed with 0, 0.3, 0.6, 0.9, or 1.8 g N/pot Where plants were given low or medium N levels at the first topdressing, tiller number was increased by high N supply in the second application, where high N was given in the first application, tiller number was not increased by later N applications. Grain number/ear increased with increasing rates of N in the second topdressing except for the 1.8-g treatment.

151 Technological Study of Phosphate Fertilization of Paddy Soils. Takashi Yoshino and Koichi Honya (Tohoku Agr. Exp. Sta., Morioka, Japan). *Tohoku Nogyo Shikenjo Kenkyu Hokoku* No. 40, 185-208 (1970) (Japan). *CA 74*, 124282 Six-year studies (1960-1966) on the effects of fertilizers on paddy soils are reported. The yield response of rice to P was closely related with P uptake at tillering stage. During the tillering period, the minimum required content was 0.3% P_2O_5 and during ripening period, 0.15%. The number of tillers increased in proportion with the content of P in the plant. A logarithmic relation was found between P content of plant and available P in soils. Available P means the sum of *A* value and fertilizer P. Different temperature levels (17.4, 20.5, 25.7°) influenced the uptake of P. A significant relation was found between inorganic P content of soils and *A* value. Almost all of the applied P was accumulated as inorganic form and gradually released and made available to the later crops. The residual effect of the P was usually 25% of the initial amount.

KOREA

152 Salt Tolerance of Rice and Other Crops in Reclaimed Soil Areas. IV. Effectiveness of Nitrogen-Phosphorus-Potassium Fertilization in Reclaimed Salty Areas. H B. Im (Coll. Agr., Seoul Natl. Univ , Seoul, Korea) *Soul Taehakkyo Nonmunjip, Chayon Kwahak, Saengnongge*, 20, 15-30 (1969) (Eng). *CA 76*, 152595 The effect of N, P, and K fertilization on rice on reclaimed salty Korean soils was examined. The soils are low in total N and humus, high in P and K, and have a high pH and exchangeable base content. Compared to plants grown in nonsaline soils, absorption of N and Na by plants grown in these soils was markedly increased, Si absorption was slightly enhanced, and that of Ca and K was inhibited Nitrogen fertilizers decreased the absorption of Na and P_2O_5 and enhanced K absorption; K_2O inhibited the Mg absorption. Grain yield was increased by fertilization with N and P_2O_5, but was unaffected by K_2O.

153 Salt Tolerance of Rice and Other Crops in Reclaimed Soil Areas. IX. Rooting and Yields in Saline Soil of Rice Seedlings Reared in Different Conditions. H. B. Im, U. K. Lim, and C. S. Hoang (Coll. Agr , Seoul Natl. Univ., Seoul, Korea). *Han'guk Toyang Biryo Hakhoe Chi 4* (1), 79-85 (1971) (Eng). *CA 76*, 152585. Rice, variety Kwonok, was germinated in H_2O, soil, and saline soil and transplanted to a reclaimed soil having an average salt concentration of 0.67%. Two levels of $(NH_4)_2SO_4$ and urea were used Plants germinated in normal nonsaline soils had the greatest rooting ability when transplanted to the saline soil Roots of saline-soil germinated seedlings showed a high respiratory activity, whereas the water-germinated seedlings had the lowest activity. There were no differences in the effect of N sources on the yield of rice. Germination of rice in normal and saline soils increased rice yields by 33 and 22%, respectively, over those germinated in water.

154 Effects of Silicate and Phosphate Application on the Growth of Rice Seedlings. M. K. Kim (Coll Agr , Chungnam Natl. Univ., Taejon, Korea) *Han'guk Toyang Biryo Hakhoe Chi 3* (1), 17-21 (1970) (Korean). *CA 76*, 125755. A dry paddy soil was treated in laboratories with three levels of silicate (wollastonite) and phosphate; N and K levels were constant. Nongrim 25 rice was sown. After five continuous cultures, rice plants and the soil were analyzed. Dry matter of rice seedlings was significantly increased by increased P absorption and when the SiO_2 absorption increased. The higher the available P in the soil, the lower was the silica content as well as its absorption by the plant, and the $SiO_2:P_2O_5$ ratio in the plant was significantly decreased. Wollastonite application increased available SiO_2 and exchangeable Ca in the soil. The SiO_2 absorption and the $SiO_2:P_2O_5$ ratio in the rice plant was also significantly increased. A higher correlation coefficient was obtained between the exchangeable Ca and the SiO_2 content or $SiO_2:P_2O_5$ ratio in the rice plant than between the available SiO_2 and exchangeable Ca in the soil itself. The $SiO_2:P_2O_5$ ratio in plants can be checked by controlling the $SiO_2:P_2O_5$ ratio in the soil. The correlation between the $SiO_2:P_2O_5$ ratio in plants and the available $SiO_2:P_2O_5$ ratio in soil was very high (r = 0.82).

155 Effect of a Split Application of Potassium on Paddy Rice on Acid Sulfate Soils. Y. S. Kim and C. S. Park (Inst. Plant Environ., Suwon, Korea). *Nongsa Sihom Yon'gu Pogo* 14, 59-64 (1971) (Korean) *CA 77*, 33461. Split application of K fertilizers increased the yield of rice by 32%. Potassium was applied four times during the growth period of rice.

156 Effect of Spacing, Nitrogen Levels, and Silica on Photosynthesis of Rice Plants. H. G. Kwon *et al* (Inst. Plant Environ., Suwon, Korea). *Nongsa Sihom Yon'gu Pogo* 14, 73-81 (1971) (Korean). *CA 77*, 60744. The effects of spacing, N levels, and SiO_2 on photosynthesis by rice plants grown on soils with Akiochi problems were studied. Wollastonite and urea increased the photosynthetic activity of rice. The increase was linear over a leaf area index from 0.5 to 5.8 for urea and from 3.5 to >7 for wollastonite. However, wollastonite had no effect on yield when high rates (130 g/pot) of urea were applied. Light transmission decreased with increasing leaf area, but wollastonite increased the light transmission by the plant stand. With increased photosynthetic activity, the uptake of N, K, and SiO_2 by rice increased linearly. Where planting density was highest (15 x 12 cm) the photosynthetic activity per unit leaf area was lowest, but the grain yield was highest.

157 Role of the Root System of Rice Plants in Relation to the Physiological and Morphological Characteristics of Aerial

Parts. IV. The Effects of Nitrogen Elimination and of Environment of Root Zones on the Characteristics of Root and Aerial Parts. J. H. Lee and Yasuo Ota (Yung Num Crop Exp. Sta., Milyung, Korea). *Nippon Sakumotsu Gakkai Kiji 39* (4), 505-10 (1970) (Japan). *CA 74*, 124253. Water and pot cultures of a Nipponbare rice variety were carried out. Nitrogen deficiency accelerated chlorophyll destruction of excised leaves and reduced the root activity. Owing to the N deficiency, the activities of the lower and upper nodal roots were reduced markedly at the tillering stage and after the division stage, respectively. When different N levels were supplied to various root zones, the mobility of N, P, K, and Mg was relatively higher, as compared with that of Ca, Fe, and Mn.

158 Phosphorus Absorption of Rice Plants Studied with ^{32}Phosphorus. Effects of the Application Level of Major Fertilizer Elements on the Phosphorus Absorption and the Growth of Rice Plants. D. W. Maeng and C. Y. Cho (Coll. Agr., Korea Univ., Seoul). *Wonjaryok Yon'gu Nonmunjip 10* (1) (Pt. 2), 55-69 (1970) (Korean) *CA 75*, 47919. Effect of N, K_2O, CaO, and Fe on the absorption of P_2O_5 and growth of rice plants was investigated, using double superphosphate and ^{32}P-labeled $Ca(H_2PO_4)_2$. Phosphorus uptake and growth were measured at planting time, 20 days after planting, young spike-forming stage, and maturing time. The greater the absorption and utilization of P, the greater were the yields of each part of the rice plant. Number of spikes, wt of grains, and straw increased on N-fertilized plots. Availability of P was greatest in N and K plots and in N and Fe plots.

159 The Use of Silicon in Korean Agriculture. C. S. Park (Inst. Plant Environ , Suwon, Korea). *ASPAC Newsl.*, No. 4, 9-10 (1971). Experiments conducted in Korea in 1968 showed that maturity of rice was positively correlated with the SiO_2 content of the straw and that infection with leaf blast disease was negatively correlated. Application of wollastonite ($CaSiO_3$) increased rice yields when topsoils contained <130 ppm available SiO_2. Rates up to 5-6 ton/ha were used and had a residual value for 4-5 years. Wollastonite was nearly as good as $CaCO_3$ as a liming material. Economic returns from wollastonite are based on $R(1.68-0.0198x + 0.000053x^2) = 2W(4.94-0.038x)$ where R = value of rice/mt = cost of wollastonite/mt and x = available SiO_2 content of topsoil.

160 Effect of the Potassium Oxide-to-Nitrogen Ratio in Rice on Yield Components. J K. Park, Y. S. Kim, and J. H. Hwang (Inst. Plant Environ., Off. Rural Dev., Suwon, Korea). *Han'guk Toyang Biryo Hakhoe Chi 4* (1), 27-32 (1971) (Korean). *CA 76*, 125771. In 1969, a pot experiment with ten treatments including control (without K) was carried out in order to study the effect of high N rates and K topdressings on rice. When K was applied 70% as basic dressing and 30% as topdressing at the ear-formation stage, a considerable increase in yield of paddy was obtained as compared to the application of whole K as basic dressing. The K_2O:N ratio in plant was positively correlated with the yield components before heading; the K_2O:N ratio of heading stage was highly correlated with ripening percentage.

161 Effect of Lime on Growth of Rice and Changes in pH, Eh, Fe^{2+}, and Aluminum in an Acid Sulfate Soil. N. J. Park, Y. S. Park, and Y. S. Kim (Off. Rural Dev., Inst. Plant Environ., Suwon, Korea). *Han'guk Toyang Biryo Hakhoe Chi 4* (2), 167-75 (1971) (Eng). *CA 76*, 125751. Toxicity of acid sulfate soils to rice is primarily due to Al accompanied by low pH and strong reduction processes in the soil. Another toxicity factor appears to be Fe^{2+}. The effect of liming on changes in pH, Eh, Al, and Fe^{2+} in soil and leachate was examined at 2-week intervals during the growth of rice Liming increased the grain yield significantly. There was no difference between dolomite and $Ca(OH)_2$. The latter seems to react more rapidly with the soil than dolomite, more effectively increasing the pH of soil and leachate. The Eh of the limed soils decreased rapidly just after submergence and appeared to change inversely to soil pH. The sulfide formed in control soils was 10.3 mg S/100 g soil, whereas in limed soil it was 0.3 mg S/100 g. More Fe^{2+} was produced in the limed than in the control soil, but after heading the latter contained more Fe^{2+} than the former. Liming decreased the Fe^{2+} content in the leachate. Aluminum was almost undetectable in limed soil and leachate.

162 Effect of Potassium on Rice Plant Grown on an Akiochi Soil. Y. D. Park, Y S Kim, and C S. Park (Inst Plant Environ , Suwon, Korea) *Potash Rev* 23/36, 8 pp (1971). *Soils Fert. 34*, 4275 In pot experiments on soil causing Akiochi disease, application of Si and Mn (to remedy low contents in the plants) did not produce healthy plants unless K was also applied. Omission of K led to stunted growth, poor root development, severe root rot, lodging and leaf symptoms characterized by minute brown spots The accumulation of elements other than K in the plant was attributed to the stunted growth, decreased dry-matter production and inhibited nutrient movement caused by K deficiency.

163 Effect of Potash in Relation to the Application of Wollastonite on Rice. Y S. Park, *et al* (Inst. Plant Environ., Suwon, Korea). *Potash Rev* 16/54, 12 pp. (1971) *Soils Fert. 34*, 5237. In a pot experiment on sandy loam soil of pH 6.3 containing 1.4% organic matter, 125 6 ppm available SiO_2, 24 ppm P_2O_5 and 0.15 meq K/100 g soil, paddy yields were increased by a combined basal application of K and wollastonite, which may be due largely to the increase in soil K, Ca, and Si and to increased K_2O, CaO, and SiO_2 concentrations and SiO_2 N and K_2O.N ratios in the straw. An interaction occurs between K and wollastonite. Increased application of Si decreases the K uptake and increased K application descreases Ca and Mg uptake. The wollastonite consisted of 22 2% of one-half N HCl soluble SiO_2, 38% CaO, 3.38% MgO and possessed 43.4% of alkalinity

164 Effect of Ammonium and Nitrate Nitrogen on the Growth, Contents of Mineral Nutrients, and Uptake of ^{32}Phosphorus in Rice Plants. S. C Shim, H. S. Ahn, and H. D. Chung (Radiat. Res. Inst Agr., Seoul, Korea). *Wonjaryok Yon'gu Nonmunjip 10* (2) (Pt 2), 63-71 (1970) (Korean). *CA 75*, 47921. Effects of nitrogen fertilizer (as ammonium N or nitrate N) on culm wt, wt of 1000 grains, and top straw production of rice plants were investigated. Three time application greatly increased these factors The effects of nitrate N on the contents of P_2O_5, K_2O, silica, Mn, and Fe at different stages of growth of rice plants were also presented.

165 Effect of a Soil Amendment on Phosphate Efficiency in a Low-Productivity Paddy Soil. S. C. Shim, J. S Ki, and J. K, Chung (Radiat. Res. Inst. Agr., Off. At. Energy, Seoul, Korea). *Han'guk Toyang Biryo Hakhoe Chi 4* (1), 21-6 (1971) (Korean). *CA 76*, 125770. The effects of soil amendments (mixture of basic slag with Cu, Mn, Zn, and B) on P uptake by

rice and on the yield of rice on low-productive paddy soils were studied. The combined effect of soil amendment and phosphate application on the grain yield was high; the grain wt, maturing rate, and seed setting rate were also increased. Soil amendment appears to improve phosphate efficiency; grain wt, maturing rate, and seed setting rate are all improved as the phosphate rate was increased. Phosphate tends to accelerate plant growth at earlier stages of plant growth whereas soil amendments retarded the growth, inhibiting excessive tillering. Soil amendments increased Si and Mn, but decreased P, Cu, and Zn contents in the rice plants.

MALAYSIA

166 Effect of Various Phosphate Fertilizers on the Yield of Paddy on an Acid Swamp Soil. K. T. Joseph and V. Sooryanaryana (Univ. Malaya, Kuala Lumpur, Malaysia). *Int. Rice Comm. Newsl. 20* (2), 24-6 (1971). *FA 5*, 791. Acid swamp soils, derived from granitic alluvia, have an inherently poorer nutrient status than the humic gley soils more commonly used for rice production in Malaysia. They respond readily to N and P. A pot test was used to determine the response of paddy to three P sources: double superphosphate (0-40-0), Christmas Island rock phosphate (36% total P_2O_5), and basic slag (18% total P_2O_5). Bahagia (an improved *indica* variety) was transplanted into soil with a pH_{KCl} of 4.0 from the Kuala Pilah district. The P was incorporated into the top 2 in. of soil at rates equivalent to 40 and 160 lb P_2O_5/acre; split N application totaled 100 lb/acre. Rate of P had no effect on yield. Double superphosphate resulted in a yield equivalent to 3487 lb/acre of paddy compared to 3000 lb/acre for basic slag and rock phosphate. There was no check plot.

167 The Growth Phase and Effect of Fertilizer Application on Rice in Malaya. V. Comparison of Fertilizer Response in Leading *indica* Varieties and Analytical Survey of Yield Components. K Sugimoto (Trop. Agr Res. Cent., Tokyo, Japan). *Nippon Sakumotsu Gakki Kiji 40*, 88-94 (1971) (Japan). *Soils Fert. 34*, 4258. Of five varieties tested, two short-term varieties Ria and Bahagia, characterized by smaller plant height, shorter culm length and lower straw wt, yielded larger numbers of panicles and showed better fertilizer response than the long-term varieties. Ria showed the best yielding ability at high fertilizer rates, but had the disadvantage of a low percentage of ripened grains under adverse field conditions. With Bahagia, the numbers of panicles and spikelets/m^2 were lower, but ripening ability was higher than with Ria; yields were limited however by the occurrence of lodging.

PAKISTAN

168 Differential Response of Indigenous and Exotic Varieties of Rice to Some Selected Fertilizer Treatments. Habibur-Rahman, G. S. Shah, and G. A. Shah (Agr. Res. Inst., Tarnab, Peshawar, Pakistan). *Agr. Pak. 21* (1), 19-28 (1970) (Eng). *CA 74*, 140214. The effect of fertilizer treatments on different rice varieties was evaluated over a 2-year period. The new rice varieties (TRR1) responded better to the treatment than the native Basmati and J.P.5. The highest yield of IR8-288-3 (84.5 maunds/acre) was obtained with 120 lb N and 60 lb P_2O_5/acre. Phosphorus alone gave only small increases, and the addition of N was needed; however, too much N decreased the grain size and an addition of K decreased the grain yield. With the exception of N and P, all other nutrients were present in the irrigation water.

169 Effects of Different Methods of Zinc Application on Growth and Yields of Rice in a Calcareous Soil, West Pakistan. S. Yoshida, G. W. McLean, and K. E. Mueller. *Soil Sci. Plant Nutr. 16* (4), 147-9 (1970) A field experiment conducted at the Kala Shah Kaku Government Rice Farm demonstrated that the disorder of the rice plant known as "Hadda" can be corrected by the application of zinc. The element was applied in three ways: to the soil as $ZnSO_4$, as a foliar spray of $ZnSO_4$, or by dipping seedlings in a 1% ZnO suspension. Topdressing of $ZnSO_4$ after the observation of zinc deficiency symptoms was as effective as a basal dressing. Dipping seedlings in a 1% ZnO suspension was found to be the most practical way of correcting Zn deficiency.

PHILIPPINES

170 Protein Content of Rice Grain as Affected by Nitrogen Fertilizer and Some Triazines and Substituted Ureas. S. K. De Datta, W. N. Obcemea, and R. K. Jana (I.R.R.I., Los Banos, Philippines). *Agron. J. 64* (6), 785-8 (1972). *CA 78*, 57029. The protein content of the high-yielding brown IR480-5-9 rice cultivar varied from 9.5 to 10.2% without application of N. The highest protein of IR480, was ~ 12.5%, whereas that of IR8 was 9.8%. In another experiment the protein content of IR480 was 10.2%, while that of IR22 was 8.6%. Both rices had similar grain yields (7.8 mt/ha). The protein content of several rice cultivars was significantly higher when 150 kg N/ha was applied half at planting and half at heading than when all N was applied at planting. Simetryne at 0.5 kg/ha active ingredient, applied at panicle initiation or at heading stage of the rice crop, significantly increased the protein content and protein yield of IR22 compared with the fertilized control. Tenoran, CP17029 [2,4-bis[(3-methoxypropyl)amino]-6-(methylthio)-1,3,5-triazine], and benzomarc also increased protein content of rice grain without significantly affecting grain yields and yield components.

171 Leaf Area Index, Tillering Capacity, and Grain Yield of Tropical Rice as Affected by Plant Density and Nitrogen Level. S. O. Fagade and S. K. De Datta (I.R.R.I., Los Banos, Philippines). *Agron. J. 63* (3), 503-6 (1971). *CA 75*, 19278. To study the effects of plant density and N level on the tillering capacity, leaf-area index (LAI), and other growth characteristics and grain yield of flooded rice (*Oryza sativa*), cultivars IR8, IR305-4-12-1-3, IR127-80-1-10, and Peta were planted at three N levels in puddled soil. All cultivars were transplanted at five spacings and also broadcast. Of the three improved semidwarf rices, IR305-4-12-1-3 had the highest tillering capacity. Increasing plant density and N levels increased the LAI of all varieties at flowering. Broadcast-planted plots had higher LAI values than transplanted plots. In the sunny dry season, broadcast-planted Peta had the highest LAI value, 14.6. In comparison, IR127-80-1-10, a low-tillering line, had a LAI value of only 7.0. Grain yield increased with increased LAI values in the dry season, except for Peta which lodged severely just after flowering. In the cloudy wet season, broadcast-planted IR8 had the highest LAI value, 10.2, but it lodged. The variety IR8 that was transplanted at close spacings did not lodge and it had higher yields. Thus, even with an improved cultivar like IR8, grain yield declines at a high value

if the crop lodges.

172 Effects of Solar Energy and Soil Moisture Tension on the Nitrogen Response of Upland Rice. R. K. Jana and S. K. De Datta (I.R.R.I., Los Banos, Philippines). *Int. Symp. Soil Fert. Eval. Proc. 1*, pp. 487-97 (1971). *FA 5*, 2073. Field experiments indicated that N response of upland (nonflooded, rainfed) rice is poor if the crop is grown within the so-called available moisture range of the soil, for example, between the field capacity and the wilting point. The optimum soil moisture condition for high grain yield and N response appeared to be between the maximum water holding capacity and the field capacity. Thus adequate and uniform rainfall distribution is required for good vegetative and reproductive growth. For high grain yield and N response, however, the crop must receive adequate solar energy during the reproductive and ripening periods. When moisture and solar energy are not limiting and management practices are at optimum levels, high-tillering lowland varieties with high yield potentials and good plant type, such as IR8, outyield the upland varieties such as Palawan, even under upland conditions.

173 Response of Rice Plants Grown in Three Potted Luzon Soils to Additions of Boron, Sulfur, and Zinc. R. C. Lockard, J. C. Ballaux, and E. A. Liongson (Univ. Kentucky, Lexington, Ky.). *Agron. J. 64* (4), 444-7 (1972). *CA 77*, 74172. Three low-yielding Luzon soils, Quingua clay loam, Bantog loam, and Umingan loam, on which plants did not respond sufficiently to N, P, or K, were tested in pot studies with three levels of B, S, and Zn. None of the soils was deficient in B, as additions of B resulted in decreased yield and the development of foliar symptoms resembling those of B toxicity. Plants in two soils responded to the addition of S; those in Quingua clay loam gave a greater response than those in Bantog loam. Addition of Zn did not increase the yield of plants in any of the three soils. However, nontreated young plants growing in Umingan loam exhibited symptoms resembling those of Zn deficiency. The level of each nutrient in the straw was increased by the addition of that nutrient to the soil. The most pronounced effect was on the S level in the plant when S was applied to the soil. The linear or quadratic equation to calculate this relation is presented for each nutrient. The highest level of B applied to the soil significantly increased the level of S in the straw.

174 Phenolic Compounds and the Rice Blast Disease as Influenced by Nitrogen Fertilization. R. Sridhar (I.R.R.I., Los Banos, Philippines). *Riso 21* (1), 25-31 (1972) (Eng). *Soils Fert. 35*, 3498. In pot experiments CO13 (blast susceptible) and CO29 (blast resistant) rice varieties growing in waterlogged soil were fertilized with 0, 20, 40, 60, and 80 lb/acre N as $(NH_4)_2SO_4$ when 15 days old, and inoculated with spores of *Pyricularia oryzae* when 20 days old. Total and *o*-dihydroxy phenol contents were higher in CO13 than in CO29 during the early growth stages but the position was reversed during later growth stages. Nitrogen fertilizing generally decreased phenolic compounds in both varieties but inoculation with *P. oryzae* increased phenolic compounds and the increase was greater in the resistant variety.

175 Effects of Mineral Nutrition on Tillering of Rice. S. Yoshida and Y. Hayakawa (I.R.R.I., Los Banos, Philippines). *Soil Sci. Plant Nutr. (Tokyo) 16* (5), 186-91 (1971) (Eng). *FA 4*, 1220. The concept of relative tillering rate was introduced into studies on the relationship between N, P, and K nutrition and tillering, and on varietal differences in tillering performance. It seems that 5% N, 0.2% P, and 1.5% K in the leaf blades are required for the maximum tillering rate. Below these values, tiller number starts to decrease. If the nutrient content of the leaf blades is decreased to 2% N, 0.03% P, and 0.5% K, the tillering rate becomes zero. The total number of tillers per hill seems to be important in tiller production. Shading within the hill caused by the increased number of tillers may retard subsequent tiller production. The efficiency of N in tiller production varies with variety. More tillers are produced at the same N content by the higher tillering variety than by the lower tillering variety.

SRI LANKA (CEYLON)

176 Response of Rice to Different Forms of Nitrogen Fertilizer. D. M. Rodrigo, B. M. Nizar, and P.S.G. Perera (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Trop. Agricst (Ceylon) 125*, 65-75 (1969). *Soils Fert. 33*, 4875. Ammonium chloride was generally superior to urea, $(NH_4)_2SO_4$, ASN, CAN, and NH_4NO_3.

177 Nutrient Deficiency and Physiological Disease of Lowland Rice in Ceylon. III. Effect of Silicate Fertilizers and Dolomite for Increasing Rice Yield. Yasuo Takijima, H.M.S. Wijayaratna, and C. J. Seneviratne (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Soil Sci Plant Nutr. (Tokyo) 16* (1), 11-16 (1970) (Eng). *CA 74*, 99014. Because of insufficient Si in soil, the effects of dolomite slags on growth and yield of rice were studied in pot and field experiments. The slag additions increased rice yields 15-30% and resulted in higher Si uptake and good maturity of grain. Straw analysis showed that slags lowered N and Fe and raised the content in rice of P, K, and Mg, as well as Si. Straw residues left on the field at harvest removed about 220 kg SiO_2/ha/season. Therefore, 860-1100 kg of slag was considered as an appropriate fertilizing dose, depending upon soil conditions.

178 Nutrient Deficiency and Physiological Disease of Lowland Rice in Ceylon. IV. Remedy for Bronzing Disease of Rice. Yasuo Takijima and M. Kanaganayagam (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Soil Sci. Plant Nutr. (Tokyo) 16* (1), 17-23 (1970) (Eng). *CA 74*, 99015. Soils causing rice bronzing were tested in pot and field experiments in 1967-68 to find remedies for the disease. Application of K was most effective for increasing the growth and yield of rice, followed by phosphate and slags However, even balanced doses of NPK did not eliminate the bronzing symptoms. Air-drying and liming of the surface soil before planting increased rice production and prevented the occurrence of bronzing. Both measures associated with increased doses of K and slags were recommended as the best means for controlling the disease. The supposed mechanism of bronzing and the effect of some meteorological factors on disease incidence are discussed.

179 The Effect of Slaked Lime on Rice Yield at Panagoda, Pussellawa and Bombuwela. M. W. Thenabadu (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Trop. Agricst (Ceylon) 125*, 111-18 (1969). *Soils Fert. 53*, 4874. On Panagoda soils (clay loams of pH 5.3) and Pussellawa soils (sandy clay loams of pH 5.1) rice responded to up to 3 ton/acre and 1 ton/acre, respectively, of slaked lime. There was no response to lime on the humic clay loam (pH 5.4) at Bombuwela but there was a response to up to 1 ton lime/acre on the sandy soils (pH 5.2).

180 Fertilizer for Rice. M. W. Thenabadu. *J. Soil Sci. Soc.*

Ceylor, 1, 128-45 (1970). *Soils Fert. 35*, 3488. A discussion, with special reference to Ceylon, dealing with NPK nutrition of rice and specified fertilizers and their application.

181 Influence of Time and Level of Nitrogen Application on Growth and Yield of Rice. M. W. Thenabadu (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Plant Soil 36* (1), 15-29 (1972). *FA 5*, 1357. A greenhouse sand-culture experiment was conducted to study the effect of increasing or decreasing N supply at various stages of growth on the growth, yield, and yield components of rice. Adequate N during the vegetative phase of growth encouraged tillering which had a bearing on the number of panicles per plant. Excess N during the reproductive phase of growth produced panicles with unfilled or partly filled grains. Similar effects were observed when the N status of the growth medium was changed from a low to a high level at the stages of reduction division and anthesis. A decrease in yield was observed when plants growing at a low level of N were transferred to a high level at the end of the vegetative phase. High levels of N in the growth medium at time of heading and after increased the concentration of N in the grain. There was an inverse relationship between yield of filled grain and N in the grain.

182 Nutritional Disorders of Rice in Ceylon and Their Countermeasures. M. W. Thenabadu (Agr. Res. Inst., Peradeniya, Ceylon). *World Crops 24* (1), 38-41 (1972). *Soils Fert. 35*, 2580. A review of the N, P, K, and Si fertilizing of rice and of the effects of and remedies for excess acidity, H_2S toxicity, and "bronzing" disease.

183 Tracer Studies on the Efficiency of Combined Nitrogen and Phosphorus Fertilizers for Rice as Influenced by Time and Method of Application. M. W. Thenabadu, M. M. Jauffer, and S. M. Willenberg (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Trop. Agricst (Ceylon)* 126, 159-74 (1970). *Soils Fert 34*, 3338. Uptake of fertilizer-N was greater from early application (such as at transplanting) than from late application. A combination of $(NH_4)_2SO_4$ and superphosphate was superior to ammophos + nitric phosphate in its effects on grain yield, but $(NH_4)_2SO_4$ and ammophos were better sources of N as far as uptake by plants was concerned. Percentage of P derived from the fertilizer was greater with application at transplanting than a fortnight before primordial initiation. The experimental soils were sandy loams of pH 6 (organic matter 2-2.37%, CEC 13.6-14.8 meq/100 g). Experimental data (such as effects of NP on plant height, number of tillers, grain yield and dry-matter production) are given in tables.

184 Preliminary Studies with Ammonium-Sulfate-Nitrate as a Source of Nitrogen for Rice on Ill-Drained Soils. M. W. Thenabadu and K. Wickremasinghe (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Trop. Agricst (Ceylon)* 125, 95-8 (1969). *Soils Fert. 33*, 4876. Ammonium-sulfate-nitrate gave higher grain yields of rice than $(NH_4)_2SO_4$ or NH_4NO_3 possibly due to its effect on retarding soil reduction.

185 Experiments with Granular-Compound-Fertilizers on Rice in the Dry-Zone of Ceylon. M. W. Thenabadu, K. Wickremasinghe, and T. B. Perera (Cent. Agr. Res. Inst., Peradeniya, Ceylon). *Trop. Agricst (Ceylon)* 126, 175-90 (1970). *Soils Fert. 34*, 3340. In the wet zone of Ceylon, granular compound fertilizers (for example, 10-10-10 at 450 lb/acre before planting) were superior to straight fertilizers, but in the dry zone they were not. Greatest profit was obtained from 15-15-15 applied at 300 lb (before or after planting).

TAIWAN

186 Results of Experiments on the Fertility of Paddy Soils in Regions North of Miaoli in Taiwan. C. C. Chen (Taiwan Agr. Res. Inst., Taipei, China). *Nung Yeh Yen Chiu* 20, 21-39 (1971) (Ch). *Soils Fert. 34*, 5232. Data from numerous trials and soil analyses during 1966-68 on strongly acid soils of north Taiwan indicate that for most soils, applications of 72 kg/ha K_2O + 72 kg P_2O_5 are sufficient, but 150 kg P_2O_5 is necessary for new paddy soils on diluvium.

187 Effect of Fertilizers on Rice Diseases. C. C. Chien and C. L. Chu (Taiwan Agr. Res. Inst., Taipei, China). *Nung Yeh Yen Chiu 19* (2), 62-71 (1970) (Ch). *Soils Fert. 34*, 4259. Sclerotial disease and sheath rot increased with increasing fertilizer rate (2 to 3 dressings). Brown leaf spot was more prevalent however at low N rates. Increasing K may decrease the occurrence of stem rot.

188 Fertilizer Response and Fertilizer Absorption Rate of Main Rice Varieties in Taiwan. Tsai-Fa Ch'iu (Taiwan Agr. Res. Inst., Taipei, China). *Nung Yeh Yen Chiu* 20, 1-20 (1971) (Ch). *Soils Fert. 34*, 5233. Two *indica* varieties, Taichung 65 on latosol and Tainan 5 on slate alluvial soil and sandstone shale alluvial soil were higher yielding than three *japonica* varieties. A significant yield response to N occurred but not to P and K. The mean absorption rates for N, P, and K were 25.5, 2.3 and 9.5%, respectively; all the absorbed P presumably came from soil P. The mean amounts of N-P_2O_5-K_2O absorbed by a single crop were 82-39-125 kg/ha. Yield increments of up to 8% were obtained with silicate slag depending on locality and variety.

189 Techniques of Nitrogen Fertilization of Rice Plants. I. Effect of Late Topdressing of Nitrogen on the Yield and Nutrient Uptake of Rice Plants. Tsai-Fa Ch'iu and Wen-Liang Huang. *Nung Yeh Yen Chiu 19* (3), 26-41 (1970) (Ch). *CA 75*, 19280. The yield of rice grain increased 4% when 40% of the N fertilizer was topdressed late in the growing season as compared to the control in which all N fertilizer was applied during the early growing season. The late N topdressing also increased the N content of the rice grain.

190 Cultivation of Ratooned Rice. III. Effect of Plowing Depth and Amount of Fertilizer on the Reviability and Yield of Ratooned Rice. C. F. Hsieh, S. Kao, and C. Chiang (Taiwan Agr. Res. Inst., Taipei, China). *Nung Yeh Yen Chiu 17* (4), 24-33 (1968) (Ch). *Soils Fert. 34*, 1701. The reviability of ratooned rice tended to decrease but culm length and number of panicles increased with increasing plowing depth. High rate of fertilizing of the preceding crop decreased the reviability of the ratooned crop. Grain yield was highest with 25 cm plowing depth.

191 Effect of Application Conditions of Nitrogenous Fertilizer on the Physical and Chemical Properties of Rice. Po-Tung Hsieh *et al* (Dep. Agr. Univ., Natl. Taiwan Univ., Taipei, China). *Chung Kuo Nung Yeh Hua Hsueh Hui Chih 9* (1-2), 92-7 (1971) (Ch). *CA 76*, 33203. An increase in the amount of N fertilizer applied to rice plants led to an increase in the crude protein content of milled rice, particularly when part of the fertilizer was applied at the panicle-initiation stage. The amylose content of rice starch was not affected by the

amount of N fertilizer applied. The peak viscosity of rice flour decreased while the pasting temperature increased with an increase in the crude protein content of milled rice.

192 Effect of Lime, Presubmergence, and Phosphate Fertilizer on the Growth and Yield of Rice on a Flooded Acid Latosolic Soil. I. T. L. Wang (Taiwan Agr. Res. Inst., Taipei, China). *Chung Kuo Nung Yeh Hua Hsueh Hui Chih 9* (1-2), 14-20 (1971) (Ch). *CA 76*, 45079. Phosphate fertilization increased the height, number of tillers, and the yield of rice grown in an acidic latosolic soil. Lime had no positive effect on rice. Presubmergence in water was beneficial in warm seasons but injurious in cool ones.

193 Effect of Lime, Presubmergence, and Phosphate Fertilizer on the Growth and Yield of Rice on a Flooded Acid Latosolic Soil. II. T. L. Wang (Taiwan Agr. Res. Inst., Taipei, China). *Chung Kuo Nung Yeh Hua Hsueh Hui Chih 9* (1-2), 21-5 (1971) (Ch). *CA 76*, 58251. In greenhouse study, $CaCO_3$ was added to the pots at the rate of 3 and 6 ton/ha, the periods of presubmergence were 2 and 4 weeks, and P was applied at 0, 25, and 50 ppm. $CaCO_3$ at both levels increased the pH of the soil during the first 10 weeks of submergence, but had no significant effect on the chemical components of soil solution. Lime did not significantly increase the yield of grain or straw. Presubmergence did not affect the vegetative growth but decreased the grain yield. Phosphate fertilizer increased the rice yield significantly.

194 Effects of $CaCO_3$, $CaSiO_3$, and Organic Manure on the Growth and Yield of Rice on a Flooded Acid Latosolic Soil. T. L. Wang (Taiwan Agr. Res. Inst., Taipei, China). *Nung Yeh Yen Chiu 20* (2), 47-55 (1971) (Ch). *Soils Fert. 35*, 720. In greenhouse experiments on latosolic soil of pH 4.8, containing 2.23% organic matter, 3.5% active Fe and low in base saturation, $CaCO_3$ application markedly increased soil pH, decreased water-soluble Fe and Mn after 6 weeks' submergence, and increased grain and straw yields by 27 and 23%, respectively, at the 5 ton/ha rate. Calcium silicate had no effect on yields or soil chemistry. Application of 0.25% organic manure gave the best yield increases (48% and 36%, respectively) but produced no chemical changes in the soil solution. Application of $CaCO_3$ and organic manure simultaneously was ineffective or decreased yields. A residual effect of lime on the second crop produced greater yield responses than for the first crop.

195 Study on Mineral Nutrition and Root Development of Rice Plants in a Poorly Drained Paddy Field. P. S. Yang and S. F. Cheng (Pingtung Inst. Agr., Taiwan, China). *Soils Fert. (Taiwan)* (1970) (Eng). *Soils Fert. 35*, 717. A study of rice growth under different drainage conditions showed that growth (height, wt, tiller number) was significantly worse under poor drainage than under well-drained conditions; poor drainage affected Fe, Mg, Mn, P, and Si contents, but did not materially affect Ca, K, and N uptake.

THAILAND

196 The Efficiency of Mixed and Compound Fertilizers Containing Ammonium and Nitrate Forms on Rice. A. Jugsujinda (Techn. Div., Rice Dept., Bangkok, Thailand). *Thai J. Agr. Sci. 4* (1), 1-11 (1971). *Trop. Abstr. 27*, 1835. Dry season trials with the irrigated, lodging resistant rice variety RD1 and IR8 and a growth-cycle of 125 days, were conducted in Thailand on very fertile clay soils. The results showed that ammonium-nitrate-phosphate, and calcium-ammonium-nitrate mixed with double superphosphate were equally effective in increasing grain yield compared to control. Dressings of ammonium sulfate + double superphosphate at 60 kg N and 60 kg P_2O_5/ha or at double this rate gave the best results, irrespective of application as basic or as split dressings, and increased grain yields by some 800 kg/ha over that of the control treatment.

197 Efficiency of Mixed and Compound Fertilizers Containing Ammonium and Nitrate Forms on a New Hybrid Rice Variety. Sombhot Suwanwaong and Aroon Jugsujinda (Rice Dept. Bangkok, Thailand). *Int. Symp. Soil Fert. Eval. Proc. I*, pp. 699-708 (1971). *FA 5*, 2073. Calcium ammonium nitrate and ammonium sulfate, each mixed with concentrated (double) superphosphate, were compared with ammonium nitrate phosphate (20-20-0) when applied in split doses at the rate of 60 kg of N and P_2O_5/ha. The experiment was conducted in the Central Plain of Thailand during the dry and wet season of 1969 using a new high yielding, short stature, photo-insensitive hybrid strain RDI, recently released by the Rice Department. A single basal application of these fertilizers at the rate of 120 kg of N and P_2O_5/ha was also tried. The results showed that these mixed and compound fertilizers were equal in their effects in increasing rice yield. Whereas at one location (Petchburi) a higher grain yield was obtained with ammonium sulfate plus concentrated superphosphate, at another location (Chainat) the highest yield was found with the use of ammonium nitrate phosphate. The single basal application of combined NP and mixed fertilizers at the rate of 120-120 kg/ha did not give higher yield than the split application at 60-60 level. If the cost per unit of N/P is attractive, ammonium nitrate phosphate fertilizer may also be used as an excellent compound fertilizer for flooded rice in view of the ease of handling and application of this granular material.

NORTH VIETNAM

198 Effect of Time and Depth of Nitrogen Application on Growth and Yield of Rice. V. Y. Neguyen (Agr. Res. Inst., Hanoi, North Vietnam.) *Acta Agron. (Budapest) 20* (3-4), 311-17 (1971) (Eng). *Soils Fert. 35*, 1661. Experimental plots (40 m^2) were treated with 40 kg/ha each of P_2O_5 and K_2O. Nitrogen was applied as $(NH_4)_2SO_4$ at the rate of 60 kg N/ha, either by broadcasting or by placing 15-20 g balls composed of fertilizer + soil (1 + 10) in the hills 1 week before transplanting. Placement minimized N losses from waterlogged soils and produced rice yields that were 20-25% higher than those from broadcast $(NH_4)_2SO_4$. Placement of 0.2 g N/kg soil in ball form was also made at 5-15 cm depths in pot experiments.

HUNGARY

199 Effect of the Amount of Sunlight on the Effectiveness of Ammonium Sulfate Towards the Rice Plant. R. Vamos and F. Takacs (Jozsef Attila Univ., Szeged, Hungary). *Riso 21* (1), 33-41 (1972) (Eng). *Soils Fert. 35*, 3496. Yields of rice growing in solonetz, solod and heavy acid meadow soils are influenced to a large extent by sunlight. Insufficient sunlight in the reproductive phase after stem elongation leads to slow plant growth and root replacement and sulfate reduction in the waterlogged soil; H_2S toxicity occurs leading to root rot. The application of $(NH_4)_2SO_4$ aggravates these conditions. However if there is sufficient sunlight, plant metabolism and, in particular, root growth is vigorous enough to overcome H_2S toxicity, and $(NH_4)_2SO_4$ fertilizer can double rice yields under these circumstances.

ITALY

200 Effect of Soil Submergence, Plant Population and Soil Fertilization on Growth and Yield of Rice. H. K. Pande and R. S. Tripathi. *Riso 19*, 201-5 (1970) (Eng). *Soils Fert. 34*, 1702. Best growth and yield of rice (Taichung 65) on a lateritic soil were obtained with a high level of fertilizing (120 kg/ha and 75 kg each of P_2O_5 and K_2O) combined with medium plant population (160,000 hills/ha) and low level of submergence (8 ± 3 cm).

201 Influence of Soil Compaction and Nitrogen Fertilization on Growth of Rice. S. B. Varade and E. A. Patil. *Riso 20* (3), 219-23 (1971) (Eng). *Soils Fert. 35*, 1653. Soil compaction to 1.88 g/cm^{-3} produced by the passage of a tractor and roller resulted in increased rice yields, prevented N losses through leaching, reduced hydraulic conductivity and increased the efficiency of N utilization. Puddling was less effective in this respect. On compacted soil the response of grain yield to 20 kg/ha N was equivalent to that to 60 kg/ha N with puddling.

NETHERLANDS

202 Nitrogen Nutrition of Rice Plants Measured by Growth and Nutrient Content in Pot Experiments. II. Uptake of Ammonium and Nitrate from a Waterlogged Soil. W. Dijkshoorn and M. Ismunadji (Inst. Biol. Chem. Res. Field Crops Herb., Wageningen, Netherlands). *Neth. J. Agr. Sci. 20* (1), 44-57 (1972) (Eng). *CA 77*, 47346. The uptake by rice plants of NH_4^+ and NO_3^- from flooded soil was studied in pots fertilized with NH_4^+, NO_3^-, K^+, Cl^-, and SO_4^{2-} in varying proportions. Denitrification caused a shortage of N and restricted the uptake when NO_3^- alone was used. With the more stable NH_3, the plant growth and its N-incorporating capacity determined the quantity of N absorbed. Plant growth was less when KNO_3 was replaced by NH_4Cl than when KNO_3 was replaced by $(NH_4)_2SO_4$. Apparently this difference in growth was related to the accumulation of Cl^- within the tissues, causing a decrease in concentration of carboxylates to a very low level indicative of a nutritional stress.

203 Nitrogen Nutrition of Rice Plants Measured by Growth and Nutrient Content in Pot Experiments. III. Changes during Growth. W. Dijkshoorn and M. Ismunadji (Inst. Biol. Chem. Res. Field Crops Herb., Wageningen, Netherlands). *Neth. J. Agr. Sci. 20* (2), 133-44 (1972) (Eng). *CA 78*, 3206. Young rice plants in flooded sand cultures grew better in a NH_4 than in a NO_3^- medium. The difference in yield was initiated in plants receiving NH_4 by a higher rate of tillering and leaf expansion during the first stage of exponential growth. When the foliage canopy was full, and the gain in dry matter became linearly related to growth duration, NO_3^- was less readily assimilated than NH_4. Restoration of N to a depleted culture of well developed plants showed that NH_4 effected an earlier growth renewal so that on NH_4 medium the plants yielded more at the same date than those on a NO_3^- medium, although they finally regained the same rate of linear growth. On the NO_3^- medium the plants contained more carboxylate than on the NH_4 medium, irrespective of age and temporary shortage of N.

204 Nitrogen Nutrition of Rice Plants Measured by Growth and Nutrient Content in Pot Experiments. I. Ionic Balance and Selective Uptake. M. Ismunadji and W. Dijkshoorn (Inst. Biol. Chem. Res. Field Crops Herb., Wageningen, Netherlands). *Neth. J. Agr. Sci. 19* (3), 223-36 (1971) (Eng). *CA 76*, 112001. Rice plants were grown in sand immersed in H_2O at different concentrations of NO_3^-, NH_4^+ and K^+. The plant growth and carboxylate values (C-A) were reduced when K was in short supply. The C-A is the difference between C (mequivalent of cations) and A (mequivalent of anions). The excess cations are considered to be in the form of salts of organic acids. Replacement of NO_3^- by NH_4^+ at the highest level of KNO_3, with K kept constant, increased the yield and the number of tillers per plant. Carboxylate values decreased from 1000 mequivalent/kg of dry matter to 800. Superior results with NH_4^+ are attributed to a reduced rate of production of carboxylates which prevents excessive accumulation. Injury by nitrate is associated with excess carboxylates in the tissue.

205 The Influence of Various Nitrogen Forms on the Growth of Two Rice Varieties. F. P. Koop and A. van Diest (Agr. State Univ., Wageningen, Netherlands). *Int. Symp. Soil Fert. Eval. Proc. I*, pp. 665-78 (1971). *FA 5*, 2073. Two rice varieties were grown on continuous-flow cultures containing N as NH_4 or NO_3, or as a combination of the two. The influences of these variations on dry matter production, on organic anion content, and on Fe and Mn contents were studied. Both rice varieties gave maximum dry matter production on a nutrient solution containing NO_3 and NH_4 in a ratio of 3.2:1. Yields declined when NH_4 was absent from the nutrient solution, and when NH_4 was the only form of N present. Organic anion content was highest for the "NO_3 only" treatment and decreased with increasing proportions of N present in NH_4 form. In contrast with other gramineous plants examined, rice appears to have a large portion of its organic anions present in the form of oxalates. When dry matter production is plotted against organic anion content, a second degree curve is obtained with a maximum at the organic anion content associated with the nutrient treatment with a NO_3:NH_4 ratio of 3.2:1. The fitting of the data to the curve improves when the quantity of mobile organic anions (for example, total organic anions minus oxalates) is used as independent variable. The yield depression observed in the "NO_3 only" treatment might be caused by excessive uptake of Mn during the early stages of plant development. This nitrate

induced Mn excess manifests itself in symptoms resembling those caused by Fe deficiency. The symptoms disappear when growth proceeds, but dry-matter production remains suboptimal.

U.S.S.R.

206 Effect of Trace Elements on Rice Plants. G. Kayumov. *Tr. Tadzh. Sel'skokhoz. Inst.* 15, 75-82 (1971) (Russ). *CA 78*, 56972. Rice seed treatment with trace elements, especially with B and Zn resulted in uniform seed germination, high plant stand, and ~20-25% increased grain yield. Cobalt, Cu, Mn, and trace element mixtures also increased the rice yield significantly. Soil-applied 5 kg $CuSO_4$/ha was also highly effective; it increased the yield and successfully controlled algae in rice plantations.

207 Use of Ammonium Chloride in the Fertilization of Rice. B. I. Laktionov and B. K. Shirenko. *Khim. Sel. Khoz. 9* (2), 95-6 (1971) (Russ). *CA 74*, 124261. The effect of NH_4Cl on yield of rice in the Kherson region was studied on a dark-chestnut sandy light-loamy soil. Accumulation of chlorides in the soil at various growth stages of the plant and the development and yield of rice were examined. Ammonium chloride was not less effective than $(NH_4)_2SO_4$. However, the application of NH_4Cl presented great difficulties because of its clogging Before recommending NH_4Cl as a fertilizer, its physical properties should be improved.

208 Action of Nitrogen Fertilizer on the Productivity of Rice in the Fallow Section of Crop Rotation. V. F. Shashchenko (Vses. Nauch.-Issled. Inst. Risa, Krasnodar, U.S.S.R.). *Khim. Sel. Khoz. 8* (8), 562-5 (1970) (Russ). *CA 74*, 22206. Ninety kg N must be applied during the first rice cropping year, 120 kg in the second year, and 250 kg in the third, and fourth year, to obtain 65-70 q/ha rice yields. Two-thirds of the N is applied before sowing, and the last third is applied at tillering.

BOOKS AND REVIEWS

209 Rice Fertilization. A Six-Year Isotope Study on Nitrogen and Phosphorus Fertilizer Utilization. Intern. At. Energy Agency, Vienna, Austria. *Tech. Rep. Ser. No. 108*, 184 pp. (1970). *FA 4*, 174. Tests on rice fertilization were carried out during 1962-68 in rice-growing countries by scientists of the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture of the Agriculture Section of the IAEA Laboratory at Seibersdorf. Surface placement of P was superior to shallow or deep placement. Mixing ammonium sulfate and superphosphate stimulated P uptake from fertilizer placed at a shallow depth but not on the surface. Applications of superphosphate to nurseries had no effect on the relative utilization of soil and fertilizer P after transplanting. Late timing and splitting of P applications resulted in a slight reduction in the utilization of P from the fertilizer. Flooding generally tended to increase the soil P supply but did not appreciably affect the availability of P from superphosphate. On rice soils in South-East Asia the increase in soil P availability upon flooding was often relatively small. When ^{15}N-labeled $(NH_4)_2SO_4$ was used on large-scale field trials, it was found that the efficiency of N utilization for most soil types could be greatly increased by placing the fertilizer at 5-15 cm depth at transplanting time or by applying it two weeks before primordial initiation on the surface as one single dose. In field and pot experiments it was found that in soils of extremely low or high pH the depth of placement had no appreciable effect on the utilization of N from the fertilizer. Ammonium sulfate, Ammophos B (monoammonium phosphate-ammonium sulfate), and urea behaved similarly in respect to timing and placement. Sodium nitrate was inefficient as a source of N, although late applications were slightly better than early ones. Ammonium nitrate and nitric phosphate were less available than ammonium sulfate and urea. Greenhouse tests suggested that the greater effectiveness of shallow placement as compared with surface application of $(NH_4)_2SO_4$ on the utilization of N from the fertilizer was caused by gaseous losses of N from the surface. Depending on soil type, the losses may be as high as 70% of the applied fertilizer. Sterilization of the soil by means of radiation and subsequent growing of rice under sterile conditions showed that the effect of placement of $(NH_4)_2SO_4$ disappeared. This illustrates the role of microorganisms in explaining the losses of N from fertilizers in acid to neutral soils. Direct losses of NH_3 can take place in calcareous soils.

210 The Intern. Bibliography of Rice Research. Annual Supplements. (1970, 1971). *The Intern. Rice Research Institute.* Manila, Philippines: Library and Documentation Center, The Intern. Rice Research Inst., P. O. Box 583. These bibliographies are a continuation of the International Bibliography of Rice Research, 1951-60, and the 1961-69 Supplements. The contents list the areas of "The Rice Plant, Rice Growing, Plant Protection, The Rice Product and Economic and Social Aspects."

211 International Symposium on Soil Fertility Evaluation Proceedings. I. Editors, J. S. Kanwar *et al. New Delhi, India: Indian Soc. Soil Sci. Indian Agr. Res. Inst.*; 1117 pp. (1971). This proceedings consists of 110 papers presented at the title symposium at New Delhi in February 1971 by international authorities. The papers are classified in six broad groups: methods of evaluating soil fertility, relation of soil test results to crop response, crop response to fertilizers, residual effects of fertilizers, soil tests and response to micronutrients, and value of soil testing.

212 Response of High-Yield Paddy Varieties to Potassium: Experimental Results from Various Rice Growing Countries. G. Kemmler (Buntehof Agr. Res. Sta., Hannover, Germany). *Int. Symp. Soil Fert. Eval. Proc. I.*; 391-406 (1971). *FA 5*, 2073. The new high-yielding paddy varieties (HYV) need a doubling or tripling of N rates. Similar consequences for the application of K are to be expected. High-yielding varieties remove substantial quantities of K, amounting to 140-200 kg K_2O at yields of 5 ton grain/ha. The response of HYV to K application in the presence of NP was confirmed in numerous

field trials carried out recently in Burma, India, Ceylon, and Madagascar. On most soils yield increases were between 7 and 13 kg grain/kg K_2O. In Malaysia, Indonesia, and the Philippines, where the number of relevant trials is limited, the results were less conclusive. From the observations in India and Ceylon it can be concluded that application at rates higher than 60 kg K_2O/ha and splitting into basal and topdressing is recommended. At 60 to 70 kg K_2O/ha the response was 400 to 600 kg grain. Adding the same K rate as topdressing increased the response to about 1 ton/ha.

213 Role of Micronutrients in Paddy Cultivation. M. Singh. *Riso 19*, 135-41 (1970) (Eng). *Soils Fert. 33*, 4873. A review, with 51 references.

214 Soils and Fertilizers in Taiwan. *Taipei, Taiwan, China: The Society of Soil Scientists and Fertilizer Technologists of Taiwan,* 14 Wenchow St. Each volume contains articles and abstracts, in English, covering fertilizer experiments on rice.

LIST OF PUBLICATIONS

Acta Agron. (Budapest) [Acta Agronomica (Budapest)]
Afr. Soils (African Soils)
Agr. Pak. (Agriculture Pakistan)
Agr. Res. J. Kerala (Agricultural Research Journal of Kerala)
Agr. Res. Rev. (Agricultural Research Review)
Agrochimica
Agron. J. (Agronomy Journal)
Agron. Trop. (Paris) [Agronomie Tropicale (Paris)]
Ark. Agr. Exp. Sta. Bull. (Arkansas Agricultural Experiment Station Bulletin)
Ark. Agr. Exp. Sta., Rep. Ser. (Arkansas Agricultural Experiment Station, Report Series)
Andhra Agr. J. (Andhra Agricultural Journal)
Arroz, Colombia
ASPAC Newsl. (ASPAC Newsletter, Food and Fertilizer Technology Center, Taipei, Taiwan)
Assam Agrian
Aust. J. Exp. Agr. Anim. Husb. (Australian Journal of Experimental and Animal Husbandry)

Bragantia

Chugoku Nogyo Kenkyu (Chugoku Agricultural Research)
Chung Kuo Nung Yeh Hua Hsueh Hui Chih (Journal of the Chinese Agricultural Chemical Society)
Curr. Sci. (Current Science)

Exp. Agr. (Experimental Agriculture)
Experientiae

Fert. News (Fertiliser News)

Ghana J. Agr. Sci. (Ghana Journal of Agricultural Science)
Gifu Daigaku Nogakubu Kenkyu Hokoku (Research Bulletin of the Faculty of Agriculture, Gifu University)

Han'guk Toyang Biryo Hakhoe Chi (Journal of the Korean Society of Soil Science and Fertilizer)
Hokuriku Nogyo Shikenjo Hokoku (Bulletin of the Hokuriku Agricultural Experiment Station)
Hyogo Kenritsu Nogyo Shikenjo Kenkyu Hokoku (Bulletin of the Hyogo Prefectural Agricultural Experiment Station)

Indian Farming
Indian J. Agron. (Indian Journal of Agronomy)
Indian Soc. Soil Sci., Bull. (Indian Society of Soil Science, Bulletin)
Int. Rice Comm. Newsl. (International Rice Commission Newsletter)
Int. Symp. Soil Fert. Eval., Proc. I, 1971 (International Symposium on Soil Fertility Evaluation, Proceedings, New Delhi, 1971)
Isotopes Radiat. Invest. Fert. Water Use Effic. Countries Asia Far East (Subbiah, B. V. India) (Isotopes and Radiation Investigations on Fertilizer and Water Use Efficiency in Countries of Asia and the Far East)

Japan Agr. Res. Quart. (Japan Agricultural Research Quarterly)
J. Indian Soc. Soil Sci. (Journal of the Indian Society of Soil Science)
J. Res. Punjab Agr. Univ. (Journal of Research, Punjab Agricultural University)
J. Soil Sci. UAR (Journal of Soil Science of the United Arab Republic)

Kagoshima Daigaku Nogakubu Gakujutsu Hokoku (Bulletin of the Faculty of Agriculture, Kagoshima University)
Khim. Sel. Khoz. (Khimiya v Sel'skom Khozyaistve)

La. Agr. Exp. Sta., Bull. (Louisiana Agricultural Experiment Station, Bulletin)
Labdev, Part B
Lavoura Arrozeira

Madras Agr. J. (Madras Agricultural Journal)
Mesopotamia Agriculture
Mysore J. Agr. Sci. (Mysore Journal of Agricultural Science)

Neth. J. Agr. Sci. (Netherlands Journal of Agricultural Science)
Nippon Dojo-Hiryogaku Zasshi (Journal of the Science of Soil and Animal Fertilizers, Japan)
Nippon Sakumotsu Gakkai Kiji (Proceedings of the Crop Science Society of Japan)
Nongsa Sihom Yon'gu Pogo (Research Reports of the Office of Rural Development)
Nung Yeh Yen Chiu (Journal of Taiwan Agricultural Research)

Oryza

Pak. J. Sci. (Pakistan Journal of Science)
Pak. J. Sci. Res. (Pakistan Journal of Scientific Research)
Philipp. Agr. (Philippine Agriculture)
Physiol. Plant. (Physiologia Plantarum)
Plant Soil (Plant and Soil)
Potash Rev. (Potash Review)
Proc. Nat. Acad. Sci., India, Sect. A (Proceedings of the National Academy of Sciences, India, Section A: Physical Sciences)
Proc. Symp. Recent Advan. Crop Prod. (Proceedings of a Symposium on Recent Advances in Crop Production, Kanpur, India: Uttar Pradesh Institute of Agricultural Sciences)

Radiat. Radioisotop. Soil Stud. Plant Nutr., Proc. Symp. 1970 (Radiation and Radioisotopes in Soil Studies and Plant Nutrition, Proceedings of a Symposium held at the University of Agricultural Sciences, Bangalore, India, 1970)
Rev. Agron. Noroeste Argent. (Revista Agronomica del Noroeste Argentino)
Rice J. (Rice Journal)

Sand Dune Res. (Sand Dune Research)
Soil Sci. (Soil Science)
Soil Sci. Plant Nutr. (Soil Science and Plant Nutrition)
Soil Sci. Plant Nutr. (Tokyo) [Soil Science and Plant Nutrition (Tokyo)]
Soil Sci. Soc. Amer., Proc. (Soil Science Society of America, Proceedings)
Soil Sci. Soc. (Ceylon) [Soil Science Society (Ceylon)]
Soils Fert. Taiwan (Soils and Fertilizers in Taiwan)
Seoul Taehakkyo Nonmunjip, Chayon Kwahak, Saengnongge (Seoul University Journal, Biology and Agricultural Series B)

Tamagawa Daigaku Nogakubu Kenkyu Hokoku (Bulletin of

the Faculty of Agriculture, Tamagawa University)
Tech. Rep. Ser. IAEA, Vienna (Technical Report Series, International Atomic Energy Agency, Vienna, Austria)
Technology
Tennessee Valley Authority, National Fertilizer Development Center, Muscle Shoals, Alabama
Tohoku Nogyo Shikenjo Kenkyu Hokoku (Bulletin of the Tohoku National Agricultural Experiment Station)
Trop. Agricst. (Ceylon) [Tropical Agriculturist (Ceylon)]
Tr. Tadzh. Sel'skokhoz. Inst. (Trudy Tadzhikskogo Sel'skokhozyaistvennogo Instituta)
Union Burma J. Life Sci. (Union of Burma Journal of Life Sciences)
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