

Fertilizer Placement for Rice

ammonium-form nitrogen drilled into seedbed before flooding increased rice yields 25% to 50% in placement experiments

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Ammonium-form fertilizers have special significance in the production of the California rice crop because ammonium nitrogen is the only inorganic form that can be maintained in continuously flooded soils. However, the maintenance of ammonium nitrogen is dependent upon proper fertilizer placement. When ammonium nitrogen is placed at a depth of 2"-4" in a rice seedbed prior to flooding, its maximum utilization for increased rice yields is realized. Nitrogen which is converted to nitrate nitrogen before or after flooding will be denitrified and lost from the soil as nitrogen gas.

Recognition that ammonium-form nitrogen is essential for California rice—grown on land continuously flooded during most of the growing season—was established in early fertilizer trials. Recent studies have shown the importance of maintaining the ammonium form of nitrogen in the soil after it has been applied.

Maintenance of ammonium nitrogen in the soil after flooding is possible because flooded soils develop two distinct and different zones in respect to nitrogen transformation. In a very thin layer of soil—not more than one-fourth inch deep—where broadcast fertilizer might accumulate, there exist conditions for chemical and biological oxidation. This layer contains oxygen supplied by the water and also that released by living aquatic plants. Oxidation products such as nitrates, sulfates, and ferric iron are found in this layer. Ammonium nitrogen which is adsorbed on colloidal particles, exists in this layer only temporarily because it is converted to nitrate nitrogen which moves with percolating water.

Immediately beneath the surface oxidizing layer and extending into the entire plow layer, is a zone where reducing con-

ditions prevail. This reduction layer develops after about three days of continuous submergence, and the soil remains reductive until the water is removed. The oxygen contained in the soil before flooding is used up by soil microorganisms and it is not replaced.

Nitrates are not found in the reduction layer, but ammonium nitrogen applied into that zone remains unchanged and is available as a source of nitrogen for rice. Nitrate nitrogen which exists in this zone, or which has moved from the surface layer in drainage water is denitrified. The nitrogen transformed by denitrification escapes from the soil as a gas without benefit to plants.

Different methods of applying ammonium fertilizers to rice—surface, combined surface and subsurface, and subsurface nitrogen applications—have been studied during the past four years. Ammonium sulfate—to supply 30 pounds of

actual nitrogen per acre—was applied by: 1, broadcast in the water after flooding; 2, broadcast on the dry seedbed, just prior to flooding; 3, broadcast on the dry seedbed before flooding but mixed by disking to a soil depth of 4"; 4, drilled to a depth of 2" in bands 12" apart; and 5, drilled in bands 12" apart to a depth of 4" just prior to flooding.

The growth, nitrogen uptake and yields of rice from the various treatments were studied. The rice yields were converted into index values with the unfertilized rice equal to 100. The yearly yield index values and the four-year average are shown in the accompanying table in the center column.

The highest yields of rice were produced where the ammonium sulfate was drilled into the seedbed to a depth of 2"-4" prior to flooding. This nitrogen, drilled into the reducing layer, maintained the nitrogen supply enabling better growth and yields of rice. Ammonium sulfate applied broadcast on the surface and mixed into the soil prior to flooding gave better yields than where it was allowed to remain on the surface. Surface applied nitrogen gave a little earlier growth stimulation to the rice, but this effect did not last longer than 14-21 days. Applications made into the water after flooding gave the lowest yields. Nitrogen was not lost in run-off water, but losses which occur after nitrification and subsequent denitrification were large.

California rice crops utilize ammonium nitrogen most efficiently when it is drilled into the seedbed prior to flooding. In a number of experiments ammonium-form nitrogen placement has increased yields from 25% to 50% over similar fertilizer treatments applied by broadcast methods. The necessity of us-

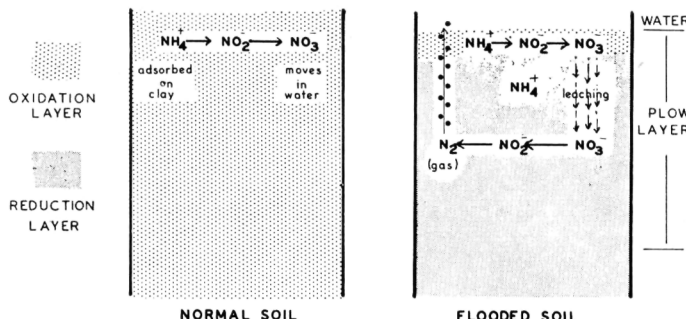
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Yields of Rice in Experiments at Biggs Field Station

Fertilization*	Rice yield index				
	1953	1954	1955	1956	Av.
Unfertilized	100	100	100	100	100
Broadcast in water	106	111	..	..	108
Broadcast on dry seedbed . .	122	118	118	126	121
Broadcast and disked . . .	..	132	118	130	126
Drilled 2" deep . . . .	..	..	140	143	142
Drilled 4" deep	142	137	133	146	140

* Nitrogen applied as ammonium sulfate at rate of 150 pounds per acre equal to 30 pounds actual nitrogen per acre.

Lower left—Diagrammatic illustration of how nitrogen transformed by denitrification escapes from the soil as a gas without benefit to plants. Lower right—Subsurface—drilled—applications compared with surface—broadcast—applications of ammonium sulfate on California rice. Left front—60 pounds actual nitrogen broadcast. Center—60 pounds actual nitrogen drilled 4" deep.



the product is cased after freezing, costs are slightly higher with all methods. With the manual and the semi-mechanical methods the higher cost is caused by a reduction in the production standard for the casing workers to approximately 155 cases per hour. This increases estimated variable costs about 2% with the manual method and 8% with the semi-mechanical method. With the mechanized method an additional worker is required to guide the cartons from the freezing trays into the casing machine. This would increase estimated labor costs by \$1.70 per hour per machine. Changes in the analysis—necessitated by these cost differences—

could be approximated by corrections in the larger table on the preceding page. Such correction would show a moderately decreased cost advantage of the semi-mechanical method over the manual and of the mechanized method over both, with the amount of change depending on rate of output and number of hours operated.

To estimate potential savings to be effected by the mechanization of the casing operation in some plants—or producing areas—adjustments in production standards, wage rates, equipment replacement and depreciation, and other charges might be appropriate. Questions of plant

flexibility and availability of qualified equipment maintenance personnel in small plants, as well as variation in charges for labor and equipment, might well enter the calculations but with suitable adjustment of the basic data, computations could be made for such cases.

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This is the second in a series of progress reports on efficiency in the processing and marketing of frozen fruits and vegetables. The studies are being conducted cooperatively with the State Experiment Stations in Washington, Oregon, and Hawaii and the Agricultural Marketing Service, U.S.D.A.

WEEDS

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were drained beginning June 15 when the rice was 7"—8" high. The fields drained rapidly and it was possible to get into the fields with ground equipment by June 23.

The spray equipment was mounted on a track-type tractor with special extensions attached to the tracks. The extensions were needed only in a few exceptionally wet spots in the field. A volume of 28 gallons per acre was applied at 20 pounds pressure through a broadjet nozzle covering a 40' swath.

All spraying was done at night—to take advantage of still air conditions and minimize the possibility of drift from air movement—with 220 acres sprayed in three nights. Because of concern over mounting daytime air temperatures, 100 acres were left unsprayed. Previous experimental work and field experience had shown increased susceptibility of the rice plant to injury when daytime temperatures reached 95°F and higher. During the period of spraying—June 23, 24 and 25—maximum day temperatures ranged from 95°F–100°F. On June 26 the maximum reached 101°F. It rose to 105°F on June 27 and 108°F on June 28, falling thereafter.

The MCPA was applied to part of the field at 10 ounces of actual MCPA per acre. Due to error in mixing, another part of the field received only 4¾ ounces of actual MCPA. Weed control was good even at the lower rate but was better at the 10-ounce rate. Skips and unsprayed areas were a mass of weeds with rice plants barely discernible. The most abundant weed was umbrella sedge with water plantain and burhead present in quantity.

Flooding was begun soon after the spraying and it took an average of six days to reflood the various fields. The entire operation from draining to flooding covered 19 days.

The average yield on the 220 acres

sprayed was 4,450 pounds of dried paddy rice per acre. The unsprayed field yielded 2,200 pounds per acre. The rice lodged in the unsprayed field when the water was taken off before harvest because the heavy growth of umbrella sedge pulled the rice down as it settled. The sprayed rice did not lodge.

All investigative work to date indicates that 55–65 days after planting is the safest period to spray. However, the two instances of plane and ground rig application indicate the possibility of early spraying on drained rice with MCPA at low rates. MCPA is more selective than 2,4-D and that increased selectivity is especially important if spraying is done early or when temperatures are high.

Early spraying should be considered as a last resort where weed competition is extremely severe.

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rice to eliminate the milled rice variable which would exist if pounds head were used. An approximate pounds head value can be obtained by multiplying the per cent by an appropriate total rice value—for example—80% times 70 pounds total milled rice gives 56 pounds head rice.

The yield of total milled rice in the humidified drying-air study was reduced significantly by an increase in drying temperature or a lowering in drying humidity. The reduction rate was nearly constant as drying progressed.

Humidification of the drying-air improves the quality of the dried rice remarkably. One-pass drying at 110°F and about 33% relative humidity produced

the same head yield as three-pass drying at 110°F with unhumidified air. Higher humidities produced even higher head yields.

Humidification caused an extension of the drying time. The three-pass drying required 2.2 hours. One-pass humidified drying required 4.5 hours to yield the same quality product.

Checking of the rice increases at a faster rate as drying progresses at any given humidity. During the removal of the first 4% of moisture—at 130°F—12% checked while 45% checked during the last 4% of moisture removed.

The results of these studies indicate the possibility of increasing both yield and quality of column-dried rice by using elevated humidity drying air. However, because this process extends the drying time considerably, a procedure would be required that would yield satisfactory capacity such as stage single-pass drying—using high-temperature low-relative-humidity air to remove the first few per cent of moisture, finishing with lower-temperature higher-relative-humidity air—reducing the number of passes by humidifying during one or more passes or additional drying capacity to use complete low-temperature high-relative-humidity drying.

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ing an ammonium source of nitrogen and providing for its maintenance in flooded soils for rice was shown to be an important factor in achieving the best utilization of nitrogen for the best growth and yields of rice.

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