RAPID RECLAIMING OF SALINE-SODIC SOILS WITH RICE

Douglas J. Munier
Farm Advisor
University of California
Cooperative Extension
Bakersfield, California

Kater Hake
Farm Advisor
University of California
Cooperative Extension
Bakersfield, California

David R. Woodruff
Private Consultant
Bakersfield, California

Norman Olsen
Farmer
Bakersfield, California

<u>An Overview</u> - Douglas J. Munier

It is our purpose to give you much of the information necessary to make a decision whether or not to use rice as a reclamation crop. Historically, many different crops have been used for soil reclamation, including barley sorghum, irrigated pasture, rice, among others. Rice as a reclamation crop has the potential to reclaim soil much more quickly than other crops. The reclamation process will be discussed in more detail later.

Growing a crop of rice, with the right soil amendments, will rapidly reclaim a saline-sodic soil, commonly referred to as alkali, but it will not turn <u>all</u> poor ground into highly productive farm land. A crop of rice won't help reclaim saline-sodic soil caused by a high perched water table, nor will it help if there is a complete sealing of the soil surface with no water penetration, and neither will it benefit virgin ground with no salt problems. Salt affected soils are the result of numerous salts. Special attention is given to sodium and boron salts because of specific problems they cause. High sodium levels in the soil result in poor water penetration and high boron levels are toxic to plant growth. Poor crop growth could also result from poor quality irrigation water, for which rice will be no help. Not only should saline-sodic virgin ground be considered, but poorly producing alfalfa land never fully reclaimed is a candidate for rice reclamation. These alfalfa fields can sometimes be recognized by low yields, poor water penetration, and/or the presence of many alkali weeds. However, saline-sodic problem should be confirmed with soil tests before rice reclamation is seriously considered.

So the most important step in using rice for rapid reclamation is to clearly define the production problems limiting crop growth. Once the problem or problems are defined, it can be determined if a rice crop will reclaim the field.

There are some basic essentials for rapid reclamation of alkali soils with rice. These are:

- Appraisal of the problem
- Adequate drainage
- Grading for rice
- Application of proper amendments if needed
- Supply and application of good water
- Selection of proper crops
- Financing to see it through

Many of these necessities will not be clear black and white decisions, but every effort must be made to clearly define each issue.

Rapid reclamation of saline-sodic soils with rice has many advantages. A first time rice grower in Kern County averaged 3600 pounds of rice per acre over 500 plus acres. Not only is their yield good for a first time rice grower, but their yield is amazing considering the soil conditions. Soil EC_e's were around 20 mS/cm and boron levels were around 40 mg/Kg. Under these severe conditions, text books indicate yield reductions of 75 to 100% of normal yields.

Rice may not always do as well under these severe conditions, but further work needs to be done to assess the yield potential of rice as a reclamation crop under a wide range of saline-sodic soil conditions.

Agronomic Aspects - David R. Woodruff

The other speakers will bring out the benefits of using rice culture to reclaim soil so I will bring out some of the things that need to be considered when initiating a rice program.

A good set of soil analysis will allow one to know the degree of reclamation that is needed. They may be referred to later for nutritional guidance as well as compared with soil analysis taken after some reclamation has occurred.

Once the base has been established there are certain cultural practices that must be followed to be successful in a rice venture.

The field must be level or leveledto a grade. Water must cover all the check and still not be too deep in the lowest areas. Water depth of 2 to 6 inches is best. Shallow water will reduce the rice stand and result in poor water grass and broadleaf weed control. Deep water will cause reduced stands because the plant cannot make it through the water. Many spotty stands are caused by deep water during stand establishment.

Good borders are very important. It cannot be stressed enough to make sure your borders are big and well packed to resist washout. Sodic and saline soils are often quite powdery when worked and are difficult to pack, so care must be taken to insure this is done. Borders should be placed at a .3 to .4 fall. This will allow a difference of about four to five inches in each check and is the maximum fall advisable. Less fall is better. One other point, when making borders, as soon as the border is closer than 25 to 30 feet from the edge of the field, go perpendicular to the edge rather than making a long narrow strip. You won't be able to harvest the grain in a narrow strip anyway.

Drop boxes must be installed so that wash outs will not occur. The use of plastic sheeting and straw will help. Once water has been put in the field, borders and drop boxes that wash out are very difficult to get back into proper shape. A little preplanning will save much time and expense later.

After a field has been prepared with boxes and borders the next operation is fertilization and seed bed preparation. Nitrogen fertilizer is generally applied two to four inches deep in dry soil. Either urea, or an ammoniacal form should be used, with ammonium sulfate being the most common. Excessive nitrogen can cause lodging, and when lodging occurs before or shortly after heading, yield losses can be great. The seed bed should be corrugated, with a distance between shanks of about 9-12 inches. Once this is done and the field is ready for water, if the soil analysis taken earlier shows the soil pH is high (above 8.0) and the zinc level is below 1.0 ppm then add 10 to 15 pounds of zinc. Many sources of zinc are available with the most common being zinc sulfate. Zinc is applied just before flooding the field and the zinc is not incorporated into the soil.

The seeding rate is generally 150 to 175 pounds per acre with best results on marginal soil requiring the higher rates. The seed is soaked in water one or two days, drained and sowed into the water.

Just a quick run down the approximate schedule of events following seeding:

Before emergence, algae and tadpole shrimp can be a problem. Usually, on the first year rice, shrimp will not be much of a problem. Algae can weigh down the emerging leaves and if a continuous mat is formed, then the seedling can not go through it.

Fourteen to sixteen days after seeding, water grass needs to be controlled if present.

Thirty to forty days after seeding, broad leaf weed control should be considered.

Forty to fifty days careful watch of the nutrient levels by tissue analysis can avert a problem developing later on in the growing season.

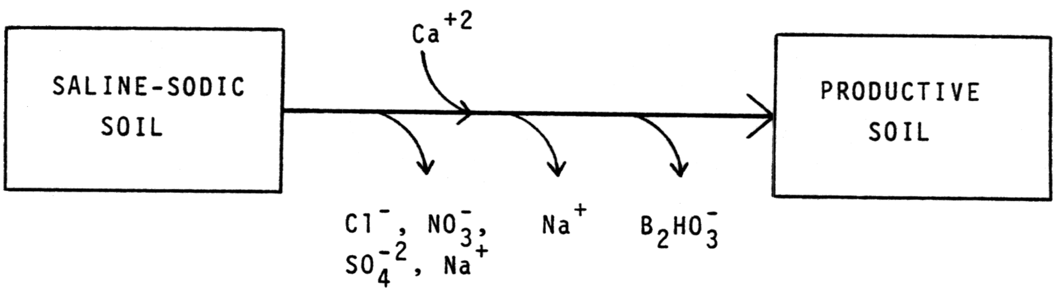
This talk, or course, does not give all the details of the operation but will act as a guide so that you can investigate and find out just how to do the various operations within your own farming organization.

Summarizing then, a level field, with good strong borders and boxes are necessary for rice Proper fertilization and pest management coupled with good water control will go a long way in making a success of the rice crop in a reclamation program.

Reclamation Process, Beginning To End - Kater Hake

Most growers involved with reclamation understand that saline-sodic (high salt and high sodium) soils are detrimental to crop production and the only way to remove them from the soil is by leaching. But, is this enough to answer some of the management questions that always arise in farming. Questions like: When should soil amendments be applied, before or after reclamation with rice? If the soil permeability is low, would irrigation amendments benefit reclamation? Should crop residue be burned or incorporated prior to rice production? Would the addition of manure help? These are questions that to answer require an understanding of the reclamation process beyond applying gypsum, water and wait.

Soil reclamation is simply leaching of salts. We could reclaim soils with several midwestern downpours if it were not for the inconvience that nonsaline water doesn't easily move through sodic soils and that some toxic elements aren't readily soluble. Two factors limit leaching, the solubility of toxic elements Na and B and permeability-infiltration of the soil. In the leaching process, represented here diagrammatically, the less tightly bound ions are leached with less water than tighter bound sodium and boron ions.



We improve the leaching process by: rice growth, the anaerobic decomposition of organic matter, adding a source of calcium ion to displace sodium, and possible permeability benefits from gypsum salts, surfuric acid, and crop residue.

Submerged anaerobic decomposition of organic matter, straw, manure, and crop residue, produces carbon dioxide and organic acids, both of which are beneficial in reducing soil pH, solubilizing $CaCO_3$, and releasing sodium into the soil solution. Rice has a similar benefit, with the evolution of carbon dioxide from root respiration.

Maintaining high water conductivity and infiltration is essential for soil reclamation. Soluble salts, especially chloride will leach with one good saturation volume. Boron, which is bound by Al and Fe oxides and Na, which is bound by soil cation exchange surfaces, require great volumes of water to be removed. Application of calcium salt as gypsum to the soil surface can increase infiltration by increasing the salinity of the irrigation water and displacing sodium from the soil particles. Sulfuric acid application to the soil followed by extensive leaching has been shown to increase the removal of boron by decreasing the soil pH to a level where boron is more soluble. Rice growth will further increase leaching beyond the benefits or organic matter or calcium salts alone. Possibly this is due to roots and tillers physically preventing the sodic soil from sealing together. Sulfur in strong reducing conditions, such as present in flooded fields high in organic matter, can produce H_2S, a gas toxic to rice roots. This detrimental effect of sulfur amendments (gypsum, soil sulfur, sulfuric acid) is evidenced by black roots with a sulfur smell and is normally acceptable when compared with the benefits to reclamation of sulfur containing amendments and organic matter.

Rice is quite tolerant during germination, but young seedlings are very sensitive. EC_e of 4-8 will cause high mortality. Rice is significantly less tolerant to salt than barley, cotton, sugar beets, and only slightly more tolerant than alfalfa. But, rice is the preferred crop for fast reclamation, growing in soil with EC_e above 20 and boron above 35 ppm. Both are above the levels that would cause high mortality in rice. The answer to this anomaly points out one of the main benfits of rice for reclamation. Rice is grown in a solution and can tolerate over-irrigation and flooding. The irrigation water must be of acceptable quality, low Sodium Adsorption Ratio, SAR, to allow growth in the low boron and low sodium water that leaches through the soil.

The benefits of rice to reclamation appear impressive: generating income, improving soil structure by organic matter additions, increasing leaching, reducing soil pH and tolerating severe saline, sodic and boron soils. With understanding of the reclamation process and the role rice plays, growers can better manage the crop to obtain maximum reclamation benefits.

<u>Economics of Rice Production</u> - Norman Olsen

Our goal in this reclamation program must be to make these marginal soils into highly productive soils as quickly as possible in a sound, economical way. It is a fact that once the alkali has been removed, these soils are highly productive and can be farmed successfully with a good return for the investment.

You have already been told how the reclamation process takes place, with the addition of a source of calcium to replace sodium on the soil particles. You have heard about the importance of thoroughly leaching the entire soil profile and you have heard how rice growing fits nicely into this reclamation process.

Before considering the specific economics in rice production as a reclamation crop, we first need to grasp the economics of struggling to farm marginal, low productive, partially developed alkali soil. There is nothing, I believe, more frustrating to a farmer than to plant a crop and get half a stand, or if you do get a stand, to soon realize that plants that are growing will probably not produce more than half a crop and therefore half an income. Or if you have idle, totally undeveloped alkali soil, you are aware of the high cost of property taxes, water taxes, and interest on your investment for which you have no return.

Let us consider for a minute the economics of farming marginal, alkali infested soil. As an example, let us use a 100 acre cotton field or 100 acre hay field. If normal production in your area on good ground is 2 bale cotton or 9 to 10 ton hay, but on your marginal alkali ground your production is 1-1/4 bales cotton or 5 to 6 tons hay, here is how the economics will look:

100 acres hay x 9 tons = 900 tons x \$80/T = \$72,000 Gross

100 acres hay x 5 tons = 500 tons x \$80/T = 40,000 Gross

Net reduction in gross income 32,000 Gross

100 acres cotton x 2 bales = 200 bales x \$425 = \$85,000 Gross

100 acres cotton x 1¼ bales = 125 bales x \$425 = 53,000 Gross

Net reduction in gross income = 32,000 Gross

We are all aware that growing costs are generally the same whether you are farming the good ground or the marginal ground. In both the cotton and the hay example we see our net reduction in income amounts to \$32,000 per year or <u>\$320 per acre per year</u>. In other words, <u>every year</u> this farmer is losing <u>\$320 per acre</u> by not fully reclaiming this ground. This is why my personal philosophy is and has been to spend and do what is necessary to get alkali land fully reclaimed and into full production.

Let us examine the specific economics of rice production:

ECONOMICS OF RICE PRODUCTION ON MARGINAL, ALKALI SOILS

Cost of Production (excluding land payments, taxes, and depreciation)

	PER ACRE
Ground preparation - Labor and Fuel	$ 29.00
Discing (2) $6.00/Ac; Chisel (1) $6.00/Ac; Land plane (2) $6.00/Ac; Disc and Harrow (1) $3.00/Ac; Contouring and boxes $8.00/Ac	
Fertilizers	51.00
Ammonium Sulphate - 100 Lbs. N $30.00; Urea - 50 Lbs. N 11.00; Zinc - 15 Lbs. Zn 10.00	
Pesticides, Herbicides, Bluestone	20.00
Airplane - Agricultural chemicals, seeding (7 passes)	35.00
*Water - Power costs (6 - 8 A.F.	100.00
Seed - 175 Lbs.	26.00
Irrigation labor	10.00
Miscellaneous, Repairs, Management, etc.	20.00
*Soil Amendment - H_2SO_4, 1 ton/Ac + water run	100.00
Total Preharvest Costs	$391.00
Harvest Costs, combine, haul, dry	
$2.40/cwt. dry weight x 50 cwt. sacks/Acre	120.00
Total Cost of Production	$511.00
Income	
50 Sacks (cwt.)/Acre x $10.50 =	$525.00
Net Income Over Operating Expenses	$ 14.00

Highly variable - depends on local conditions

As these figures indicate, your income should pay for all cash costs except land payments and taxes.

I realize these figures aren't too exciting, unless you consider what has happened to your marginal alkali ground and what you can expect in the future on this soil.

Economically, where do we go from here? What cropping plans can now be used and what kind of yields can you expect?

Usually, after this kind of reclamation program the soil will produce near normal yields if proper management is followed. The ideal program is to plant hay and follow with cotton in 4 - 5 years. The only additional expense over normal costs for establishing hay is that after the seed is planted the field should be top dressed with 1000 pounds of sulfuric acid, which will cost about $40.00/Acre. This will help the weaker areas (such as old contour border areas) and result in a perfect stand of hay. Also, plan on treating water with acid to increase water penetration, costing only a few dollars per acre per year.

You should with this program and with proper management, obtain normal or near normal yields of good quality hay. Following hay this soil will produce normal cotton production for your area.