EFFECTS OF LIMITED SUPPLEMENTATION

	Amount of supplement fed	
	Zero	5 lb per head per day
Days on feed	142	142
No. of animals	21	21
Initial wt., lb.	634	631
Average daily gain, lb.	1.5	1.75
Dressing per cent	57.9	60.8
Carcass grade: % of animals in grade		
Good	5	67
Standard	86	33
Utility	9	0

these trials was that the animals receiving barley free choice, in addition to the pasture, showed no signs of "yellow" fat in the carcasses at slaughter.

Under this system, steers consumed 10 to 15 pounds of barley per head plus enough pasture to gain between 2.25 and 2.75 pounds daily. Acceptable slaughter condition was attained in the usual 120 to 150 day feeding period. This system compensates for periods of short forage supply because the cattle merely increase barley consumption and maintain weight gains. This is particularly important towards the end of the pasture season.

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CONTAINER RESEARCH FOR VEGETABLE SEED

THE RESULTS of the research on containers for vegetable seed show that, in order to maintain the vigor and germination that the seed possessed at harvest, it is necessary to dry the seed and package it in moisture-resistant containers. Completely satisfactory containers are tin cans, pouches of aluminum foil laminated to polyester or polyethylene, or pouches of powdered aluminum in polyester. Containers almost as satisfactory and adequate for most storage conditions are aluminum laminated paper bags, thick polyethylene bags, and asphalt laminated paper bags.

In progress now is a study of why increasing moisture content in seeds shortens the life of seeds. This problem is being approached by studying the biochemical processes which change with aging, particularly loss in activity of enzymes.—*James F. Harrington, Department of Vegetable Crops, University of California, Davis.*

CONTROLLED AVAILABILITY FERTILIZERS

PART V OF A FIVE-PART SERIES

Ion Exchange Fertilizers and Ammoniated Organic Matter

O. R. LUNT · R. H. SCIARONI · A. M. KOFRANEK

The feasibility of supplying fertilizer minerals to plants by means of ion exchange resins has been known—and used for research purposes—for many years. Recently this technique has received attention as a commercial means of supplying nutrients safely and in large quantities for prolonged availability to high value plantings. Investigations have shown that the method can be very effective on commercial flower and nursery crops. It remains to be seen if this approach will be economically competitive with other controlled availability fertilizers being developed.

In principal, the exchange resins supply nutrients in much the same way as clay in soils. The adsorbed positively charged particles on the resins may be exchanged for other positive ions supplied by the plant root or by the irrigation water. Negatively charged particles such as phosphate and nitrate are supplied by exchange reactions to the roots of plants in the same manner as are the positive ions. The analogy with soil clays does not hold too well since clays have little anion exchange capacity.

The mixture of resins being used for fertilizer carriers was found to have a positive ion exchange capacity of 109 me (milli-equivalents) per 100 g (grams) and a negative ion exchange capacity of 233 me per 100 g. The positive ion exchange capacity of the mixture is about the same as most reactive clays. Leaching losses of nutrients from the fertilizer are relatively small if irrigation waters are low in salts and only moderate even when irrigation waters are fairly high in salts. The analysis of the fertilizer is reported to be 3.2–3.5–2.5 in N, P_2O_5 and K_2O.

Surface dressings of the exchange resin fertilizers are not very effective unless the irrigation water contains moderate concentrations of soluble salts. When the resin is in the root zone, the roots of plants have no difficulty in obtaining nutrients from the resins. In contrast to coated fertilizers and metal ammonium phosphates, exchange resin fertilizers can be stored in moist soils for long periods without loss of effectiveness or contributing to the salinity level of the soil. They can also be steam sterilized without apparently affecting subsequent availability of the fertilizer.

Application rates of the exchange resin fertilizers are usually expressed in terms of volume percentages to be used because bulk densities of soil mixes used for ornamentals vary greatly. Excellent quality potted chrysanthemums were produced with no further maintenance other than tap water during a three month period by incorporating exchange resin fertilizers at the rate of 10 per cent by volume. The soil mix used was highly susceptible to leaching. Several nursery plants including cyclamen, aphelandra, *Philodendron selloum*, sheffelera and gloxinia (grown using a sub-irrigation technique) produced good to excellent growth over a seven week period when 8 per cent, by

Potted chrysanthemum plants grown to maturity by incorporating ion exchange resins into soil prior to planting cuttings, January 20, 1961. Pot on the left (C) received 0.4 g of nitrogen from urea-formaldehyde plus single superphosphate and potassium glass frit incorporated into the soil before planting. Thereafter the plant was maintained on a liquid fertilizer program until flowering—a program considered to be essentially perfect. Plant 2 received 10%, plant 3 received 5%, plant 4 received 3.3%, and plant 5 received 2% of exchange resins by volume of the total soil. Treatments 2 through 5 were maintained only with tap water after planting. The control treatment (C), and treatment 3 produced plants of excellent commercial quality, but treatment 2 was somewhat better and matured earlier. When 3.3% or less exchange resins were used, the plants were nitrogen deficient and of inferior quality.

volume, of the resin was included in the soil mix. Six per cent by volume was also very effective except for aphelandra, where it was apparently too low. A volume percentage of 12—of the ion exchange resin fertilizer—proved to be too high for aphelandra, philodendron and sheffelera. Optimum application rates will depend on the plant species, irrigation practices and water quality.

Single applications of ion exchange fertilizers are capable of supplying nutrients at an adequate rate over periods of up to three months, under typical nursery conditions, with a relatively good margin of safety against injury from excessive application. This is adequate for the production of many of the potted plant crops.

Ammoniated sawdust

The ammoniation of sawdust or other types of cellulose-containing materials provides a means of producing organic nitrogen and improving the utility of organic wastes. The reactivity of ammonia with organic matter has been known for some time and the commercial utilization of the process has been investigated by several groups. In one process being developed commercially, sawdust is acidulated, heated to an elevated temperature and neutralized with anhydrous ammonia. The product has a charred appearance but otherwise has the shape and size of the original sawdust. Phosphoric acid may be used for acidulation, making the resultant product also a carrier of phosphorus. Of particular interest is the fact that about one half of the nitrogen has been converted into insoluble forms and the remainder is apparently intimately distributed through the particles, presumably combined with the acid negative ion. The following properties were found for a sample supplied by the producer.

Percentage of Nitrogen soluble in water	47
Percentage of Nitrogen soluble in normal sodium chloride	53
Percentage of Nitrogen distillable with magnesium oxide	58
Percentage of Nitrogen in exchangeable form	9
Positive ion exchange capacity per 100 g.	43
Increase in soluble salts in soil mix solution per lb Nitrogen per cubic yard of soil	3200 ppm

The moderate increase in soluble salts shows that substantial amounts of nitrogen can be applied at a single application. Using material containing 4 per cent total nitrogen, as much as 1.5 lb of nitrogen has been incorporated into soil per 100 square feet without injury to typical ornamental plantings. About one half this quantity can be incorporated per cubic yard of soil mix. These rates are about three or four times as high as are safe with inorganic nitrogen sources. Plant response has been rapid since about one half of the nitrogen is water soluble. The water soluble fraction diffuses out of the particles slowly when the soil is not saturated with water. The organic fraction of the nitrogen is mineralized in about four to six weeks under favorable conditions.

Ammoniated sawdust is also of interest because of its contribution to physical properties of soils. Having a low bulk density of about 16 pounds per cubic foot, it is an effective diluent in fine textured soils and improves soil tilth. The chemical and physical properties of ammoniated sawdust adapt it well for use in landscaping operations—particularly new installations in subsoils or other poor soil situations. Observations extending over a five year period indicate the "charred" sawdust is decomposed very slowly. As a soil amendment the ammoniated sawdust has a long life.

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HYDROGEOLOGICAL STUDIES

A PILOT INJECTION of tritiated water has been made into the groundwater in a study of the groundwater and surface hydrology of foothill areas in the Sierra Nevada in Placer County. Results from the initial trials confirm the movement of groundwater in the jointed rock formations as predicted from groundwater contour maps. The movement and subsequent detection of the tritiated water over distances of hundreds of feet indicates that the joint system is well connected.

Tritiated water injected into wells at depths of 40 feet below the surface has been detected in the leaves of native oak trees downslope from the well, showing that these trees are obtaining part of their water supply from the groundwater system. These results will lead to more refined studies of the depth of rooting of trees and brush species and of their dependence on and the magnitude of water use from groundwater.—*Robert H. Burgy and David C. Lewis, Jr., Department of Irrigation, University of California, Davis.*