FISH SOLUBLES

as fertilizer for growing plants

FISH SOLUBLES AS FERTILIZER FOR GROWING PLANTS

revised edition

by

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INTRODUCTION

Fish have been used for fertilizer for unknown centuries. In the third millenium B.C., Mesopotamians produced and exported fish oils, which certainly left them with a residue of fish scrap. Since it has become quite apparent that the ancients, back even to the Neanderthals, were just as smart as we are, the Mesopotamians undoubtedly found the logical use for the scrap-manuring fields. In France oil had long been made from a fish called merlan (Gadus merlangus), with the scrap dried, ground, and packed in airtight casks for sale as manure. In the 16th and 17th centuries Basque, Breton, and English fishermen caught pilchards (Clupea pilchardus) for oil, again with the scrap sold for fertilizer.

Our own New England Abnaki and Wampanoag Indians, by the record of the Mayflower's Pilgrims, put a fish in each "hill of corne" and saved the Plymouth Colony from starvation by teaching the Pilgrims to do likewise. At least one anthropologist, Dr. Lynn Ceci, thinks that their friend Tisquantum or Squanto actually learned it during a previous stay in England and the Pilgrims, agricultural innocents that they were, didn't realize that manuring with fish was an ancient practice. Whatever, the Indian name for today's principal industrial menhaden (Brevoortia tyrannus on the Atlantic Coast, Brevoortia patronus on the Gulf of Mexico) was Munnawhateaug, translated by Roger Williams in the 18th century as "that which manures".

Yet, with all the historical record, a scientific understanding of the real value and exact properties of fish as fertilizer is still being sought. Until the 1940's the American menhaden industry depended heavily on sale of fish scrap as fertilizer, still without knowing just why it helped field and garden crops. Then the lower cost of petroleum-derived chemical fertilizers, and their aggressive marketing, combined with war-time demand for the protein content of fish scrap for stock and broiler feed supplements, all but ended the production and use of fish fertilizers.

Now, forty years later with the price of petroleum soaring, many source countries unstable politically, and our own reluctant realization that accessible world petroleum resources may not last out the 20th century, fish fertilizer is becoming economically and environmentally desirable for crop growing.

Factors in the renewed interest include:

+ In the early sixties, the market for fish meal as a protein supplement became depressed and producers--the menhaden fishery on the East and Gulf Coasts and pilchard on the West--began to seek other uses for these primarily industrial fish.

+ Recent growth of "organic farming", independent of petroleum-derived fertilizers, has helped create a new though still relatively small market.

+ Today's consumer of farm products, as part of growing environmental awareness, is coming to consider fish fertilizer as possibly a better component of our grain and vegetables.

+ The National Pollutant Discharge Elimination System and the Solid Waste Management Acts have stimulated research in the processing industries, both of industrial fish and of food fish such as tuna and herring with waste of entrails and other inedible parts, to find productive uses for what usually has been disposed of overboard or in city sewers. With menhaden, converting the wastes--stick or press water at the reduction plants and wash water from the catcher boats--to fish soluble nutrients (FSN) for agricultural uses was found ideal. The stick or press water is the liquor left after steam extraction of oil from the fish, and wash water is water rich with fish blood, oil, and small fragments of fish left in the holds of the fish boats after unloading. Most of these two by-products is obtained from the menhaden and tuna fisheries.

EXPERIMENTAL METHODS

In production of FSN, stick and wash waters are mixed, and condensed. The source of ingredients and the condensation process greatly affect the highly complex chemical composition of FSN. The proportions of amino acids, proteins, lipids, vitamins, and inorganic elements vary according to the fish source and processing method.

Experiments have been conducted at Virginia Polytechnic Institute and State University, with financial support from Zapata Haynie Corporation of Reedville, VA, on crops to determine what food crops and decorative plants benefit most from FSN fertilization. Plants of different species were grown under identical greenhouse conditions to compare the effects of FSN, Hoagland nutrient solution (HNS) containing all necessary inorganic mineral nutrients, and commercial grade fertilizer commonly used by growers.

Plants were started from seeds, seedlings, or cuttings. Fertilization with FSN, HNS, and commercial fertilizer continued until the plants were ready for market, or from three to twelve months. Root and stem growth, leaf production rate, flowering, and fruiting were compared at set intervals. As can be seen from comparative pictures (Figure 1), the plants responded positively to FSN fertilization.

Included in experiments to date have been decorative plants such as philodendron or cordatum (*Philodendron oxycardium*), pothos (*Scindapsus aureus*), peperomia (*Peperomia obtusifolia*), schefflera or umbrella plant (*Brassaia actinophylla*), and the food plants tomatoes, peas, radish, (Figures 2 and 3), lettuce, soybeans, sweet corn, and field corn (Figure 4).

Each group of plants was fed with various concentrations at different times. Some were fed following "market" directions for FSN or 1 tablespoon per gallon of water (15 ml per 3.8 l; X on identifying cards in photos) or 2 tablespoons per gallon of water (30 ml per 3.8 l; 2X) with each feeding of one cup (240 ml) per pot once (1W) or twice (2W) a week, and fresh preparation of "food" for each feeding. HNS was used full strength, and a 25-10-10 (nitrogen-phosphorus-potassium) commercial fertilizer was used at 1/5 the rate.

The philodendron and pothos plants fertilized with FSN and commercial fertilizer responded well and attained marketable size in 10-12 weeks. The

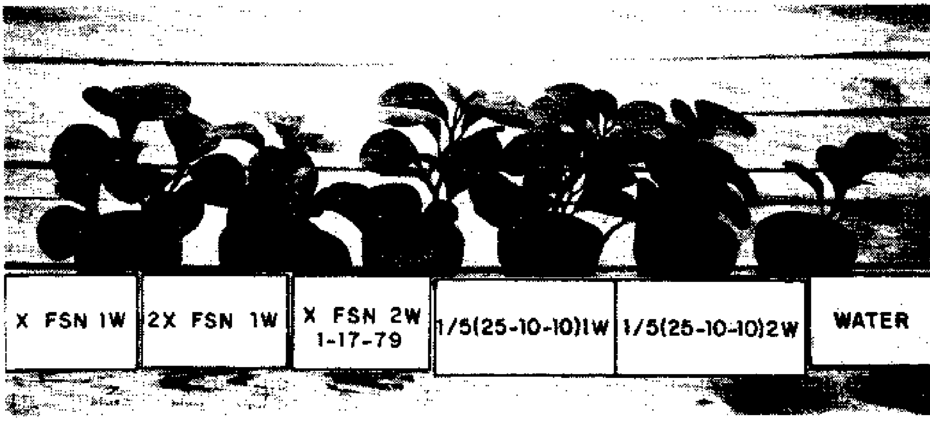

Figure 1. Growth of Peperomia Plants Fertilized with Fish Soluble Nutrients (FSN) and Inorganic Fertilizer (25-10-10)

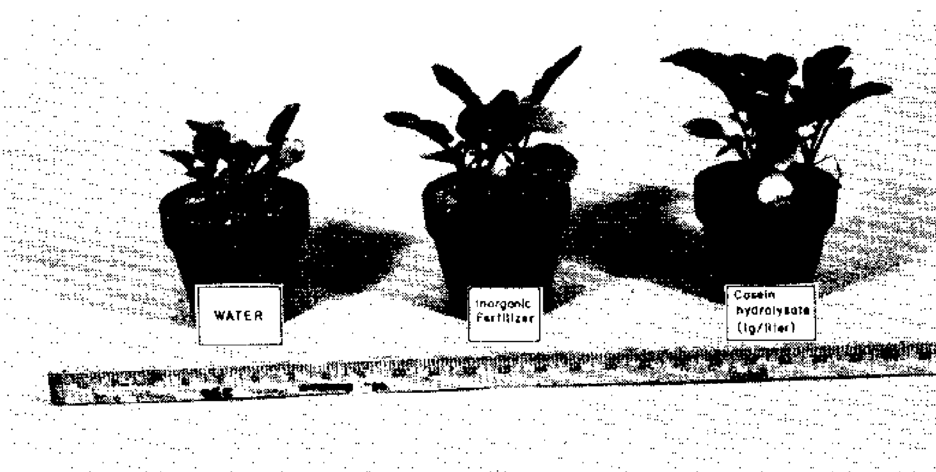

Figure 2. Growth of radish in sand cultures fertilized with water only, Inorganic Fertilizer, and Casein hydrolysate (1 g/liter)

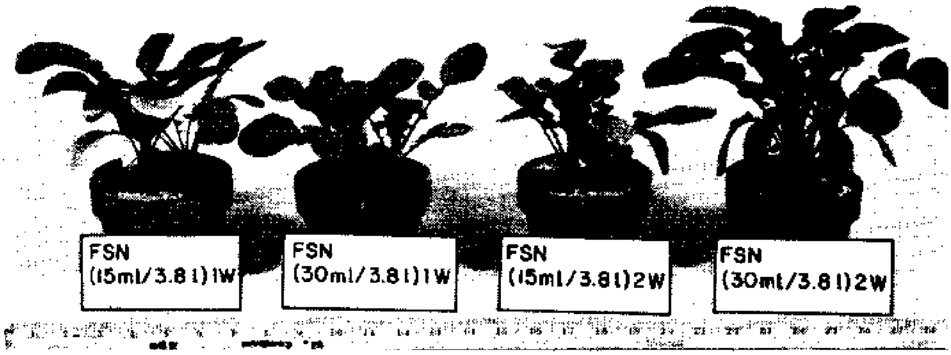

Figure 3. Growth of radish in sand cultures fertilized with Fish Soluble Nutrients (FSN) at two rates and two frequencies - FSN weekly, 15 ml/3.8 liters; FSN weekly, 30 ml/3.8 liters; FSN weekly, 15 ml/3.8 liters; and FSN twice weekly, 30 ml/3.8 liters

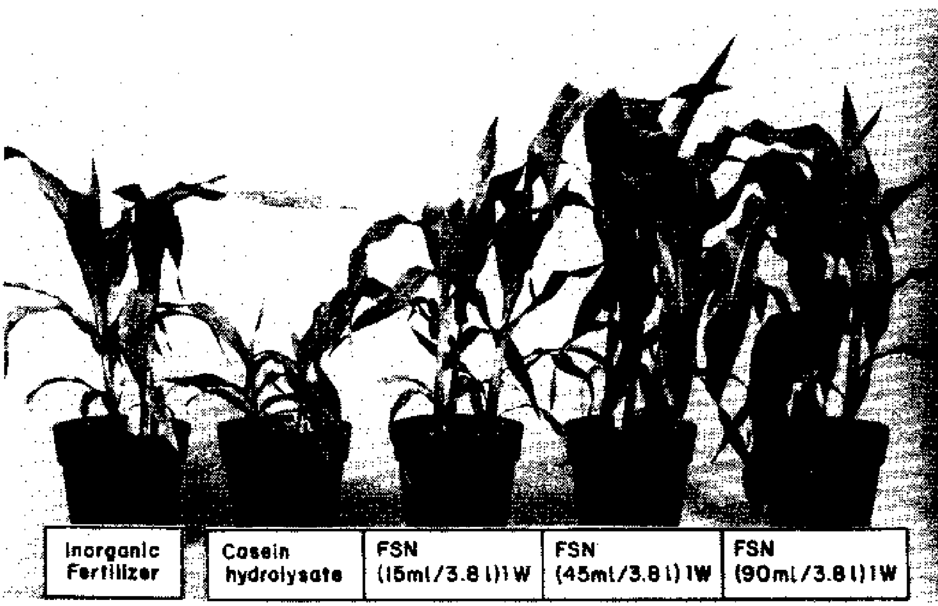

Figure 4. Growth of corn in sand cultures fertilized with Inorganic Fertilizer; Casein hydrolysate; Fish Soluble Nutrients (FSN) weekly, 15 ml/3.8 liters; FSN weekly, 45 ml/3.8 liters, and FSN weekly, 90 ml/3.8 liters

height, vigor and color of the plants grown with FSN compared favorably with plants fertilized with inorganic fertilizer (see Figures 5 and 6). The quality of the plants was excellent.

Peperomia plants responded well to FSN fertilization and showed healthy vigorous growth. The plants fertilized with FSN were almost as good as the plants fertilized with inorganic commercial fertilizer as indexed by plant height and leaves produced (see Figure 7).

Schefflera seedlings fertilized with FSN and inorganic fertilizer grew well and attained marketable size in 10-12 weeks. The plants grown with FSN showed a dark-green coloration and a bright sheen foliage and attained size similar to plants fertilized with inorganic fertilizer (see Figure 8). The plants were of excellent quality and responded well to FSN fertilization.

The conditions in these experiments were the "ideal" but may be altered by the user or grower. For house plants, similar media with good drainage may be used with good results. Concentrations and number of applications likewise may be varied (see Figure 9). FSN adapts easily to use at home, in the greenhouse, or on the farm, yielding excellent results in each area. The odor of the concentrates is tolerable, and barely noticeable when diluted in water.

Experiments with greenhouse tomatoes grown in sand culture condition showed that a crop could be grown to market size with nutrients derived solely from FSN (see Figure 10).

The general growth and fruit yield compared favorably with those of plants raised with HNS, but with a slight delay of flowering and fruit ripening in the FSN-treated plants. Earlier seeding would compensate here.

In one experiment, Fireball variety of tomato seeds were sown in a vermiculite-white quartz sand medium, and the seedlings transplanted to coarse sand in clay pots. The plants were fertilized at intervals with various concentrations of FSN, and a complete inorganic nutrient solution, with Fe at 5 ppm added as NaFeEDTA. During the first three weeks the plants treated with HNS weekly grew better than those with FSN. Later plants fertilized with 1 tablespoon concentration of FSN once or twice weekly grew better and produced more dry matter compared to HNS, but with flowering time delayed.

At harvest time the dry matter of the shoot and roots was about the same in both sets. Plants fertilized with two tablespoons of FSN weekly or bi-

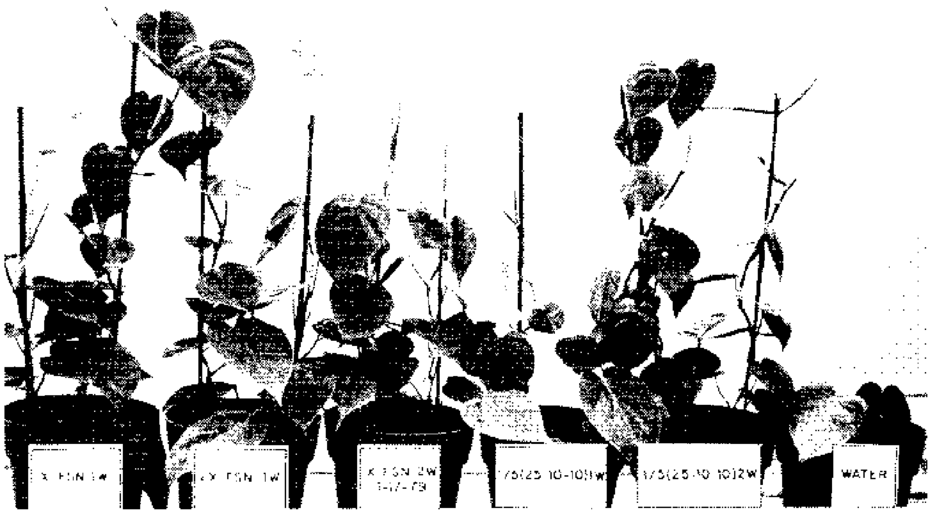

Figure 5. Growth of Philodendron Plants Fertilized with Fish Soluble Nutrients (FSN) and Inorganic Fertilizer (25-10-10)

Figure 6. Growth of Pothos Plants fertilized with Fish Soluble Nutrients (FSN) and Inorganic Fertilizer (25-10-10)

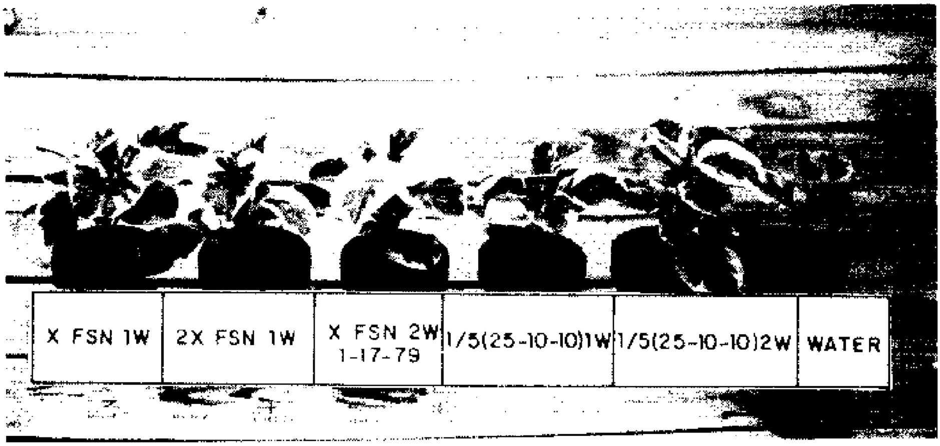

Figure 7. Growth of Peperomia Plants Fertilized with Fish Soluble Nutrients (FSN) and Inorganic Fertilizer (25-10-10)

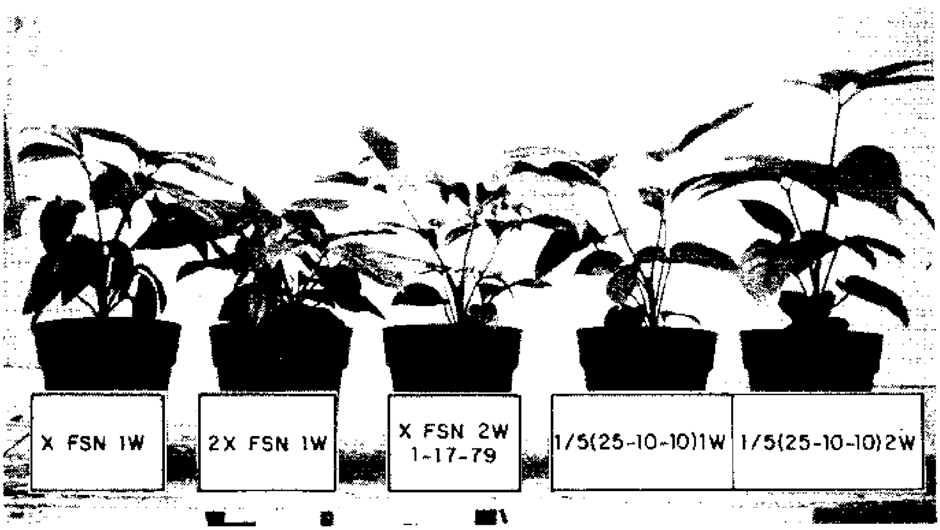

Figure 8. Growth of Schefflera Plants Fertilized with Fish Soluble Nutrients (FSN) and Inorganic Fertilizer (25-10-10)

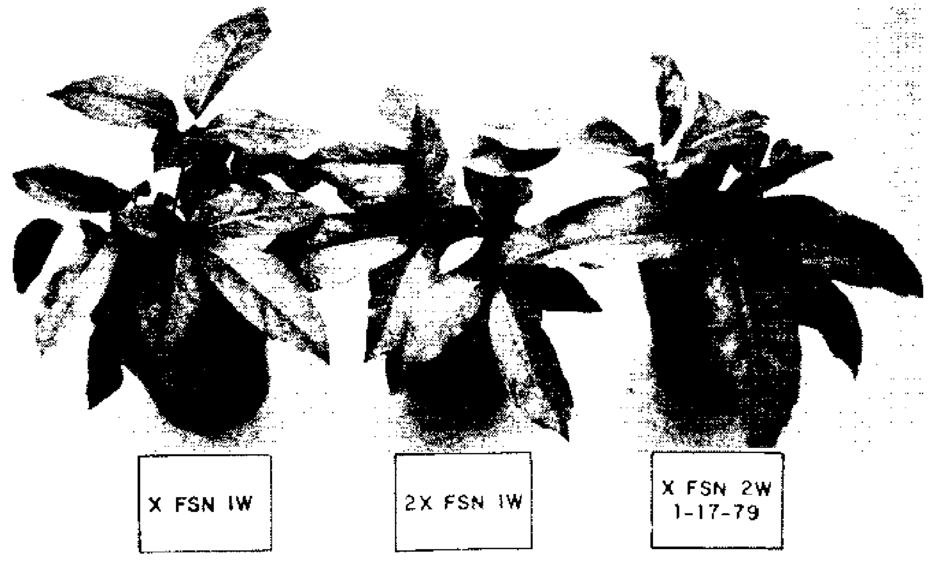

Figure 9. Growth of Schefflera Plants Fertilized with Fish Soluble Nutrients

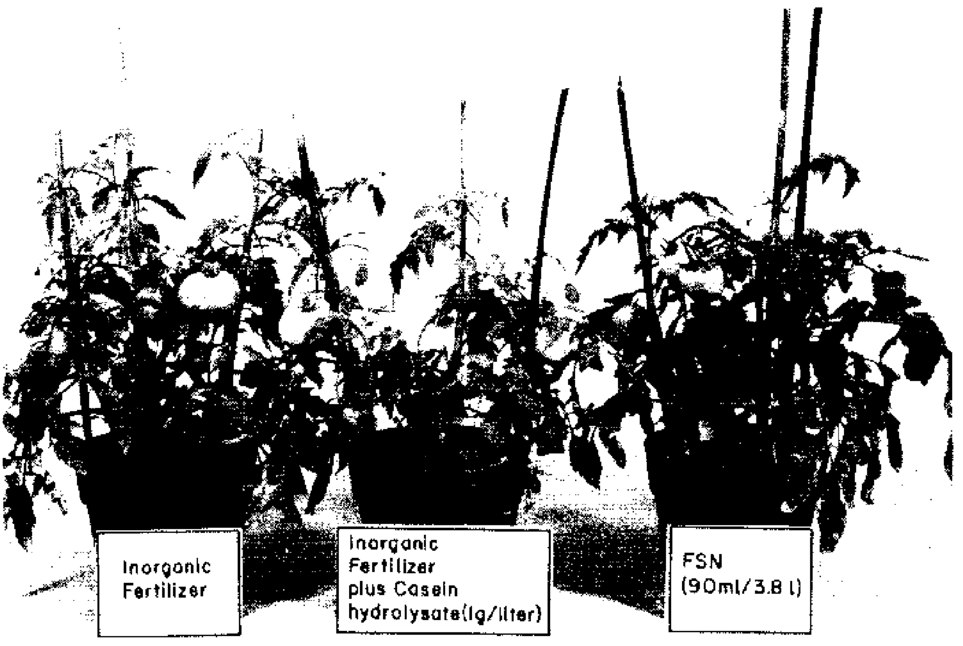

Figure 10. Growth of tomato plants fertilized weekly with Inorganic Fertilizer, Inorganic Fertilizer plus Casein hydrolysate (1 g/liter), and Fish Soluble Nutrients (90 ml/3.8 liters)

weekly grew higher than those given HNS or one tablespoon of FSN weekly, but yield did not differ and fruit size was significantly reduced.

In a second experiment, greater fruit yield was obtained from plants fertilized three times weekly with HNS than from those treated on a similar schedule with a diluted (1/4 strength) FSN. At half strength, there was no difference in plant height or fruit size, but shoot weight and fruit yield were lower in FSN-treated plants, with ripening delayed.

Fruit size with 1/4 strength HNS was significantly larger than at 1/2 strength, but total fruit yield was less. Shoot growth and fruit yield were greater in plants fertilized with 1/2 strength FSN or HNS with 1/4 strength.

Additional general advantages in using fish solubles fertilizer include:

+ Fish solubles easily mix with water and can readily be injected at seeding or applied in the irrigation system to crops, thus requiring less labor with fertilization and watering done in one operation.

+ A more uniform distribution of fertilizer can be attained.

Thus, fish soluble nutrients have been found a most effective and practical fertilizer for crop plants in the fields, greenhouses, gardens, and homes. The general growth, appearance, and quality of plants so fertilized were excellent compared with those raised with comparable rates of inorganic nutrients or commercial grade fertilizer.

Crop plants valued most for foliage or vegetation, such as umbrella tree, responded best. FSN can, however, cause a slight delay in flowering time and fruit ripening of some plants such as tomatoes, valued for their fruit. Therefore, in a fruit crop to be ready for the best prices of the early market, early seeding will compensate. The favorable effects of prolonging the life and keeping plants green and healthy with fish solubles fertilization will allow consumers to enjoy the plants and products longer.

CHEMICAL COMPOSITION OF CROPS

The fertilization of decorative plants and food crops with fish soluble nutrients has produced favorable results. However, the effects of fish solubles fertilization on the mineral composition of the edible parts of food crops is essential in order to ensure its safe usage as a source of fertilizer. In order to determine these effects peas, tomatoes, lettuce and radishes were selected for testing.

Peas (Pisum sativum L. ev. Little Marvel), tomatoes (Lycopersicon esculentum Mill cv. Fireball), lettuce (Lactuca sativa L. cv. Buttercrunch), and radishes (Raphanus sativus L. Cherry Belle) were grown under greenhouse conditions in pots containing a sand medium. The sand medium had the following properties: pH 8.1; NO_3-N, 5 ppm; P_2O5, 4 ppm; K_{20}, 11 ppm; CaO, 571 ppm; MgO, 30 ppm; 0.1 percent organic matter; and 230 ppm of soluble salts (1:2 soil to water extract). The peas, lettuce, and radishes were grown during the spring months at 18 degrees C during the night and 24 degrees C during the day. The tomatoes were grown in the late spring and early summer months at 21 degrees C night and 28 degrees C day temperatures. The crops were grown to harvest maturity, then the edible parts were collected for mineral composition determination. For the analyses, peas were removed from the pods, separated in half and oven dried for 18 hours at 100 degrees C. Ripe tomatoes were sliced in halves and the seeds separated from the pulp, and dried for 18 hours at 100 degrees C. Radish storage roots and lettuce leaves were freeze-dried for 48 hours. The plant materials were wet ashed before the mineral elements were determined by the atomic absorption spectrophotometric technique.

The mineral composition of peas from plants fertilized with fish solubles was generally higher than in those fertilized with inorganic Hoagland nutrient solution (HNS). The exception was for the amounts of K and Cu. The levels of N, P, Ca, and Mn increased with fish solubles fertilization. The Na level of peas was high only in plants fertilized twice per week with fish solubles. Heavy metal content of peas fertilized with fish solubles were all below the level of detection.

Tomato fruit, or flesh, fertilized with fish solubles had lower levels of K, Mg, Ca, Zn, and Cu than the fruits of plants which were fertilized with

HNS. The levels of N, P, Ca, and Mn were increased with fish solubles fertilization. Na and Ni contents of fruits fertilized fish solubles were higher than fruits of plants fertilized with HNS. No excessive heavy metal accumulation was found in fruits derived from fish solubles fertilization.

In lettuce leaves, the content of macronutrients, except K, and the micronutrients, except Mn, of plants fertilized with fish solubles was higher than for those fertilized with HNS. The Na level of lettuce leaves fertilized with fish solubles was three-fold higher than lettuce leaves fertilized with HNS. The levels of heavy metals did not differ between lettuce leaves which were fertilized with fish solubles and those fertilized with HNS.

The P and Mg contents of radish storage roots fertilized with fish solubles compared favorably with plants fertilized with HNS, but K, Ca, and Mn levels were lower. The Na and Fe levels of radish storage roots were higher than in roots fertilized with HNS. The levels of heavy metals present in radish storage roots fertilized with fish solubles were not excessive when compared with plants fertilized with HNS.

The results of the tests indicate that (a) fish solubles fertilization altered the mineral content of different vegetable crops; (b) the mineral composition of reproductive structures, such as pea seeds and tomato fruits, was favorably altered and showed no detectable heavy metal accumulation; (c) the mineral composition of vegetative parts, such as lettuce and radish storage roots, tended to show a greater amount of certain heavy metal accumulation; and (d) the dynamics of heavy metal absorption should be defined for the utilization of fish solubles as a fertilizer for crops where the vegetative parts are valued and consumed as food.

Table 1. Elemental Composition of Menhaden Fish Solubles of Different Origin by Neutron Activation Analysis

Element	Eastern Gulf Coast	Central Gulf Coast	Western Gulf Coast	Atlantic
		Macronutrient Concentration (%)[1]		
Potassium (K)	2.6	3.1	3.7	3.5
Magnesium (Mg)	†	†	†	†
Calcium (Ca)	†	†	†	†
Sodium (Na)	1.6	1.9	2.1	2.3
		Micronutrient Concentration (ppm)[2]		
Molybdenum (Mo)	<4	<5	<5	<6
Zinc (Zn)	†	67	†	109
Copper (Cu)	†	†	†	†
Manganese (Mn)	45	11	15	21
Nickel (Ni)	†	†	†	†
		Trace Element Concentration (ppm)[3]		
Silver (Ag)	<4	<3	<5	<5
Arsenic (As)	8	14	9	14
Gold (Au)	<0.02	<0.02	<0.03	<0.03
Barium (Ba)	†	†	†	†
Bromine (Br)	100	91	131	130
Cadmium (Cd)	†	†	†	†
Cerium (Ce)	<4	<4	<9	<6

Element	Eastern Gulf Coast	Central Gulf Coast	Western Gulf Coast	Atlantic
Chlorine (Cl)	40,700	25,450	34,550	36,900
Cobalt (Co)	2	3	†	4
Chromium (Cr)	<6	<5	<2	<8
Cesium (Cs)	<0.9	<0.7	<1.3	<1.0
Dysprosium (Dy)	<0.5	<0.2	<0.2	<0.2
Europium (Eu)	<2.1	<1.5	<0.8	<1.2
Hafnium (Hf)	<0.7	<0.6	<1.8	<0.8
Mercury (Hg)	<0.8	<1.1	<1.1	<1.3
Iodine (I)	<5	<12	10	22
Lanthanum (La)	<1.2	<0.8	<0.9	<1.0
Lutetium (Lu)	<0.1	<0.2	<0.2	<0.2
Lead (Pb)	<10	<10	<9	<10
Rubidium (Rb)	†	†	†	†
Ruthenium (Ru)	†	†	†	†
Antimony (Sb)	<0.8	<1.8	<0.4	<1.1
Scandium (Sc)	0.1	<0.1	0.3	0.1
Selenium (Se)	<5	<2	<6	<5
Samarium (Sm)	0.5	0.3	<0.8	0.8
Tin (Sn)	<98	442	310	<96
Strontium (Sr)	†	†	†	†
Tantalum (Ta)	<0.4	<0.4	<0.6	<0.6
Tellurium (Te)	†	†	†	†
Thorium (Th)	<1.9	<1.5	<2.7	<2.5
Titanium (Ti)	†	†	†	†

	Eastern Gulf Coast	Central Gulf Coast	Western Gulf Coast	Atlantic
Uranium (U)	<0.9	< 1.2	< 1.3	< 1.5
Vanadium (V)	<2.5	1.9	3.0	3.3
Tungsten (W)	<2	<2	<10	<3
Ytterbium (Yb)	<0.9	<1.3	<1.4	<1.6
Zirconium (Zr)	†	†	†	†

[1]"†" indicates element concentration could not be determined by NAA due to background interferences.

[2]"<" indicates concentration below given value. Background interferences prevented actual determination.

[3]Lead (Pb) was determined by atomic absorption spectroscopy. Concentration was below the 0.02 ppm detection limit of the instrument.

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