

LOAN COPY ONLY

FISH SOLUBLES AS FERTILIZER FOR GROWING PLANTS

by

Louis H. Aung and George J. Flick

NATIONAL SEA GRANT DEPOSITORY PELL LIBRARY BUILDING URI, NARRAGANSETT BAY CAMPUS NARRAGANSETT, R I 02882

VPI-SG-80-09

Sea Grant Program Extension Division Virginia Polytechnic Institute and State University Blacksburg, Virginia 24061 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 (Gadue merlangua), 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 <u>Mayflower's</u> 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 (*Brevoertia tyrannus* on the Atlantic Coast, *Brevoertia patronus* on the Gulf of Mexico) was *Munnachatemiq*, 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 wartime 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.

1

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 petroleumderived 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.

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

2

nutrients, and commercial grade fortilizer commonly used by growers: Plants were started from seeds, seedlings, or cuttings. Fortilization 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. and included in experiments to date have been decorative plants such as philodendron or cordatum (Philodendron oxycardium), pothos (Seinanpaus aureus), peperonia (Peperonia abturi/olia), schefflera or umbrella plant (Brissaia actinophylla), and the food plants tomatoes, peas, radish, lettuce, soybeans, sweet corn, and field corn. 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 1: X on identifying cards in photos) or 2 tablespoons per gallon of water (30 ml per 3.8 1; 2X) with each feeding of one cup (240 m1) 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. 384 395 **** ***** 应激微 X FSN 2W X FSN 1W 2X FSN 1W 1/5[25-10-10]1W 1/5/25-10-10/218 WATER 1-17-79 å. : **: :** 生態總總學 1200 😎 🏵 🗑 🖉 🖉 🖉 🖗

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

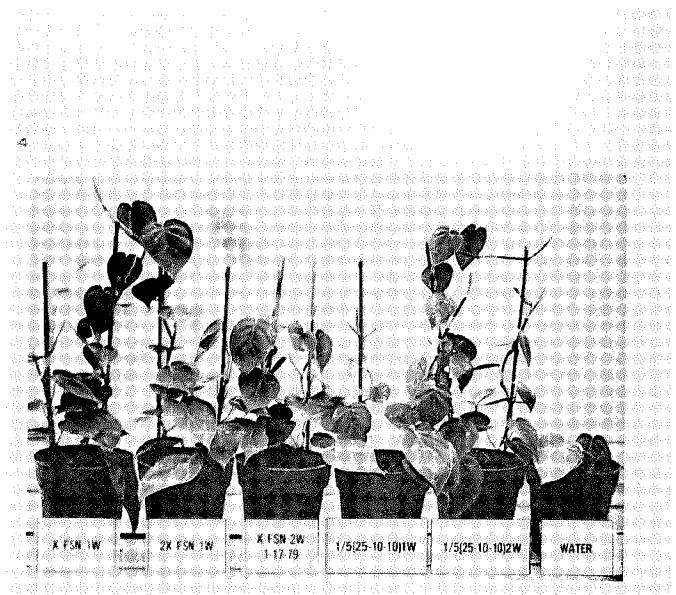
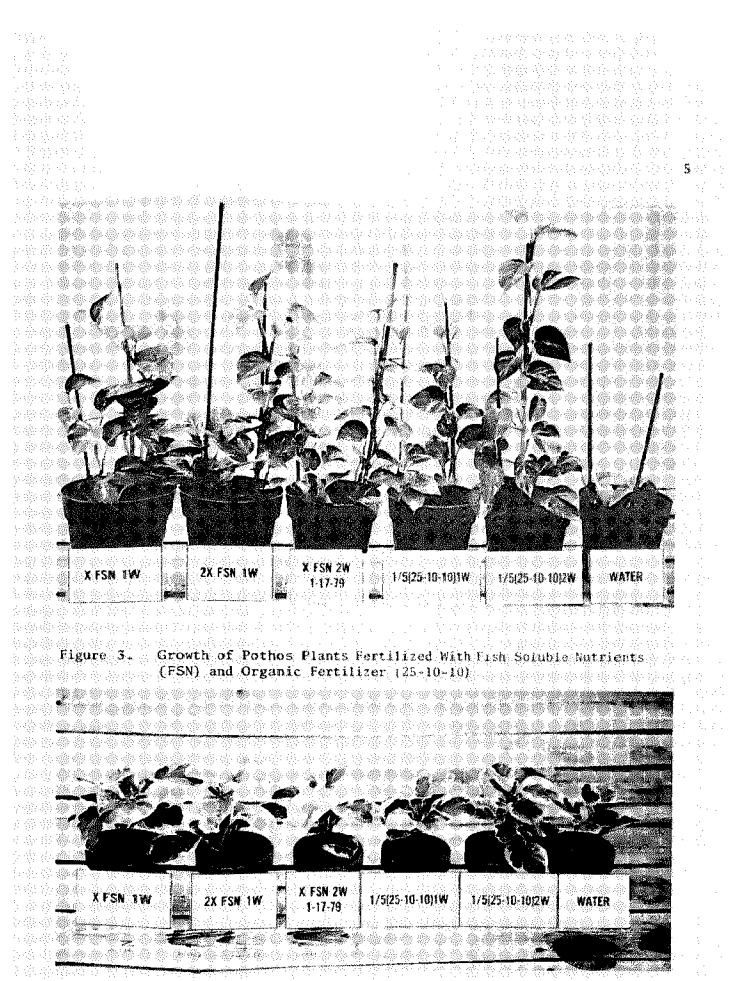
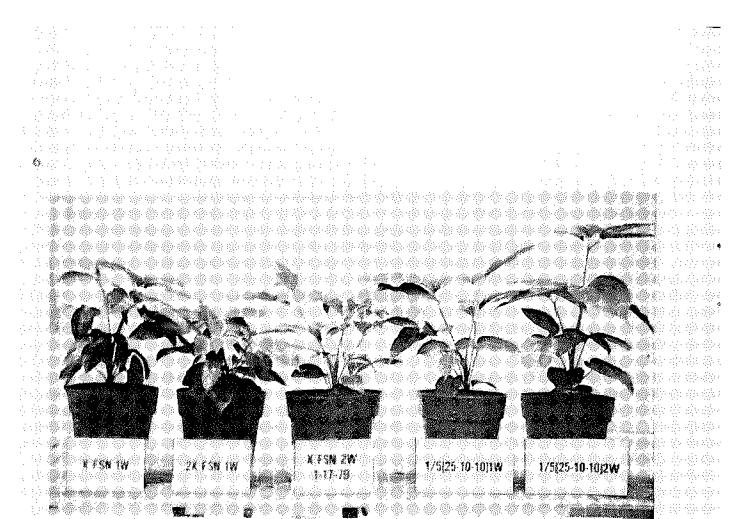


Figure 2. Growth of Philodendron Plants Fertilized with Fish Soluble As a second s The philodendron and pothos plants fertilized with FSN and commercial Certillizer responded well and attained marketable size in 10-12 weeks. The stronght sviger and color of the plants grown with ESN compared favorably with plants Fortilized with inorganic fortilizer (see Figures 2 and 3). The sust it was the plants are excellented and and a state of the restriction was preserved. Peperomia plants responded well to FSN fertilization and showed healthy vigorous growth. The plants fortilized with FSN were almost as good as the plants fertilized with inorganic commercial fertilizer as indexed by plant height and leaves produced (see Figure 4). Schofflern seedlings fortilized with FSN and inorganic fortilizer 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 5). The plants were of excellent quality and responded well to FSN fertilization.



Growth of Peperomia Plants Fertilized With Fish Soluble Mutrients (FSN) and Inorganic Fertilizer (25-10-10)

Figure 4



성상은 것 수 없을까? Tigure () (nowth of Schefflers Plants Pertilized With Fish Soluble Ant rients (PSH) and Inorganic Fertilizer (25-10-10) The conditions in these experiments were the "ideal" but may be altered by the user or grower. Nor house plants, similar media with good drainage may be used with good results. Concentrations and number of applications A kewine may be varied (see Figure 6) of FSN adapts easily to use at home. in the groundouse, or on the farm, yielding excellent results in each area. The solar of the concentration is tolorable, and barely noticeable, when diluted Experiments with greenhouse commutes grown in sand culture condition. showd that a cropicauld begroon to market size with matricuts derived and the first STATION AND THE REPORT OF A DECEMBER OF A the general growth and fruit yield compared favorably with those of plants raised with BNS, but with a slight delay of flowering and fruit ripen-电子子学 ing in the FSN treated plants. Carlier seeding would compensate here. In one experiment. Fireball variety of tomato seeds were sown in a versionits white quarty and medium, and the seedlings transplanted to coarse sand in clay pots. The plants were fertilized at intervals with var-

t sola de la Calificació de la Califica - 本事告書令事命 - 문 문 음 운 만 속 🕯 - 프 쇼 문 ֎ 수 ֎ ֎ ֎ 7, ? 9. († 19. (* 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. († 19. (\$\$ @ \$\$ @ \$**`\$**\$ - 中学学学学学学 化 《日本中市中市市市市市 la di ta di

 x FSN 1W
 2X FSN 1W
 X FSN 2W

 Figure 6. Growth of Schefflera Plants Fertilized With Fish Soluble Nutrients (FSN).

ious concentrations of FSN, and a complete inorganic nutrient solution, with Fe at S 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-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 1/2strength, but total fruit yield was less. Shoot growth and fruit yield were a show he greater in plants fertilized with 1/2 strength FSN or HNS with 1/4 strength. Additional general advantages in using fish solubles fertilizer inetude: a contra contr + 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 follage 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 day of the carly market, early sceding 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. Acknowledgment: We thank Mr. Anthony P. Bimbo, Zapata Haynie Corporation he had the hypothestic of Reedville, Virginia, for his support and encouragement when the help 小手生,你这些你还是off this work,当你能要你要我的感觉我要要要要要要要要要要要要要。 Contern-ready Manuscript Prepared by Jean B. Breven and the state of t 一部合学学校 医普通马克曼斯辛克多克曼斯特鲁克 新教学会会 医方容易 化分子化 法法法法 医方法法 偷偷偷偷偷偷偷偷 医生物学 医生物学 医生物学 医生物学 医生物学

Table 1. Elemental Composition of Menhaden Fish Solubles of Different Origin by How is it is a set Neutron Activation. Analysis is the part of the property is the set of the part of Eastern Contral Western Element Gulf Coast Gulf Coast Gulf Coast Atlantic Macronutrient Concentration(%)¹ 部部Potassium。(K)部的考2.6分析的现象形式的3.1%的情况的现象形式7.7分析的分析。 3.5 Magnesium (Mg) Calcium (Ca) 9**1-6**8-8-8-8-8-8 9 9 **1 9** 9 Sodium (Na) 2.1 Micronutrient Concentration $(ppm)^2$ 승규는 왜 가 가 가 다. <6 8 8 8 8 **6**7 8 8 音音音 会会法 Zinc (Zn) 109 电电动物中 Copper (Cu) 安法 由十字母 -2 基·全**+**道·台·组+号·音· 운 소송으로 - **-** + -21 3.44 27 3.11 28 3.14 Manganese (Mn) Nickel ((Ni))部語為自己的思想要要要要要要要要要要要要要要 生态 古美 赤 本 生 生 Trace Element Concentration (ppm)³ < **≤4** à à 🗳 🔅 🎼 Silver (Ag) # # \$ **\$** # **\$ \$** # # # # <5: Arsenic (As) 14 Gold (Au) <0.02 <0.02 為·• 與發展為發展發展。 Barium (Ba) 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -Bromine (Br) 100 130Cadmium (Cd) the cost to the 法公告 法法合准 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. ³Lead (Pb) was determined by atomic absorption spectroscopy. Concentration was below the 0.02 ppm detection limit of the instrument.

	아노 같 음악을 효율되었다. 이 아 노크 가 가 가 아이			
운영한 학교는 전 전 전 전 전 경영관과 전 전 전 전 전 전 전	되는 영상 11월 동생 신문 제품 11월 54일 - 14일	중 및 한 것 12 관 관 관 년 1. 외국 중 관 관 관 관 관 관 가	가 가 있는 아이는 것 같은 것을 알았다. 같은 아이는 것 같은 아이는 것 같은 것 같	사망가 다니가 관람을 놓았 사람은 동네나는 관람을
	1997년 1997년 1997년 1997년 - 1997년 1 1997년 - 1997년 1			· · · · · · · · · · · · · · · · · · ·
${}_{10}^{10}$, ${}_{$	가슴을 상황 솔슬레 - 가슴 가 가 봐 봐.	医基础 金金油 半有子	·슬슬 수 수 순 한 한 관계 1 1 1 1 1 1 1 1 1 1 1 1 1	
	an tan 19 sebagai kerabatan An diputan dari dari dari dari dari dari dari dari	persense personalise de la companya de la companya Esta de la companya d	a nagi dan seperajat dan dipertekan dari di. Sebelar dan dipertekan dipertekan di	te i porte de la constante de La constante de la constante de
	Eastern	Central	Western	
Element	Guir coast	Gulf Coast	Gulf Coast	Atlantic
Cerium (Ce)			si in	4
Chlorine (Cl)	40,700	25,450	34,550	36,900
Cobalt (Co)				
Chromium (Cr)	n de de la de de de la la Secto de S 6 s de de d	8 (8 49 49 49 49 49 49 49 4 17 5 4 4 4 4 4 4 4 5 4 6 4 4 4	2	n (n - 1973) - 1974 - 1974 - 1974 1974 - 1974 - 1975 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 - 1974 -
Cesium (Cs)	<0 <u>-</u> 9	8 4 6 7 20.7 6 7		× 1.0 €
Dysprosium (Dy)	<0 . 5	≤ 0.2	< 0.2	< 0,2
Europium (Eu)	≥	\$\$\$\$ 64.\$ \$	은 상품이 가운 이 것은 이 옷이 가 온다. 이용이 가슴이 가운 아주	· 你带着老 ~1,2 * 4
Hafnium (Hf)	≥ ÷ ≷ d • 7	0.6	<1.8	< 0.8
Morcury (Hg)	<0 . 8			
Todine (1)	ê ê ⊗s ê ê ê ê		10 () () ()	· · · · · · · · · · · · · · · · · · ·
Lanthanum (La)	> () () () () () () () () () (≤ 0.8	≥ 42 42 43 43 42 43 43 44 43 43 43 43 43 43 43 43 43 43	[14] 김 영 영 왕 왕 왕 생 4 [14]
Lutetium (Lu)	×0,1		20.2	20.2
Lead (Pb)	a Bara da Bara da . Sectora ≤10 a como a	<10	2 : : : : : : : : : : : : : : : : : : :	<10
Rubidium (Rb)	시 가 같은 것 같은 것 같은 것 같은 말 말 <mark>+</mark> 말 순구분은			
Ruthenium (Ru)				
Antimony (Sb)	en en an an an an an an En gin de d ≪0≩8 ∯, dis a	9 19 19 30 30 19 10 10 10 10 10 10 10 10 10 10 10 10 10	:	
Scandium (Sc)	0.1	0.000	0.3	0.1
Selenium (Se)	a da se te se se se se E 6. (5 s ≤5 6) de se se	9 - 10 - 10 - 10 - 10 - 10 - 10 - 10 - 1	김 가장이 관심 작품이 있는 것은 이상이 없는 것이 같	***************** }&**\$&\$< 5 & ***
Tin (Sn)	1999 - 1999 -		310	
Strontium (Sr)				
Tantalum (Ta)	<0.4) is the set of $0, 4$.		- (0,6 - (0,6
Tellurium (Te)	· · · · · · · · · · · · · · · · · · ·	general des des des des des des des		
Thorium (Th)	1.9			**************************************
Titanium (Ti)	가 가지만 가장 가장 같다. 1	한 사망한 가지 않는 것이 있다. 중 관계는 것은 물 약 중 중 중 중	: 같은 같은 아이가 같다. 같은 한 한 한 한 한 한 한 한 한 한 한 한 한 한 한 한 한 한 한	에는 한 일이가 가장하지? 2
Variadium (V)	<2.5	$x \gg x + x + x + x + x + x + x + x + x + $	e vere e que en que en en en 2 desente de 3 ∙0 de que	2019 - 2019 - 2019 - 2019 - 2019 - 2019 2019 - 2019 - 2019 - 3019 - 30 19 - 2019
			》會專展。全10 要會專用	
Ytterbium (Yb)	이 이 집에 걸릴 것은 것을 물었다.		242 강 분수 수 수 분 가 : 243 관 : 2 54 : 4 : 253	· 朱子子子子子子子子 • 朱子子子子子子子子子子子子子子子子子子子子子子子子子子
Zirconium (Zr)	an an an an an an an an a	2199년 1919년 1919년 1919년 2119년 1919년 1919년 2119년 1919년 191	(1) A set of the Apple Apple and the Appl	· · · · · · · · · · · · · · · · · · ·
역 김 신 위에 가지 가슴 첫 출수가 있는 것	가는 가는 가는 가장 말했다. 이 가는 것 것 가장 나는 것		가는 물 명 것 수가 것 같다. 탄동 법 중 문 물 중 물 중 문	· 나는 다 다 다 다 다 편지 · 다 다 다 다 다 다 만 편지
		法自己 在终端的第三		· 후 후 후 후 후 후 후 후 종

*我会的现在分词来来来来来的意思,这些我们都是我们的事实,我们就是我们的事情。 1941 COPY ONLY <u>이 승규는 승규는 승</u>규는 승규는 승규는 승규가 다 아니라. háchácáchácháchách **a thur sha har prophes**ia a staracha i o sono o sector de sector de sector de **primero de la primero de la primero de sector de sector de sector de** A sector de sector de sector de la primero de la primero de la primero de sector de la primero de sector de sec A sector de sector de sector de la primero 06650 \^~^^**~~** ************