IMPACT AND ACHIEVEMENT OF THE INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

- SOME RECENT HIGHLIGHTS -

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INTRODUCTION

It is widely recognized that the high yielding wheat and rice varieties which formed the backbone of the Green Revolution were the product of the international agricultural research centers (IARCs). That contribution saved Asia from famine and provided the foundation of the economic miracle that has profoundly changed the economic landscape of that most rapidly growing part of the world.

It is less widely recognized that the contributions of the IARCs continue:

- High yielding varieties of **wheat** and **rice** are now grown on over 300 million acres worldwide, reducing costs to low-income consumers, increasing incomes to producers, laborers, input suppliers, and marketers, and feeding an additional one billion people in the developing countries.

- Improved varieties of **corn** with increased yield potential and resistance to pests and diseases (including maize streak resistance) are now grown on **more than 100 million acres** throughout the developing world.

- Improved varieties of **other commodities**, staples in many developing countries, are beginning to enter the scene with increasing frequency.

- **Integrated pest management** is being extended to more and more commodities and regions, reducing reliance on expensive and toxic chemicals and making agricultural systems more sustainable.

- **138 crop species are being preserved in gene banks** worldwide, **conserving diverse endangered species** for use in crop improvement research.

- **Over 20,000 scientists** from national programs have been **trained** at the IARCs.

- National Agricultural Research Systems (NARS) are strengthened through continuing **close professional ties** to the IARCs.

And the IARCs benefit developed country agriculture also:

- The **centers of origin** -- which contain the largest pools of genetic diversity -- of most crops are located in developing countries. Developed country scientists collaborate with developing country colleagues to continue to breed desirable characteristics -- including resistance to emerging pests and diseases. For example, varieties with dwarfing genes from Asia are sown on **almost two-thirds of the wheat area and one-quarter of the rice area in the United States.**

- The IARCs contribute significantly to economic and social development of many low-income countries. **Developing countries are the growth cash markets of the future for developed country agricultural exports.**

INTRODUCTION

We have to do a better job of explaining the continuing vital contributions of the IARCs. This paper highlights **recent examples of impact and achievement** of the Consultative Group on International Agricultural Research (CGIAR) affiliated IARCs and non-associated centers funded, in part, by A.I.D. Centers were asked to submit examples of their recent impact and achievements. Carole Levin of the IARC Staff at A.I.D. has edited the submissions and grouped them into categories based on commodity or area of research. The result is a snapshot of the myriad of IARC impacts and achievements, not a thorough review and analysis. Individual examples do not add up to the total benefits from the CGIAR system.

The types of examples portrayed vary depending on the individual center's mandate and length of establishment. For example, older centers such as CIMMYT have more accomplishments to report than newer centers.

The international center system is a collaborative one. In many cases, the examples cited do not give full credit to the contributions made by other IARCs, universities, institutions, and/or NARS' partners. We have attempted to begin to document the interaction of the IARCs with respective U.S. universities.

However, we hope the paper is useful in demonstrating the continuing vital nature of the system. We invite the centers to continue to send in their best examples. We also invite our donor colleagues to give us their reactions. We would like to update and revise the list periodically if it seems useful.

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CEREAL CROPS

- Maize -

Resistance to Maize Streak Virus

CIMMYT has made rapid progress in developing a range of streak resistant maize of different maturities and grain types for mid-altitude ecologies. These varieties also possess resistance to leaf blight and rust, and are suitable for use in hybrid development. One advance hybrid line, for example, possesses excellent resistance to the virus, is high yielding and adapted to mid-altitude conditions, and combines well with hybrid materials used in most breeding programs of southern Africa. National programs throughout sub-Saharan Africa are using the materials extensively in breeding research and it is expected that varieties and hybrids derived from this work will reach farmers' fields within 1-2 years. The Mozambique seed company "SEMOC" has already distributed two varieties, Matuba and Umbeluzi, that are derived from CIMMYT.

Maize streak virus is the most serious disease of maize (corn) grown in Africa, effecting 14 million acres. Early infection on highly susceptible maize can result in 100% yield loss. A serious outbreak in Kenya in 1988, for example, resulted in 80% of that year's harvest being lost, an estimated $216 million in foregone grain.

Transplanting Maize to Rice Fields in Vietnam

Rice farmers in North Vietnam have employed a new technology of sprouting maize in their paddy dikes 10-15 days before the September rice harvest. The maize seedlings are then transplanted into still wet rice fields immediately after the rice is harvested. This new technology allows for a complete crop of maize in the relatively short and previously unused interval prior to January's cold. Farmers in the north are now growing transplanted winter maize on more than 100,000 hectares with an average yield 40% higher than the average for maize throughout Vietnam. CIMMYT's early maturing, high yielding variety MSB40 has been crucial to the success of this new technology.

Winning the Battle of the Sexes in Maize to Protect Farmers From Drought

New maize varieties have recently been developed that can yield at least 30% more grain under mid-season drought than conventional varieties. Even when there is plenty of rain, the new varieties outyield older ones. An estimated 80% of the corn grown in lowland tropics, which includes much of Africa, suffers yield reductions from drought.

The success of these varieties lies in the anatomy of the corn plant each of which produces male flowers (pollen laden tassels at the top of the plant) and female flowers (the ear, in which each kernel sprouts a "silk" to receive a pollen grain). With adequate water, the male and female flowers develop simultaneously. However, when drought strikes mid-season, the male and female flowers do battle and the farmers are the causalities -- suffering heavy yield losses. The male flowers monopolize the plant's scarce carbohydrates to tassel at the usual time, leaving little left for the female flowers. The development of the silks are consequently delayed and produced out of sequence with the tassels. As a result, much of the pollen falls before the silks are developed leaving many unfertilized. Without fertilization, corn kernels do not fill with sugar and starch and the harvest is greatly reduced.

CIMMYT scientists used maize's male favoritism to their advantage. They subjected maize plants to severe drought stress at flowering and selected only those in which silks appeared soon after the male flower emerged. When tassel and silk development most nearly coincided, grain production was highest. Varieties were chosen that showed near synchrony for male and female flowers under both dry and adequate moisture conditions. Their goal was to not only protect farmers from drought, but to make sure the maize varieties could also deliver when the rains were good.

Several promising varieties have been released to national agricultural research programs in Central America and adopted by farmers in the region's drier areas. Maize breeders in more than 20 developing countries are also adapting the new varieties to their local conditions.

Hybrid Maize Technology is Fuelling Private Sector Economy

IITA has developed hybrid maize varieties that have been the catalyst for the development of a growing private sector seed industry in Nigeria. This is a rare occurrence for an African developing country where most large scale seed production enterprises are government owned, backed by foreign assistance.

IITA began its hybrid maize research in 1979. By special request of the Nigerian government and with their financial support, IITA developed high yielding disease resistant hybrids. By 1985, two indigenous private seed companies were established with the technical assistance and supervision of IITA scientists. A number of large-scale farmers also began to grow hybrid maize in the country. Demand increased twenty-fold during the next five years leading to the formation of more commercial companies to take advantage of this new market.

Today, there are 13 seed companies in Nigeria, eight of which are indigenous and privately owned. IITA played a very significant role in the formation of this private sector industry. None of these companies would have been established if they had to conduct the timely and costly research themselves. Initially, they were formed to take advantage of IITA's hybrid maize research results. Now they are producing and marketing other seeds to include open-pollinated maize varieties, rice and vegetable seeds.

- Millet/Sorghum -

Acceptance of ICRISAT's Pearl Millet Varieties in India

Based on data from breeder seed supplied to public and private seed companies, the area under ICRISAT pearl millet downy mildew resistant cultivars in India in 1991 is estimated to be about 1 million hectares of ICMV 1, 1.5 million hectares of ICMH 451, and 800,000 hectares of ICTP 8203. The commercial value of the increased production of these cultivars was estimated at $54 million in 1991. ICRISAT estimates that ICMV 1 alone has contributed at least $17 million per annum to Indian agriculture since 1987.

The pearl millet variety ICMV 155, released in India in 1991, is resistant to downy mildew and consistently yields 12% more grain and 9% more fodder than ICMV 1. It has replaced ICMV 1 at several locations. This year, ICRISAT has distributed ICMV 155 breeder seed to 19 seed-production agencies in India. For the first time in India since the 1960's, farmers have an

alternative choice of a pearl millet variety before the downy mildew strikes any of the cultivated varieties.

Controlling Sorghum Midge Without Pesticides

ICRISAT scientists are now working to breed midge resistance into the sorghum plant and have made significant progress. ICRISAT began by screening the 15,000 sorghum germplasm accessions from its gene bank. Of these, nine were identified as being a stable and diverse source of resistance to the sorghum midge. These were then used to develop sorghum varieties that are highly resistant to midge and with yield potential comparable to that of commercial cultivars. The result: under heavy midge infestation midge-resistant lines show less than 30% grain damage compared with more than 90% in the susceptible hybrid. One variety, ICSV 745, has been widely tested in the midge-endemic areas of Karnataka, India, in collaboration with the University of Agricultural Sciences in Dharwad. Under midge infestation, ICSV 745 yielded 100% more than the commercial hybrids. Seed of this variety has been distributed to farmers in the states of Maharashtra and Tamil Nadu, large-scale adoption is expected.

Sorghum midge is a very destructive grain sorghum pest throughout much of the world. Under epidemic conditions in areas endemic to midge (parts of India: Karnataka, Tamil Nadu, and Maharashtra; Ethiopia, Yemen, Kenya, Tanzania, Western Africa, Australia, the United States, and Central America), midge-susceptible commercial cultivars would fail to produce any grain. Current recommendations for its control include cultural and chemical measures that have many limitations.

- Rice -

Rice/Pasture Technology for Acid Savannas

Over 12,000 acres of a CIAT savanna rice, Orizica Sabana 6, grown in association with improved pastures, has been established in Colombia's eastern plain savannas -- a region with acid soils where planting of agricultural crops was previously non-existent. Orizica Sabana 6 is the first cultivar of rice bred for acid savannas.

In the rice-pasture system, farmers plant both crops simultaneously after preparing the land. The rice is planted in rows and the pasture -- a mixture of grasses and legumes -- is broadcast. Farmers harvest the rice about four months later and graze cattle on the pasture. One hectare of improved pastures can accommodate six times more cattle and produce nine times the weight gain than a hectare of native savanna.

This new technology is expected to have a large impact on production systems of Colombia's savannas, and to spread to the savannas of Brazil and Venezuela. It should open the gate to sustainable rice-pasture farming systems and the recovery of overgrazed pasture land on 200 million hectares of savanna.

A Practical Solution to Rice Paddy Rat Control

IRRI scientists have developed a simple, chemical-free, active barrier system for controlling rat populations in rice paddies. It entails surrounding the rice field by a low fence of sheet plastic containing small holes every few feet with a simple wire-mesh trap behind each hole. The rice

serves as the bait. When the rats smell the rice, they run or swim around the plastic fence looking for a hole to enter and get caught in the traps. In field tests, up to 15 rats have been taken from a single trap hole. The system costs $200 to protect a one-hectare field. Although this may seem like a large sum for a peasant farmer, when pre-harvest rice losses typically amount to one fifth or more of the crop, the fence pays for itself in a single season.

Rice is the world's most important food crop and yet rodents, including rats, mice and bandicoots, devour between 80 and 100 million tons of it a year -- enough to fed 500 million people. Rats thrive in the rich wet environment of rice paddies, digging their burrows into the paddies' dividing banks. Despondent farmers have resorted to extreme methods for controlling these pests with little success: poison, flame-throwers, sticky traps, and barn owls. In some parts of Asia, farmers surround their fields with dangerous high-voltage electric wires. In the Philippines 15 accidental deaths have resulted from electrocution. IRRI believes that the active barrier system may prove to be worth the investment in terms of human life, eliminating the use of dangerous electric wires. A Filipino farmer confirmed that an added benefit of the new system was the rats themselves. Rice-fed rat is considered a delicacy by many, as well as a protein source.

Women Profit From Rice Micromill

IRRI has designed a time- and money-savings portable rice micromill to replace hand-pounding, a difficult task often done by women. In Central Luzon, Philippines, women account for 79% of the hired labor for irrigated rice and 55% for rainfed rice. Their earnings, however, do not reflect this fact with the biggest share of profits going to rice millers and traders.

Before the IRRI micromill, women had to walk 2 to 6 miles to the nearest commercial rice mill. Hauling rice to the mill can cost up to one-fourth its value. Women who couldn't afford to have their rice milled had to pound it by hand, which takes 30-40% of their time each day.

Today, three women's groups from remote villages in Matalom, Leyte, Philippines, are sharing an IRRI micromill. Together, they are milling rice for neighbors and farmers from nearby villages. In just two months, each women's group has earned $45 to $75 profit from their milling activities. The profits are being channeled back to the members as low-interest loans for household needs and rice farming expenses, such as labor and fertilizer. IRRI is still assessing what the micromill will mean in terms of increased income for women and their households. What is more obvious is the substantial reduction in the drudgery of pounding rice by hand. The micromill can process 50 kilograms of rice per hour while it takes a women approximately half a day to hand-pound 5 kilograms of rice.

The micromill is portable, costs less than a new color TV, and can be driven by either an electric motor or an internal combustion engine. It is as efficient as the traditional commercial village mills. IRRI is testing the micromill in other parts of Asia and adapting it to each country's village rice milling needs.

Wet-Seeded Rice Saves Money, Labor and Water

IRRI has assisted farmers in the irrigated areas of several Asian countries to adopt the wet seeding method of rice crop establishment in place of traditionally transplanted seedlings. Wet seeding is the practice of sowing pregerminated rice seeds on puddlied soil. This saves time because farmers don't have to spend extra days growing seedlings for transplanting. The seed is

commonly broadcast which farmers can do themselves without hiring labor for transplanting -- saving labor costs while minimizing physical exertion.

Wet-seeded rice matures earlier because the plants do not need to recuperate from uprooting and transplanting shock. It also yields significantly better under water-short conditions. One wet-seeded experiment in Central Luzon, Philippines, yielded 1 ton more rice/hectare than transplanted rice despite 20 days without water during the reproductive stage, when plants are most sensitive to lack of water. Wet-seeded rice is also more water-efficient than transplanted rice. Farmers use 20% less water because water seeding takes only 7 to 10 days of water-intensive land preparation compared to 25 to 30 days for transplanted rice. Wet seeding offers a significant potential for improving the water-use efficiency of rice grown in irrigated areas. This is especially important because irrigation water will become a critically limiting factor in the coming years.

Farmers in several Asian countries are now wet seeding their rice. For example, almost 70% of the farmers in District I of the Upper Pampanga River Integrated Irrigation System in Central Luzon, Philippines, have switched to wet seeding. These farmers made an average of 15% more profits than those who transplanted their rice.

- Wheat -

Durable Resistance to Wheat Leaf Rust

Leaf rust is the most devastating disease of wheat worldwide causing hundreds of millions of dollars in crop damage every year. For years, CIMMYT's approach to combatting this disease has been to invest heavily in "maintenance breeding" aimed at producing a steady stream of new varieties that can replace older ones as they succumb to mutant forms of the disease fungus. In recent years, CIMMYT's strategy has changed to emphasizing combinations of genes that provide "partial resistance" to leaf rust. CIMMYT's breeding program is allowing the wheat and rust to co-exist which prevents the rust from mutating into more virulent forms. While some rusting still occurs, the progress of the disease is slowed so that yield is largely unaffected. The result is rust resistance that is long lasting. Improved wheat varieties have withstood epidemic leaf rust outbreaks for twelve years now without the use of chemical pesticides.

The development of rust resistant wheat has tremendous economic implications for farmers, food processors and consumers world-wide. Wheat is the second most important food crop in the world. Rust resistance will enable farmers to expand wheat production to many areas of the humid tropics were leaf rust flourishes. It will also help stabilize crop yields and wheat prices.

Pakistan Releases Salt-Tolerant Wheat Varieties

One consequence of the rapid growth in irrigation in Pakistan and other South Asian countries has been increasingly salty soils. CIMMYT researchers have transferred the salt tolerance of a wild grass to wheat creating high-yielding varieties that flourish in saline soils. Pakistan researchers have been quick to see the potential benefits of these new wheats, and after careful testing have released two new varieties, Pasban 90 and Rohtas 90. Both varieties are rust resistant, well adapted to varied environments, have grain that is popular with consumers, and have shown a 14% increase in yields over the long-time favorite, Pak-81. The new wheat seed is destined for

poor farmers in Punjab Province who are working soils in which excess salt now limits production. Wheat is by far Pakistan's most important crop accounting for three times the area and twice the value added share of the next two major crops, cotton and rice. Wheat supplies 72% of the calories and protein in the average diet.

Wheat Impact Study in Syria

There has been a net increase in Syrian wheat production due to the adoption of improved technology in 1991 valued at $240 million. New high-yielding wheat varieties developed under a Syria/ICARDA/CIMMYT (International Maize and Wheat Improvement Center) program cover nearly 100% of the irrigated and high rainfall production areas and contributed approximately 15% to the total increased value. Total wheat acreage did not increase.

LEGUME CROPS

- Beans -

Mexican Bean Weevil Resistance

For years, CIAT has been trying to breed genetic resistance into beans to control the Mexican bean weevil, a seed pest that devours 25% of the beans stored in Africa and 15% in Latin America. After testing 10,000 domesticated beans for weevil resistance, not a single bean variety survived attack. It wasn't until CIAT scientists used seeds collected 20 years earlier by a USDA scientist, Dr. H. S. Gentry, that resistance was found. Dr. Gentry had the foresight to recognize that a wild bean vine, considered a useless weed at the time, had genes that might be invaluable to future generations.

CIAT scientists fed these wild beans to weevils and they starved to death. Researchers from the University of Wisconsin discovered that this wild bean carried a new protein not present in domesticated varieties that blocked the weevil's digestion without an adverse effect on humans. They named the protein arcelin, after the Mexican village, Arcelia, where Dr. Gentry found the wild beans. CIAT has since bred the arcelin protein gene into 160 experimental varieties and is training national program scientists in Africa and Latin America to test and select farm varieties that carry the resistant gene. To date the resistance has been stable across regions. The arcelin genes will offer farmers an inexpensive, nonchemical means of control. Dollar savings may reach hundreds of millions annually.

- Chickpeas -

Benefits of Winter Sown Chickpeas and Their Effect on Women

The ICARDA/ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Kabuli Chickpea Project has been working to breed a better chickpea by crossing modern varieties with their "wild" ancestors who have desirable cold and drought-resistant qualities. Six kabuli chickpea cultivars have been developed and released in Morocco, Pakistan and Turkey. The cultivars all have resistance to ascochyta blight -- a constraint to winter production. Morocco and Turkey have released them for winter sowings where the crop is normally spring-sown. Adoption of winter chickpeas in the Mediterranean region has increased from 10,000 hectares in 1990/91 to more than 30,000 hectares in 1991/92.

Winter sown chickpeas produce yields 154-243% greater than spring sown chickpeas. Higher yields, however, mean increased labor requirements of women. Tunisian women, for example, make up 50% of the total agricultural labor force and 60% of the temporary hired labor. On small, poor farms, additional family labor would be required for winter sown chickpeas, increasing the already heavy workload of woman without increasing direct remuneration. On larger farms, new employment opportunities for hiring women would be created.

LEGUME CROPS

- Lentils -

U.S. Farming Community Receives New Lentil Variety

The Idaho and Washington state farming community has received a new lentil variety called "Crimson." The Crimson lentil is derived from Egyptian germplasm provided to the U.S. Department of Agriculture and Washington State University by ICARDA. The Crimson lentil is equal to or better than "Redchief", the most commercial variety in this grain class, due to its drought tolerance, earliness of maturity, upright growth habit important for mechanized harvesting, and good yield.

- Pigeonpeas -

World's First Hybrid Pigeonpea Released in India

The world's first hybrid pigeonpea was released in July 1991 in central and peninsular India. The variety, ICPH 8, developed by ICRISAT, is a landmark in ICRISAT's efforts to improve global pigeonpea production. ICPH 8 yields 30 to 40% more than conventional open-pollinated cultivated varieties, has more pods per plant and more peas per pod. It requires only half the usual time to mature which means that fungal and viral diseases to which it is susceptible have less time to damage the crop. It can also be harvested several times during the year and used in crop rotation systems -- taking advantage of pigeonpea's ability to harbor beneficial soil bacteria. ICPH 8 is suitable for cultivation in land now considered marginal due to its tolerance for abnormally dry or wet conditions.

Following the release, private- and public-sector seed companies have shown keen interest in the technology. ICRISAT has distributed parental seed of ICPH 8 to thirteen seed companies and one research organization in India. A leading private seed company, Maharashtra Hybrid Seeds, in Maharashtra, is marketing ICPH 8 seed. A network involving ten Indian agricultural universities and the Indian Council of Agricultural Research has also been established to spread the technology and produce and evaluate new pigeonpea hybrids.

Pigeonpea's Potential in the United States

ICRISAT has provided the University of Georgia with seed of both improved pigeonpea germplasm and wild relatives of pigeonpea. The University is attempting to generate basic genetic pigeonpea information and stimulate the commercial production of green peas and dry grain. The release of these varieties in Georgia and in other states such as Mississippi, indicate that pigeonpeas can be grown successfully in the southern United States. In addition to human and livestock consumption, scientists in Georgia believe that pigeonpeas can be used as food for wildlife, such as quail and deer. ICRISAT has also provided pigeonpea germplasm to the University of Florida to develop varieties which will mature in a short period of time and be amenable to mechanized harvesting. Such cultivars will be suitable for commercial production in areas of Florida where soybean is not a profitable crop.

ROOT & TUBER CROPS

- Cassava -

"Super Cassava"

Cassava has undergone a breeding breakthrough that may be a key to combating famine in Africa. IITA plant breeders have capitalized on cassava's attributes by crossing cultivated varieties with a wild species to produce plants with up to four times the normal number of chromosomes. These extra chromosomes have resulted in tremendous increases in yield and the title "super cassava". When super cassava is grown under typical field conditions, yields range from 50 to 70 tons/hectare. Cassava varieties typically grown by African farmers yield an average of 12 tons/hectare.

Cassava has been described as Africa's best hope for overcoming famine. It is rich in calories, grows best in poor soils, does not require fertilizer, can survive drought when other crops fail, and the edible tubers can be kept in the ground for over a year and dug up as needed. Cassava could also replace current industrial and feed use of maize (a very drought-sensitive crop), thus leaving more maize for food consumption. A recent survey in six countries showed that in half of the 275 African villages that had not experienced famine, cassava was the main crop. Of the villagers, 30% said they were growing more cassava as a safeguard against famine, 25% due to growing population, and 20% cited good local market prices.

Cassava Processing Technology Benefits Women

IITA has developed a package of cassava processing equipment to reduce the processing time and increase efficiency and quality of the final product. The equipment includes a peeling knife, enabling the roots to be peeled more quickly, and machines for grating, chipping, drying, and sifting cassava, and also a stove with fryer. About 40 villages in the Bauchi state of Nigeria are now using this equipment. Results have been dramatic. Women's labor productivity has increased fourfold. A ton of cassava can now be grated in six hours, a chore that previously took 25 hours. Women's average incomes have also increased by 337%, markedly improving their quality of life. The amount of cassava lost during processing has been halved, from 22 to 10%. The quantity of fuelwood required to fry a given amount of cassava has also been reduced by more than 25%, saving processing costs and conserving topical forests. The equipment package is made commercially at prices that small-scale farmers can afford. It continues to attract interest and is currently being installed elsewhere in Nigeria, Ghana and Cameroon.

Parasitic Wasps, Not Pesticides, Control Cassava Mealybug

Cassava is a major food for more than 200 million Africans. Recently, total cassava production in Africa has doubled in spite of severe drought. The gains in production are attributable to the availability of improved high-yielding, disease resistant varieties originating from IITA, and a joint effort by IITA and CIAT (International Center for Tropical Agriculture) to manage the cassava mealybug with biological control.

Cassava and it's nemesis, the cassava mealybug, are not native to Africa. Portuguese traders brought them to Africa 400 years ago. Since then, no natural enemies of the cassava mealybug have evolved to keep it under control. IITA requested CIAT's assistance to identify its natural enemies (parasitic wasps) in its native Latin America. CIAT scientists collected and shipped the wasps to

Africa where IITA found a way to package and drop them into affected areas by airplane. IITA found additional natural enemies of the mealybug in South America that were eventually released in Africa. These measures increased cassava production by 2 tons/hectare. The benefit/cost ratio of this research is estimated at 149:1 with over $2 billion in benefits to African farmers. Nigeria is now the world's largest cassava producer surpassing Brazil and Thailand.

- Potatoes -

"Hairy Potato" Reduces Insecticide Use

CIP has just recently advanced its goal of reduced insecticide use in potatoes with the development of the "hairy potato". Potatoes, the fourth leading food crop in the world, are the heaviest user of chemical pesticides, negatively affecting an estimated three million people a year. CIP and Cornell University have combined cultivated potatoes with a descendent of a non-edible wild species to produce the hairy potato.

The hairy potato has tiny sticky hairs on its leaves and stems (not the edible tubers) that trap and kill aphids, beetles and other insect pests like fly paper. According to reports from Canada and Italy, the new cultivars also show resistance to late blight, the crop's principal disease problem and cause of the potato famine in Ireland in the 1800's. By reducing the need for insecticides, the hairy potato will lower production costs and alleviate environmental problems. Both steps will help encourage production of this nutritious crop which has tremendous potential for keeping developing nations better fed.

Lowland Potato Production in the Philippines

The Philippine Department of Agriculture has begun promoting lowland potato production following several years of testing in collaboration with CIP. Farmers from 15 communities are obtaining yields upwards of 25 tons/hectare and a return on investment exceeding 500%. Until recently, potato production was limited to highland regions of the country. The success of the program is attributed to the availability of heat and insect resistant clones and to a strong local extension service.

True Potato Seed Technology Reduces Fungicide Use in Indonesia

The use of improved CIP true potato seed (TPS) cultivars (potatoes grown from seeds instead of tubers) throughout the Lembang area of Indonesia has led to a 50% reduction in the use of fungicides since their introduction. Many potato diseases are transmitted by tubers used for new plantings. Cultivars developed from TPS are more disease free. Since these cultivars mature about 15 days later than the farmers' standard variety, Granola, CIP is now testing other recently introduced TPS varieties that mature in the same amount of time as Granola. This 15 day difference dramatically cuts the need for spraying fungicides. CIP scientists estimate that these new early maturing varieties will cut the already reduced fungicide application by another 25%. This translates into and overall savings of $180/hectare, roughly 10% of the cost of production.

ROOT & TUBER CROPS

Controlling Potato Weevil with Integrated Pest Management

The number one potato insect pest of the Andes in South America is the potato weevil whose control costs exceed $100 million annually. Until recently, Andean farmers either had to live with the weevils and take their losses or use chemical pesticides to control them. Now, local government officials in the Chincheros area of southwest Peru are encouraging farmers to control the potato weevil using CIP-developed integrated pest management practices. Among these is a naturally occurring fungus which is available locally, environmentally safe, but deadly to weevils. Initially there were a small number of producers who participated and learned how to best use the fungus. Two years later, more than 200 active farm families, virtually the entire community, are using the fungus to control the potato weevil. The technology is spreading with local NGOs and women's groups getting involved. By 1994, CIP expects the technology will have spread to many corners of the Peruvian highlands.

VEGETABLE CROPS

Introduction of Kangkong to Bangladesh

In April 1991, Bangladesh was ravaged by a cyclone. Farmers lost both their crops and valuable seed stores. Horticulturists from the Bangladesh Agricultural Research Institute (BARI) and AVRDC jointly recommended the introduction of a leafy green vegetable called kangkong to restore food security to Bangladesh. AVRDC provided kangkong seed to BARI who distributed it to 900 farmers. Since kangkong can be conveniently multiplied by cuttings, farmer-to-farmer dissemination was widespread leading to quick adoption.

Kangkong is a hardy, fast growing, disease tolerant vegetable that can be raised throughout the year. It is rich in vitamins and minerals that are chronically deficient in Bangladeshi diets. Farmers liked kangkong's flavor and texture which ensured its adoption as a nutritious addition to kitchen gardens. Farmers were also quick to put kangkong to other uses such as a feed supplement for cattle and poultry. During the monsoon months when other vegetables are scarce, kangkong represented up to 50% of the volume of vegetables available in local markets, benefiting both farmers and consumers.

Biological Control of Diamondback Moth

The Diamondback moth (DBM) is a serious constraint to cabbage, broccoli, radish and cauliflower worldwide. It has been estimated that $1 billion is spent each year to control this pest. DBM is a remarkably adaptable insect that has developed resistance to most insecticides used against it. AVRDC scientists have successfully combated this pest by using two natural parasites to control it. The parasites are reared in simple net cages and released in the field. Pesticide costs have been reduced by 60 to 80%. Scientists from Taiwan, Malaysia, Indonesia and the Philippines have been trained at AVRDC in this technology and are now leading national DBM control efforts in their respective countries.

Improving Mungbeans

AVRDC has initiated the development of a molecular map of mungbean to determine the chromosome segments strongly associated with important agronomic characters like seed size, and resistance to pest such as mungbean yellow mosaic virus, cercospora leafspot, powdery mildew and bruchid beetle. The molecular map will help plant breeders develop improved mungbean varieties.

Bruchid beetles are a serious seed storage pest of mungbeans. Seed treatment with insecticides is inappropriate as the pesticides render the mungbeans unfit for human consumption. AVRDC has found resistance to the beetle in a related wild species of mungbean. The transfer of the resistance genes to cultivated mungbean varieties is in the advanced stages of development.

Mungbean is considered a minor commodity in developed countries but is a very important food legume in Asia where more than 90% of the crop is grown. During the monsoon season when green vegetables are scarce, nutritious mungbean sprouts can be germinated in the kitchen in a matter of days. In 1991, at least 730,000 hectares of AVRDC mungbeans were harvested in East Asia alone.

LIVESTOCK

Fodder Banks Boost Farm Production

Animals that depend solely on natural vegetation for nutrition suffer heavy weight losses and low fecundity. The problem is exacerbated during the dry season when grazing is scarce. To overcome these constraints, ILCA has used fodder banks -- small, densely planted pastures of nitrogen-fixing plants (legumes) -- as an appropriate feed improvement technology. Fodder banks boost livestock production by providing high-quality feed while also increasing crop production in later years by improving the soil. Early on-farm results indicate that cattle grazing on fodder banks lost less weight and produced more milk. Calf survival was increased by 20%. Today, close to 600 Fulani herd owners in Nigeria are using the technology.

The fodder banks can also have a positive contribution to food grain production. Maize grown on land that had been under a fodder bank for two years yielded more than 3 times as much grain as that grown on previously fallowed land. Two-year old fodder banks doubled soil nitrogen content and increased dramatically all measures of soil quality, reduced rainfall run-off and soil erosion.

Controlling East Coast Fever Through Infection and Treatment

East Coast fever is a virulent and often fatal tick-borne disease that threatens 25 million animals and is a severe constraint to livestock development in Africa. Advanced technologies for the characterization of pathogenic tick-borne disease organisms by ILRAD are leading to the identification and deployment of vaccine strains for improved East Coast fever control, by the infection and treatment method of immunization.

In Zanzibar, in collaboration with the government, approximately 1,000 cattle of improved genetic types have been successfully immunized with the local vaccine strain. Similarly, in Zambia, over 55,000 calves have been immunized. Mortalities due to East Coast fever amongst immunized animals were reduced to 0.5%. Immunized heifers showed normal calving rates and calf mortality has been reduced from 35% to 3%.

Development of a Vaccine for East Coast Fever

ILRAD has entered into a collaborative agreement with Smith Kline Beecham to enhance ILRAD's capacity in molecular vaccine production against East Coast fever. The collaboration provides the U.S. company, the largest producer of veterinary vaccines in the U.S., with increased experience in producing improved vaccines against livestock diseases. Field testing of a vaccine for East Coast fever is expected to commence shortly.

Control of Tick-Borne Diseases

ILRAD is collaborating in research on tick-borne diseases with Washington State University and the University of Florida to define antigens for improved vaccines and diagnostic assays for these diseases. ILRAD has also assisted a University of Florida project on Cowdriosis in Africa through its expertise in cell typing. Control of Cowdriosis and other tick-borne diseases is of direct relevance to the farming community in the United States, providing protection from disease importation from the Caribbean and South America. Cowdriosis is seen as a special threat to cattle owners in the southern U.S.

LIVESTOCK

Bovine Genetic Map

ILRAD and Texas A&M University are collaborating as members of an international network of laboratories seeking to make a bovine genetic map of disease resistance genes and other important production traits. The mapping of these traits are of vital importance to the livestock breeding industry of both developing countries and the United States. Improved selection procedures using genetic markers or introduction of genes into potentially highly productive cattle, through genetic manipulation and enhanced breeding practices, will accelerate the dissemination of important traits, such as tolerance to trypanosomiasis -- arguably the most important livestock disease in Africa constraining production on more than a third of the continent -- for improved livestock productivity.

OTHER

- Biodiversity -

Breakup of Soviet Union Puts Future Food Supply At Risk

IBPGR is working to save the world's largest collection of wild and traditional varieties of agricultural plants. The collection, held by the Vavilov Institute in St. Petersburg, Russia, includes 345,000 samples of barley, rice, vegetables and other basic food and fodder crops. Their loss threatens the security of the future food supply worldwide. The stored seeds carry genes which are crucial in arming crops against pests and in maintaining and increasing food production. In 1944, for example, the United States acquired a wheat accession from the Institute that today is being used by the USDA/Agricultural Research Service to develop the first breeding line of hard red winter wheat resistant to the Russian Wheat Aphid. Since invading the U.S. in 1986, the aphid has caused an estimated $645 million in pesticide cost and yield losses. The new breeding line is set for release this year.

The collapse of the Soviet Union has left the management of six Institute substations, which together hold 25% of the collection, in question. Lack of funding has made it impossible to ensure their maintenance. IBPGR plans to raise a total of $2.5 million to guarantee the security of the collections over the next five years. The funding will cover the costs of multiplying seed in the experiment stations and the purchase of basic storage facilities that are crucial for the collections held in Russia and the Newly Independent States. USAID has pledged $400,000.

The Vavilov collection, established in 1890, is the oldest in the world. At its height, the Institute maintained a network of 17 experiment stations throughout the Soviet republics. The collection survived the World War II Siege of Leningrad where Institute scientists chose to die of starvation rather than eat the tons of rice, peas, corn and wheat. Today, with the breakup of the former Soviet Union, the collection faces a new threat. The management of the six stations located in the Newly Independent States has been devolved to the State governments. In order for the stored seeds to remain viable, they need to be grown out every 5 years. Severe reductions in technical staff (up to 70%), lack of funding, and uncertainty about the States' ability to maintain and regenerate the seed have put the collections at enormous risk. In addition, the storage conditions in the Russian Institute are very poor and refrigeration equipment is urgently needed to ensure the security of material in the main collection.

Plants Stored in Genebanks Are Key To Revitalizing Somali Agriculture

During the recent civil unrest in Somalia, the country's two seed banks, facilities that stored samples of hundreds of varieties of food crops adapted to the country's soils and climates, were looted and today stand empty. Crops grown in the local fields haven't fared much better. Farmers have been forced to eat their seeds, which normally they would save for next year's planting, just to survive. Somalia has been left with the virtual loss of its indigenous crop genetic resources when agriculture is the country's economic mainstay, contributing nearly 70% of GDP.

Fortunately, a duplicate set of some three hundred samples of sorghum and maize (the country's principle crops) was, at the request of the Somali Government, hand carried from the country by IBPGR in 1989 and deposited in the Kenya Genebank. These seeds contain traits adapted to Somalia's particular climatic conditions through generations of cultivation by farmers and could form the basis of the country's future food security. These, along with some materials

currently housed by genebanks of the CGIAR in India and Nigeria, constitute some of the last remaining Somalia germplasm.

Efforts are now underway to produce new seed from genebank samples. However, since seed banks hold only a few ounces of seed of any given variety, the samples must be planted, harvested and replanted to build up the quantities needed to supply Somali farmers. IBPGR estimates that it will take one to two years to meet current demand. In the meantime, the future of Somali farmers will be dependent on the seed of varieties optimally suited to growing in other places.

- National Agricultural Research Systems -

Institutional Building in Bangladesh

Since 1975, IRRI has assisted the Bangladesh Rice Research Institute (BRRI) in building their capacity to develop and deliver relevant rice research findings to farmers. By 1992, BRRI breeders had developed 26 modern rice varieties which account for about 50% of the area planted to rice and produce about 72% of the total rice harvested in Bangladesh. About 93% of rice grown during the dry winter-spring season are modern varieties.

Improving the Effectiveness of Bangladeshi Agricultural Research

The Bangladesh national agricultural research system will place greater emphasis on sustainability and natural resource management, according to their new 10-15 year plan for agricultural research developed in collaboration with ISNAR. Within this context, the plan's main objectives include increasing agricultural productivity, employment, and reducing the annual variations in production.

There are ample grounds for sustainability concerns in Bangladesh, one of the poorest countries in southern Asia. The population, already 110 million is growing quickly, straining the natural resource base. By the year 2010, there will be an additional 60 million mouths to feed. There is virtually no unused cultivable land. Increased production must come from more intensive land use and higher yields. However, intensity of cultivation is already among the highest in Asia and productivity is now falling in the most intensively cultivated areas. Growing evidence suggests that such intensive land use cannot be sustained -- at least not with current technologies. New agricultural technologies are needed if production increases are to be sustained.

Bangladeshi research system leaders are aware of the imperative for action. For the past four years, they have worked in close collaboration with ISNAR to increase the effectiveness of agricultural research. There has been significant progress in research planning and management, particularly in the past year. ISNAR guided a nationally-appointed task force through a systematic procedure for setting research priorities and allocating resources. Also, research leaders have installed a management information system to assist in monitoring research programs, human resources, and budget. For the next step, research leaders plan to put the main provisions of the new strategy into operational terms for the short term (three to five years), incorporating sustainability concerns.

OTHER

Capacity Building of National Agricultural Research Systems

In February 1992, ISNAR initiated the Strengthening the Planning, Monitoring and Evaluation of Agricultural Research in Latin America project. The project will aim first to improve and then to institutionalize the processes of planning, monitoring, and evaluation in national agricultural research systems (NARS). Countries participating in the project are in Central America, the Andean and Southern Cone subregions of South America, and the Caribbean.

A three-day workshop was held in Colombia. Participants included 30 researchers and managers from public- and private-sector institutions. Workshop participants explored the strengths and weaknesses of the regions' NARS and current methods of research planning, monitoring, and evaluation. They revised and endorsed the project's plan of activities; designed the dozen case studies aimed at increasing the region's information base about research-project planning, monitoring, and evaluation that are to be completed by consultants over the next three months; identified priorities for future workshops and training events; and discussed opportunities for the institutionalization of training. Four training workshops are to be held under the project's auspices during 1993. The present phase will end in 1993 and linked to it is the "Monitoring and Evaluation Source Book for Agricultural Research Managers" publication.

- Global Climate Change -

Global Climate Change and Rice Production

Research conducted at IRRI and supported by the U.S. Environmental Protection Agency will document the emission of methane from rice paddies at Los Banos, Philippines, and will identify differences in some cultural practices in emission rates. IRRI will also have evidence of the effect of global change in ultra-violet radiation, CO_2, and temperature on rice production in the tropics. These studies aim to elucidate the mechanisms governing methane release and identify mitigation approaches.

Methane is produced whenever rice is grown in standing water. Bacterial soil decomposition of organic matter in flooded rice produces methane. Most of this methane is broken down by oxidation in the flooded soil, never reaching the atmosphere. However, 80% of the gas that does escape enters the atmosphere by passing from the roots up through the rice plant, which acts as a chimney. Smaller amounts of methane bubble up or diffuse slowly from the soil through the water. Rice cultivation annually releases an estimated 60 million tons of methane into the atmosphere. Flooded ricefields contribute an estimated 10-25% of the 500 million tons of methane emitted into the atmosphere per year. Methane has a global warming efficiency some 30 times greater than that of carbon dioxide.

OTHER

- Policy -

Improving Philippine Corn and Livestock Sector

IFPRI's research on the Philippine government's corn and livestock sectors' policies found that the prevailing trade regime, including controls over prices, production and supplies, resulted in considerable inefficiency and high costs. Liberalization of trade controls could result in a 30 to 40% savings in the cost of feed inputs and a corresponding reduction in the cost of final livestock product, an increase in domestic income from this sector, and an increase in the consumption of protein feeds. These findings strengthened the hands of those who, in an effort to secure an efficient corn and livestock sector, succeeded in replacing trade restrictions or quotas by a system of tariffs as a first major step in trade liberalization.

Bangladesh Food Policy

IFPRI's Bangladesh Food Policy Project examined the public food distribution system and found that 70% of the rural rationing program and 90% of the urban program did not reach the target groups. At the same time the system, including subsidies, constituted about 10% of the total public sector development expenditures. These findings contributed to the Bangladeshi government's decision to suspend rationing systems for food grains and to examine their price stabilization policies to include food procurement for price support and open market sale for maintaining a ceiling price. IFPRI's research also helped the government in deciding on the appropriate level of procurement price which will be consistent with market forces and meet the government's objective of price stabilization. Other research studies under the same project also contributed to Bangladesh's privatization of food procurement. The government decided to replace government-appointed procurement agents by a competitive mode of procurement through open tenders. An independent evaluation of the IFPRI project concluded that it saved $28 million per year while the project costs were $2.8 million for four years.

Facilitating Irrigation Policy Changes in Sudan

In 1991, IIMI hosted two national workshops in Sudan, one on privatization policies in regard to irrigation, the other on policies toward land and water charges. Sudanese participants included researchers, high-level civil servants, and ministers. Owing to IIMI's reputation as a neutral and disinterested party, IIMI was able to facilitate serious and objective discussions of the issues, and expose Sudanese policymakers to a range of experiences from outside the country. Sudan has since made important policy changes in the direction of privatization of irrigation facilities, and introducing market mechanisms for agricultural produce.

OTHER

- Agroforestry -

Hedgerows Protect Against Soil Erosion

ICRAF research in Kenya has clearly demonstrated the soil conservation advantages of planting and managing trees or shrubs in hedgerows on the land's contours. These hedgerows, which in some cases use nitrogen-fixing species, result in the formation of natural terraces that significantly reduce soil erosion. For example, during a typically severe storm when 2 inches of rain fell in 30 minutes, fields with only crops (no hedgerows) lost the equivalent of 34 tons of soil/hectare. By contrast, fields with hedgerows lost no more than 6 tons/hectare.

ICRAF is using this technology with a local multipurpose tree in Uganda and Rwanda where farmers cultivate on slopes as steep as 45%. The trees produce fuelwood, livestock fodder and mulch for crops. Women's farmers groups working with ICRAF scientists in southern Uganda are already enthusiastically adopting this practice.

- Bananas & Plantains -

Banana and Plantain Hybrids Resistant to Black Sigatoka Disease

For the first time in more than 45 years of *Musa* (banana and plantain) research, successful *Musa* hybrids have been produced and accepted for release to producers. Already, three hybrids from the Fundación Hondureña de Investigación Agricóla (FHIA)/Honduras have been tested in the preparatory phase of INIBAP's International *Musa* Testing Program (IMTP) and have been cleared for release as resistant to Black Sigatoka disease. Black Sigatoka disease, caused by a fungus, is the overriding constraint to banana and plantain production worldwide. Yields can be reduced by as much as half. Chemical fungicides are the only current control measure available but small farmers are in no position to use these products which have to be applied up to 45 times per year.

In the second phase of the IMTP, nine sites around the world have been selected for testing resistance to, or tolerance of, Black Sigatoka. A further ten sites are in the course of selection for similar work on *Fusarium wilt*, another disease which is devastating bananas in many parts of the world. Improved germplasm for the IMTP will come from six different breeding programs.

Bananas and plantains provide 400 million people in poor regions of the tropics with as much as 80% of their carbohydrates. They are considered one of the most important food crops for small farmers in the forest zone of Africa due to their high yields, ecologically sound cultivation practices, and rich source of potassium and vitamins A, B, and C.

OTHER

- Irrigation -

Simulation Modelling of Canal Operations in Sri Lanka

IIMI is collaborating in the implementation of a project in southern Sri Lanka to develop a computer model that simulates main canal operations. The management information and communication system developed in the Kirindi Oya project area has, for the first time since project inception, enabled the project managers to provide irrigation to all five tracts in the Kirindi Oya Right Bank Command area, thereby increasing the irrigated acreage by about 500 hectares despite experiencing less rainfall than in the previous season. This was achieved by saving about 10% of irrigation water from the previous season's cultivation.

INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

CGIAR Associated Centers:

CIAT	**International Center of Tropical Agriculture** Cali, Colombia
CIFOR	**Center for International Forestry Research** Bogor, Indonesia
CIMMYT	**International Maize and Wheat Improvement Center** near México City, México
CIP	**International Potato Center** Lima, Perú
IBPGR	**International Board for Plant Genetic Resources** Rome, Italy
ICARDA	**International Center for Agricultural Research in Dry Areas** Aleppo, Syria
ICLARM	**International Center for Living Aquatic Resources Management** Manila, Philippines
ICRAF	**International Center for Research in AgroForestry** Nairobi, Kenya
ICRISAT	**International Crops Research Institute for the Semi-Arid Tropics** near Hyderabad, India
IFPRI	**International Food Policy Research Institute** Washington, DC
IIMI	**International Irrigation Management Institute** Colombo, Sri Lanka
IITA	**International Institute of Tropical Agriculture** Ibadan, Nigeria
ILCA	**International Livestock Center for Africa** Addis Ababa, Ethiopia
ILRAD	**International Laboratory for Research on Animal Diseases** Nairobi, Kenya
INIBAP	**International Network for the Improvement of Banana and Plantain** Montpelier, France
IRRI	**International Rice Research Institute** near Manila, Philippines
ISNAR	**International Service for National Agricultural Research** The Hague, Netherlands
WARDA	**West Africa Rice Development Association** Bouaké, Côte d'Ivoire

CGIAR Non-Associated Centers:

AVRDC	**Asian Vegetable Research and Development Center** Taipei, Taiwan
IBSRAM	**International Board for Soil Research and Management** Bangkok, Thailand

CURRENT IARC/U.S. COLLABORATION

	AVRDC	CIAT	CIMMYT	CIP	IBPGR	ICARDA	ICLARM	ICRAF	ICRISAT	IFPRI
UNIVERSITIES										
Brandeis										
Calif. Polytechnic									x	
Colorado State		x	x							
Cornell	x		x	x	x	x			x	
Iowa State			x							
Johns Hopkins										x
Kansas State			x			x				
Louisiana State										
Michigan State										x
Mississippi State			x							
Montana State			x			x				
New Mexico State			x		x					
North Carolina State			x	x				x		
North Dakota State			x							
Oklahoma State			x							
Oregon State			x					x		
Purdue		x	x			x				
Rockefeller										
Rutgers										x
South Dakota State			x							
Texas A&M			x							
Tufts										x
Tuskegee										
Univ. of California			x			x			x	
Univ. of Georgia		x							x	
Univ. of Florida			x		x				x	
Univ. of Illinois										
Univ. of Kentucky									x	
Univ. of Minnesota	x		x							
Univ. of Missouri			x							
Univ. of Nebraska			x							
Univ. of Wisconsin	x							x		
Univ. of Wyoming										
Utah State			x							
Yale										x
Virginia Polytechnic										
Washington State	x	x	x			x			x	
INSTITUTIONS										
Boyce Thompson Institute		x			x					
Seattle Biomed. Res. Inst.										
Scripps Clinic										
Smith Kline Beecham										
Winrock International										
GOVT. AGENCIES										
EPA										
NASA										
NOAA							x			
USDA				x		x				

CURRENT IARC/U.S. COLLABORATION

	IIMI	IITA	ILCA	ILRAD	INIBAP	IRRI	ISNAR
UNIVERSITIES							
Brandeis	x						
Calif. Polytechnic							
Colorado State			x	x			
Cornell	x					x	
Iowa State							
Johns Hopkins							
Kansas State						x	
Louisiana State			x				
Michigan State		x					
Mississippi State							
Montana State					x		
New Mexico State							
North Carolina State							
North Dakota State							
Oklahoma State							
Oregon State		x					
Purdue		x				x	
Rockefeller				x			
Rutgers							
South Dakota State							
Texas A&M			x	x		x	
Tufts							
Tuskegee		x					
Univ. of California				x	x	x	
Univ. of Georgia						x	
Univ. of Florida				x	x		
Univ. of Illinois							x
Univ. of Kentucky							
Univ. of Minnesota					x		x
Univ. of Missouri						x	
Univ. of Nebraska							
Univ. of Wisconsin	x		x				
Univ. of Wyoming				x			
Utah State			x				
Yale							
Virginia Polytechnic							x
Washington State				x		x	
INSTITUTIONS							
Boyce Thompson Institute							
Seattle Biomed. Res. Inst.				x			
Scripps Clinic						x	
Smith Kline Beecham				x			
Winrock International				x			
GOVT. AGENCIES							
EPA						x	
NASA		x					
NOAA							
USDA						x	

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