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Narrator: AGRICULTURE PROVIDES US
WITH THE FOOD WE NEED TO SURVIVE.
TO KEEP PACE WITH AN
EVER-GROWING POPULATION
SCIENTISTS CREATED NEW SEED VARIETIES
THAT PROVIDED OUTSTANDING YIELDS
BUT ALSO REQUIRED INCREASED INPUTS --
MORE FERTILIZER AND MORE PESTICIDES --
BUT AT WHAT COST TO THE ENVIRONMENT?
PETER KENMORE
OF THE UNITED NATIONS FOOD AND AGRICULTURE
ORGANIZATION
HAS BEEN WORKING WITH
FARMERS FOR 30 YEARS
TO DECREASE THE USE OF
PESTICIDES IN RICE PRODUCTION.
Dr. Kenmore: WE HAVE BEEN ABLE BASICALLY
TO SUBSTITUTE BRAINS FOR CHEMICALS.

AND IN THAT SENSE
THE GROWTH RATE STAYS UP BUT
LESS CHEMICALS ARE USED.
Narrator: IN THE YAQUI VALLEY OF
MEXICO
RESEARCHERS ARE FINDING
THAT EXCESS FERTILIZER
RUNOFF FROM WHEAT CROPS
IS AFFECTING MARINE LIFE IN THE
GULF OF CALIFORNIA.
SO THEY ARE TURNING TO
TECHNOLOGY
TO DECREASE FERTILIZER INPUTS
WITHOUT DECREASING YIELDS.
Dr. Ortiz-Monasterio: TECHNOLOGY
LIKE THIS
CAN RESULTIN A WIN-WIN
SITUATION
WHERE THE FARMER BENEFITS
AND AT THE SAME TIME THE
ENVIRONMENT BENEFITS.
Narrator: BY SHOWING FARMERS
HOW TO REDUCE PESTICIDE AND
FERTILIZER USE
BOTH RESEARCH TEAMS HOPE TO
MINIMIZE ENVIRONMENTAL
IMPACTS
WHILE STILL PRODUCING ENOUGH
FOOD FOR OUR GROWING
POPULATION.

A STAPLE THROUGHOUT THE

GLOBE, RICE IS AN ESSENTIAL CROP
PROVIDING 60% OF THE CALORIES FOR HALF OF THE WORLD'S POPULATION.
DR. PETER KENMORE
OF THE FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS IN ROME, ITALY
HAS BEEN CONDUCTING RESEARCH ABOUT RICE PRODUCTION
IN COUNTRIES IN SOUTHEAST ASIA FOR 30 YEARS.
Dr. Kenmore: RICE, NOW AND PROBABLY FOR THE LAST 4,000 OR 5,000 YEARS
FEEDS MORE INDIVIDUALS OF THE SPECIES HOMO SAPIENS
THAN ANY OTHER FOOD.
EVOLUTIONARILY, WHY IS IT A GOOD BET?
BECAUSE IT GROWS IN PLACES THAT ARE FLOODED.
YOU CAN GROW IT IN PLACES WHERE OTHER CROPS WON'T GROW.
FLOODING TENDS TO KILL MOST OF THE WEEDS
THAT WOULD GROW UP AND COMPETE WITH THE RICE

SO YOU HAVE GOT AN ADDED ADVANTAGE.
SO YOU CAN PUT IT
INTO WHAT WOULD OTHERWISE BE A MARGINAL ENVIRONMENT.
RICE HAS BEEN A GOOD BET, AND YOU'VE GOT LOADS OF PLACES WHERE FOLKS HAVE BEEN ABLE TO COUNT ON A HARVEST.
Narrator: RICE SUCCESSFULLY FED HUMANS FOR THOUSANDS OF YEARS.
BUT IN THE MIDDLE OF THE 20th CENTURY
POPULATION GROWTH EXPLODED, OUTPACING FOOD PRODUCTION.
TO HEAD OFF POTENTIAL FOOD SHORTAGES
GOVERNMENTS ENCOURAGED AND EVEN MANDATED FARMERS TO CHANGE THEIR PRACTICE
REQUIRING FERTILIZERS TO STIMULATE GROWTH
ALONG WITH PESTICIDES TO CONTROL THE INSECTS
THAT EAT RICE PLANTS.
BUT THE RESULTS WERE SURPRISING.
Dr. Kenmore: PESTICIDES SOMETIMES CREATED
A CONTRADICTORY RESULT
WHICH WAS YOU SPRAYED

INSECTICIDES IN THE RICE FIELD
AND YOU GOT 500 TO 1,000 TIMES
MORE INSECTS
THAT WERE EATING RICE
THAN YOU HAD WITHOUT THE
INSECTICIDE.
SO THAT'S A MYSTERY.
AND FROM THAT TIME ON
ALL THROUGH SOUTH AND
SOUTHEAST ASIA
EVERY YEAR DIFFERENT
COUNTRIES WOULD REPORT
PROBLEMS LIKE THIS.
THE FIRST RESPONSE WAS SPRAY
MORE.
AND THAT CREATED OFTEN MORE
OF A PROBLEM.

Narrator: WHY WOULD USING
PESTICIDES CREATE MORE
PESTS?
Dr. Kenmore: THE BEGINNING OF
THE SOLUTION OF THE MYSTERY
IS TO SEE THERE ARE NOT JUST
TWO ECOLOGICAL TROPHIC
LEVELS.
IT ISN'T JUST THE RICE AND THE
THINGS THAT EAT RICE.
THERE'S THE RICE, THE THINGS
THAT EAT RICE
AND THE THINGS THAT EAT THE
THINGS THAT EAT RICE.

SO YOU HAVE THREE LEVELS.
AND WHEN YOU SPRAY, YOU KILL BOTH TOP LEVELS
EXCEPT FOR THE EGGS OF THE PESTS THAT ARE INSIDE THE RICE.
WHEN THEY HATCH ,THERE'S NOTHING TO EAT THEM
AND THEY GO ON HAPPILY REPRODUCING
AND YOU GET A POPULATION EXPLOSION.
IT MEANS THAT THE PEST POPULATION
IS FREED FROM ITS NATURAL CONTROLS
AND THAT'S WHAT HAPPENED IN RICE.

Narrator: THESE FINDINGS LED KENMORE TO
PROMOTE NATURAL ALTERNATIVES TO PESTICIDES
FOR VARIOUS CROPS
AN APPROACH KNOWN
AS INTEGRATED PEST MANAGEMENT, OR IPM.
IPM RELIES ON DETAILED KNOWLEDGE OF PESTS
AND HOW THEY INTERACT WITHIN THE ECOSYSTEM
TO HELP DETERMINE THE BEST

WAY TO CONTROL THESE INSECTS
WITH THE LEAST DAMAGE TO THE ENVIRONMENT.
Dr. Kenmore: INTEGRATED PEST MANAGEMENT
ACCEPTS THERE WILL ALWAYS BE SOME PESTS IN EVERY FIELD.
IF THERE'S A LOW NUMBER OF PESTS
THEY PROVIDE FOOD FOR THE NATURAL ENEMIES.
IF THERE'S TOO MANY PESTS, ONE SHOULD INTERVENE.
SOMETIMES ONE CAN INTERVENE WITH A BIOLOGICAL INTRODUCTION
WHICH CAN BE, FOR EXAMPLE, A PATHOGEN
LIKE A VIRUS OR BACTERIA THAT EATS INSECTS.
SOMETIMES, IN RARE CASES, ONE CAN INTERVENE
BY INTRODUCING AN INSECT FROM A DIFFERENT PLACE
WHO WILL THEN NATURALLY GO IN, EAT PESTS, REPRODUCE
AND STAY IN THE FIELD EATING THE PESTS FROM THEN ON.
AND IN THE LAST STEP -- PESTICIDES
ONLY WHEN THE NATURALLY

OCCURRING PEST CONTROL
ISN'T KEEPING THE PESTS TO THE
DESIRED LEVELS.

INTEGRATED PEST MANAGEMENT
USES ALL OF THESE
APPROACHES.
IT TRIES TO AVOID DISRUPTING
THE NATURAL ECOSYSTEM OF
THAT CROP FIELD.

Narrator: THE NEXT CHALLENGE
FOR KENMORE AND HIS TEAM
WAS TO PERSUADE RICE
FARMERS
WHO HAD BEEN USING
PESTICIDES FOR YEARS
TO ADOPT THIS APPROACH.
Settle: NOW, YOU MIGHT SAY, AS
PEOPLE DO
IF PESTICIDES ARE SO BAD FOR
THE SYSTEM
WHY ARE THE FARMERS
CONTINUE USING IT?
IT'S NOT OBVIOUS TO THE
FARMER WHAT'S GOING ON IN
THIS SYSTEM.
THEY DON'T HAVE A MEANS OF
COMPARING
WHAT WOULD OR WOULD NOT
TAKE PLACE
WITH OR WITHOUT PESTICIDES.

Narrator: TO HELP INTRODUCE
THESE ALTERNATE APPROACHES
TO THE FARMERS
THE RESEARCHERS STARTED
FARMER FIELD SCHOOLS.
BILL SETTLE SUPERVISES THESE
SCHOOLS
IN SOUTHEAST ASIA AND WEST
AFRICA.
Settle: I WORKED IN 20 COUNTRIES
WITH THIS PROGRAM.
AND MOST FARMERS THINK
THAT ANYTHING THAT IS
CRAWLING IN A RICE FIELD
IS POTENTIALLY DAMAGING THE
RICE.
THEY THINK THAT ANY LITTLE
DAMAGE TO THE RICE PLANTS
IS GOING TO RESULT IN YIELD
LOSS.
SO THERE'S A LOT OF INHERENT
FEAR
WITH REGARDS TO THE NATURE
IN FRONT OF THEM.
SO TO TELL THEM NOT TO BE
USING PESTICIDES
AFTER "WE" HAVE BEEN TELLING
THEM TO USE PESTICIDES
FOR THE LAST 40 YEARS, SINCE
THE 1960s AND '70s
IS DIFFICULT.

WHAT WE DO IN OUR TRAINING PROGRAMS
IS HELP THE FARMERS
DEMONSTRATE FOR THEMSELVES
WHAT'S GOING ON
BY DOING SIMPLE EXPERIMENTS.
Narrator: EXPERIMENTS ARE DESIGNED
FOR FARMERS TO BE ABLETO
OBSERVE AND UNDERSTAND
HOW PESTS ARE CONTROLLEDIN
A SYSTEM WITHOUT PESTICIDES.
Settle: WE START WITH TWO PLOTS.
ONE IS THE CONVENTIONAL PLOT
WHERE THEY DO WHAT THEY NORMALLY DO
THEY APPLY THE INSECTICIDES
LIKE THEY NORMALLY WOULD.
THE OTHER PLOT IS SOMETHING
THAT IS THE EXPERIMENTAL PLOT.
CALL IT THE IPM PLOT.
AND EVEN THERE WE DON'T TELL THEM WHAT TO DO
BUT WE SORT OF SUGGEST
"WELL, LET'S TRY NOT USING PESTICIDES
AND SEE WHAT HAPPENS."
AND SINCE NO ONE PERSON IS
INVESTED IN THE OUTCOME --
IT'S A GROUP PLOT OF LAND THAT
WE ARE SUPPORTING --

THERE'S NO RISK ASSOCIATED WITH IT.
Dr. Kenmore: AND THEY START BY LOOKING AT THE CROP
LOOKING AT THE SIZE AND QUALITY OF THE PLANTS
AND THEN BY LOOKING AT THE DIFFERENT KINDS
OF INSECTS AND FUNGI THAT ARE OBSERVED
BRINGING SAMPLES BACK, AND THEN EACH WORKING GROUP
GIVING A MINI SEMINAR TO THE WHOLE FIELD SCHOOL
ON WHAT THEY OBSERVED IN THE FIELD.

Narrator: ALTHOUGH SIMILAR TO KENMORE'S FINDINGS
THE FARMERS' RESULTS OFTEN SURPRISE THEM.
IN UNTREATED FIELDS, HERBIVORES THAT ATE RICE PLANTS
WERE KEPT UNDER CONTROL BY NATURAL PREDATORS.
BUT IN FIELDS WHERE PESTICIDES WERE USED
PLANT-EATING HERBIVORES GREW AT TREMENDOUS RATES
SINCE THE POPULATIONS OF THEIR NATURAL PREDATORS

WERE GREATLY REDUCED BY THE PESTICIDES.
Dr. Kenmore: WHY FARMERS DOING EXPERIMENTS IS SO IMPORTANT IS THEY GET TO TEST WHAT THEY HAVE BEEN TOLD
SO THAT IT PUTS THEM IN THE POSITION
OF BEING THE CRITICAL PEER REVIEWER
OF THE ASSERTIONS COMING FROM THE TRAINER.
Narrator: FARMERS ARE ENCOURAGED
TO MOVE BEYOND THEIR INITIAL SCIENTIFIC OBSERVATIONS
BY CREATING EVEN MORE ROBUST EXPERIMENTS.
ECOSYSTEM STUDIES CALLED INSECT ZOOS
ARE DESIGNED TO DETERMINE HOW VARIOUS BUGS WILL AFFECT THE RICE FIELDS.
Dr. Kenmore: THEN YOU SAY, "WELL, I'VE GOT A BUG HERE
"WHICH NOBODY KNOWS THE NAME OF, SO WE GOT TO TEST IT. IS IT GOING TO EAT RICE, OR IS IT GOING TO EAT BUGS?"
SO YOU PUT IT INTO A CAGE WITH RICE AND BUGS
AND YOU SEE WHAT IT EATS.

[SPEAKING NATIVE LANGUAGE]
Settle: SHE'S SAYING THAT THIS IS A DRAGONFLY
AND THAT IT'S USEFUL FOR EATING BROWN PLANT HOPPERS AS WELL AS OTHER PESTS.
Narrator: ANOTHER SET OF EXPERIMENTS
HELPS FARMERS UNDERSTAND HOW MUCH INSECT DAMAGE THE PLANTS CAN SUSTAIN
AND STILL PRODUCE ECONOMICALLY VIABLE YIELDS.
Dr. Kenmore: IF YOU TAKE 50% OF THE LEAVES OFF A RICE PLANT WHEN IT'S A MONTH OLD
WILL THE YIELD OF THAT CLUMP BE ANY DIFFERENT
FROM THE YIELD AT THE END OF THE SEASON
OF A CLUMP WHERE YOU DIDN'T CUT THE LEAVES OFF?
AND IF THERE ISN'T ANY DIFFERENCE
WHICH USUALLY THERE ISN'T
YOU CAN BEGIN TO OWN THE CONCEPT THAT RICE CAN ABSORB DAMAGE
AND YOU DON'T NEED TO SPRAY EVERY TIME YOU SEE LEAF DAMAGE.

Narrator: FARMER FIELD SCHOOLS HAVE LED
TO MAJOR CHANGES IN AGRICULTURAL PRACTICE.
DURING THE 1990s
MILLIONS OF INDONESIAN FARMERS DECREASED PESTICIDE USE
BY TENS OF MILLIONS OF DOLLARS.
AT THE SAME TIME, TOTAL RICE PRODUCTION DID NOT DECREASE
BUT CONTINUED TO INCREASE.
Dr. Kenmore: WITH FARMER FIELD SCHOOLS
THEY WERE EMPOWERED
ENOUGH TO GROW THE RICE
WHILE USING LESS PESTICIDES.
THE SCHOOL HAS BEEN ABLE BASICALLY
TO SUBSTITUTE BRAINS FOR CHEMICALS.
AND IN THAT SENSE
THE YIELDS STAY UP, THE GROWTH RATE STAYS UP
BUT LESS CHEMICALS ARE USED.
Narrator: INTEGRATED PEST MANAGEMENT
HAS BEEN ADOPTED
THROUGHOUT THE WORLD
INCLUDING THE UNITED STATES.
IN ARKANSAS, A GROUP OF

FARMERS
IS LOOKING FOR ALTERNATIVES
TO PESTICIDES
FOR AN EMERGING PEST THAT
THREATENS RICE PRODUCTION
THE SUGARCANE BORER.
Dr. Bernhardt: WHAT WE DO NOT
KNOW
IS HOW MUCH THE SUGARCANE
BORER IS SIMILAR
TO THE RICE STALK BORER IN ITS
HABITS
HOW ITS POPULATIONS ARE
AFFECTED BY THE CROPPING
PATTERNS.
IT HAS QUITE A NUMBER OF WILD
HOSTS
A LOT MORE THAN OUR RICE
STALK BORER.
AND ALL OF THAT IS GOING TO
PLAY A BIG ROLE
IN WHETHER THIS BECOMES A
MAJOR PEST FOR ARKANSAS
OR WHETHER IT'S GOING TO BE A
MINOR PEST
LIKE OUR RICE STALK BORER.
Narrator: LAST SEASON, RICE
FARMER CLAY POOLE
WAS THE FIRST EVER TO
EXPERIENCE
THE NEGATIVE EFFECTS OF THE
SUGARCANE BORER.

Poole: WE HAD SOME PROBLEM AREAS IN A PARTICULAR FIELD AND DIDN'T REALLY KNOW WHAT WE WERE LOOKING AT.
WE DISCOVERED THAT WE HAD A PEST
THAT IS CALLED THE SUGARCANE BORER.
IT DID SIGNIFICANT YIELD DAMAGE.
WE HAD SPOTS IN THE FIELDS WHERE WE LOST
RIGHT AT PROBABLY 100 BUSHELS TO THE ACRE.
THAT $3 A BUSHEL, THAT ADDS UP.
WHEN IT ALL BOILS DOWN, THAT'S MY PROFIT.
Narrator: IN BETWEEN GROWING SEASONS
THE FARMERS HOPE TO CONTROL THE PESTS
BY GETTING RID OF THE STUBBLE OR REMAINING STALK FROM THE PREVIOUS YEAR'S HARVEST.
Poole: STANDING STUBBLE WAS WHERE THEY LIKED TO OVERWINTER.
NOW, THAT'S ENOUGH STEM AND STALK LEFT THERE
FOR A BORER TO ACTUALLY BORE IN.

RESEARCH HAS SHOWN
THAT THE DESTRUCTION OF THE STUBBLE AFTER HARVEST
IS ONE OF THE BEST WAYS TO CONTROL
THE THRESHOLD AND THE BUILDUP OF THE SUGARCANE BORER.
POSSIBLY WE'LL KNOCK THEM DOWN ENOUGH
WHERE WE WON'T HAVE A BUILDUP
TO WHERE THEY BECOME DEVASTATING TO THE RICE INDUSTRY.
WE ARE TRYING TO GET IT TO WHERE INSECTICIDE WOULD BE THE LAST RESORT THAT WE HAVE TO USE TO CONTROL THIS PEST.

Narrator: THE FARMERS WILL NEED TO WAIT UNTIL THE NEXT HARVEST
TO DETERMINE IF THEIR SOLUTION WAS SUCCESSFUL.
Poole: WE'RE LOOKING OUT FOR THE LAND.
THE LAND MAKES US MONEY.
AND IF YOU DAMAGE THE LAND OR IF YOU ABUSE THE LAND
YOUR LAND IS NOT GOING TO MAKE YOU MONEY.

Narrator: IN THE YAQUI VALLEY OF MEXICO
WHEAT FARMERS ARE ALSO CAUGHT IN THE STRUGGLE BETWEEN MAKING A LIVING AND PROTECTING THE ENVIRONMENT.

THE YAQUI VALLEY IS AN IRRIGATED PLAIN
ON THE NORTHWEST COAST OF MAINLAND MEXICO
THAT GROWS ENOUGH WHEAT EACH YEAR
TO FEED AS MANY AS 20 MILLION PEOPLE.
THANKS TO ADVANCED SEED VARIETIES
SUPPORTED BY IRRIGATION AND GENEROUS FERTILIZER APPLICATION
THE YAQUI VALLEY HAS EARNED THE TITLE
"THE BREADBASKET OF MEXICO."
YET EVEN WITH THISB OUNTIFUL HARVEST
FARMERS' INCOMES ARE BARELY KEEPING PACE
WITH THEIR EXPENSES.
AND THE EXCESS NITROGEN FROM THEIR FERTILIZER
WASHES OUT OF THEIR FIELDS

AND THREATENS MARINE ECOSYSTEMS
THE UNDERGROUND WATER SUPPLY, AND EVEN THE ATMOSPHERE.
CAN FARMERS MAINTAIN THEIR STANDARD OF LIVING
AND STILL PROTECT THE ENVIRONMENT?
THIS QUESTION IS BEING EXPLORED BY A FRUITFUL COLLABORATION
BETWEEN RESEARCHERS AT STANFORD UNIVERSITY
AND AGRONOMISTS IN MEXICO.
PAMELA MATSON, A PROFESSOR AND BIOGEOCHEMIST
FROM STANFORD UNIVERSITY
IS ONE OF THE DIRECTORS OF THIS STUDY.
Matson: I STUDY THE CHEMICAL INTERACTIONS
BETWEEN PLANTS AND MICROORGANISMS
AND SOIL AND WATER AND ATMOSPHERE SYSTEMS
AND I FOCUS IN PARTICULAR ON NITROGEN.
A LOT OF MY RESEARCH IS FOCUSED ON WHAT HAPPENS WITH NITROGEN FERTILIZERS IN AGRICULTURAL SYSTEMS

AND HOW THEY AFFECT THE ENVIRONMENT.
Narrator: AN ESSENTIAL ELEMENT FOR ALL LIVING THINGS
NITROGEN IS THE MAIN NUTRIENT IN MANY FERTILIZERS.
Matson: ALL ORGANISMS NEED A LOT OF NITROGEN.
PLANTS AND PEOPLE
AND ALL DIFFERENT KINDS OF ANIMALS AND MICROORGANISMS
USE NITROGEN IN OUR CELLS, AND WE NEED A LOT OF IT.
AND OF COURSE, WE ARE LITERALLY BATHED IN IT.
THE ATMOSPHERE IS 78% DINITROGEN
SO THERE SHOULD BE PLENTY, RIGHT?
BUT THE PROBLEM IS THAT MOST ORGANISMS
DON'T HAVE ACCESS TO THAT DINITROGEN IN THE ATMOSPHERE.
THEY CAN'T USE IT. THEY CAN'T GET AT IT.

Narrator: WHILE CERTAIN BACTERIA CAN CONVERT THIS NITROGEN
INTO FORMS THAT OTHER ORGANISMS CAN USE

FOR MANY CROPS, MORE
NITROGEN IS STILL REQUIRED.
AND NITROGEN FERTILIZERA
LLOWS PLANTS
TO RECEIVE THE MUCH-NEED
EDNUTRIENT THAT THEY LACK.
THE USE OF FERTILIZER
DRAMATICALLY INCREASED
DURING THE GREEN REVOLUTION
WHERE, FROM THE 1940s
THROUGH THE 1960s
NEW SEED VARIETIES WERE
INTRODUCED
IN MANY DEVELOPING NATIONS,
HELPING AVOID WIDESPREAD
FAMINE.
Dr. Naylor: THE GREEN
REVOLUTION IS JUST ADAPTING
CROP VARIETIES
TO HAVE MUCH HIGHER YIELDS
ON A LIMITED LAND BASE.
AND THE KEY FACTOR WAS NEW
SEEDS FOR PLANT TYPES
AND THESE PLANT TYPES WERE
DEPENDENT ON FERTILIZER
INPUTS
TO GET THOSE HIGHER YIELDS.

Narrator:THE GREEN REVOLUTION
BEGAN
IN THE YAQUI VALLEY OF CIMMYT,
WHICH IS THE SPANISH ACRONYM

FOR THE INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER.

DR. IVAN ORTIZ-MONASTERIO IS A SENIOR SCIENTIST
IN THE WHEAT PROGRAM.
IN CIMMYT'S EXPERIMENTAL PLOTS, HE EXAMINES THE EFFECTS
OF A WIDE RANGE OF GROWING CONDITIONS
SUCH AS NITROGEN LEVELS.
Dr. Ortiz-Monasterio: WHAT YOU CAN SEE HERE
WE HAVE GROWN WITHOUT APPLYING ANY NITROGEN FERTILIZER.
IT'S A WHEAT CROP WITH VERY SEVERE NITROGEN DEFICIENCY.
THE OLDER LEAVES, WHICH ARE AT THE BOTTOM
START TURNING YELLOW FIRST
AND THEN YOU ALSO HAVE A PALE-GREEN COLOR
RATHER THAN AN INTENSE GREEN.
ALSO, THE WHEAT PLANT PRODUCED TILLERS, OR SIDE STEMS
AND HERE WE DON'T SEE ANY TILLERING.

WE ONLY HAVE ONE STEM.
AND, OF COURSE, YOU ALSO SEE THE STUNTING OF THE PLANT.
THESE PLANTS SHOULD BE AT LEAST TWICE THE HEIGHT.
Narrator: IN THE NEXT PLOT
75 KILOGRAMS OF NITROGEN PER HECTARE WERE APPLIED.
BUT THE WHEAT IS STILL SHOWING SIGNS OF NITROGEN DEFICIENCY.
Dr. Ortiz-Monasterio: I THINK THE YIELD HERE --
IT WILL PROBABLY BE ABOUT 2 TONS.
AND THE BREAK-EVEN POINT FOR THE COST OF PRODUCTION --
IT'S ABOUT 4 1/2 TO 5 TONS.
SO IT WOULD BE COMPLETE ECONOMIC FAILURE.
Narrator: IN THE FINAL PLOT
250 KILOGRAMS OF NITROGEN PER HECTARE WERE APPLIED
THE AVERAGE AMOUNT USED BY A FARMER IN THE YAQUI VALLEY.
THIS IS USUALLY ENOUGH TO GUARANTEE
A YIELD OF 7 TONS PER HECTARE.

TO ENSURE AGAINST CROP FAILURE
WHEAT FARMERSIN THE YAQUI

VALLEY
APPLY THESE VERY LARGE
AMOUNTS OF NITROGEN
FERTILIZER
MORE THAN NECESSARY IN A
TYPICAL YEAR.
SOME OF THIS IS IN THE FORM OF
AMMONIA GAS
WHICH IS BUBBLED INTO THE
IRRIGATION WATER
AND REACHES THE FIELDS
DURING IRRIGATION EVENTS.
BUT A LARGE AMOUNT -- ABOUT
75% --
IS APPLIED IN DRY FORM
ONE MONTH BEFORE THEY
ACTUALLY PLANT THE SEEDS.
Matson: THEY WERE WORRIED
THAT IF THEY DIDN'T GET IT ON
EARLY
THEY MIGHT NOT BE ABLE TO GET
IT ON LATER
WHEN IT STARTS RAINING OR IF IT
STARTS RAINING.
SO THEY WERE TRYING TO AVOID
RISK.
OF COURSE, WHAT THEY DIDN'T
REALIZE
IS THAT THEY WERE PROBABLY
LOSING A LOT OF NITROGEN
BEFORE THEY EVER EVEN GOT
THE SEEDS INTO THE GROUND.

Narrator: AND THIS EXCESS NITROGEN
CAN BE DAMAGING TO THE ENVIRONMENT.
Matson:ONE OF THE PROBLEMS WITH ALL THAT EXTRA NITROGEN GOING ONTO LAND AND FERTILIZER
IS THAT IT DOESN'T ALL GET USED BY PLANTS.
IT DOESN'T ALL GET TAKEN UP.
IN FACT, MAYBE ON AVERAGE 50% OF IT
DOESN'T STAY IN AGRICULTURE SYSTEMS
BUT RATHER GETS TRANSPORTED OUT OF THE FIELDS WHERE THEY WERE APPLIED
AND THE NITROGEN GOES OFF TO THE ATMOSPHERE
IN A NUMBER OF DIFFERENT FORMS
INCLUDING NITROUS OXIDE, WHICH IS A GREENHOUSE GAS
NITRIC OXIDE, WHICH IS AN AIR POLLUTANT.
AND SOME OF THE NITROGEN IN AGRICULTURE FIELDS
JUST LEECHES OUT THROUGH THE SOILS
INTO GROUNDWATER SYSTEMS

OR IT RUNS OFF THE SURFACE
INTO SURFACE-WATER SYSTEMS
LIKE STREAMS AND RIVERS AND
LAKES.
AND THERE IT CAUSES A NUMBER
OF DIFFERENT PROBLEMS.
THE BIG ISSUE FOR US
IS HOW TO MANAGE NITROGEN,
THAT NITROGEN FERTILIZER,
BETTER
SO THAT WE CAN STILL INCREASE
PLANT GROWTH
WE CAN STILL GET HIGH YIELDS
BUT WE PREVENT THE LOSS OF
THAT NITROGEN
INTO THE ATMOSPHERE OR INTO
THE WATER SYSTEM.

Narrator: IN THE YAQUI VALLEY
THE RESEARCH TEAM
CONDUCTED SEVERAL
EXPERIMENTS
TO DETERMINE WHERE THE
EXCESS NITROGEN WAS GOING.
TO FIND OUT IF IT WAS LEECHING
INTO THE WATER
THE RESEARCHERS FOLLOWED
THE IRRIGATION SYSTEM
TO WHERE IT DRAINS INTO THE
GULF OF CALIFORNIA.
IF THIS WATER CONTAINS EXCESS
NITROGEN

IT MAY CAUSE LARGE BLOOMS OF
SINGLE-CELLED PLANTS
CALLED PHYTOPLANKTON.

THESE BLOOMS CAN CAUSE HARM
TO THE ECOSYSTEM
BECAUSE ONCE THE
PHYTOPLANKTON DIE
THE DECOMPOSING PROCESS
LEADS TO VERY LOW LEVELS OF
OXYGEN IN THE WATER.
Matson: AND THAT KILLS FISH,
KILLS SHELLFISH
DRIVES FISH AWAY
AND CAUSES LOTS OF HARM TO
THE COASTAL MARINE
ENVIRONMENTS
AND ALSO CAUSESA LOT OF
ECONOMIC LOSSES
TO THE FISHERPEOPLE WHO USE
THOSE RESOURCES.

Narrator: RESEARCHERS USED
SATELLITE IMAGES
IN COMBINATION WITH WATER
SAMPLES
TO DETERMINE IF THE IRRIGATION
RUNOFF
FROM THE YAQUI VALLEY
WAS AFFECTING THE COASTAL
WATERS IN THE GULF OF
CALIFORNIA.

Dr. Beman: WE FOUND THESE INTENSE BLOOMS
THAT SEEMED TO COINCIDE WITH FERTILIZATION
AND THE IRRIGATION IN THE YAQUI VALLEY.
AS WE GENERATED MORE DATA AND WERE ABLE TO COMPARE THEM
WITH WHAT WE KNEW WAS GOING ON IN THE AGRICULTURE SYSTEM
WE REALLY DID FIND THIS TIGHT CORRESPONDENCE.
Narrator: MOTIVATED BY THESE RESULTS
THE RESEARCHERS WORKED TO FIND WAYS
TO MAINTAIN MAXIMUM YIELDS BUT REDUCE THE
ENVIRONMENTAL IMPACT OF THE FERTILIZER RUNOFF.
Matson: IN OUR BEST PRACTICE FARMERS WOULD HAVE APPLIED LESS NITROGEN
BUT THEY WOULD HAVE APPLIED MORE OF IT AT PLANTING
NONE OF ITA MONTH BEFORE PLANTING.
IT SEEMED LIKE A GREAT IDEA.
IT WORKED IN MOST FARMERS' FIELDS.
IT WORKED IN THE EXPERIMENT

STATION.
AND WE TALKED WITH FARMERS ABOUT IT.
BUT THEY DIDN'T ADOPT IT.
[SPEAKING SPANISH]

[SPEAKING SPANISH]
Narrator: WHEN THE RESEARCH TEAM
TALKED WITH FARM OWNERS LIKE SERGIO
THEY FOUND THAT A ONE-SIZE-FITS-ALL SOLUTION
WAS NOT APPROPRIATE IN THE YAQUI VALLEY
DUE TO THE WIDE VARIABILITY OF CLIMATE AND SOILS.
BUT THERE WAS ANOTHER OBSTACLE TO GAINING THE FARMERS' SUPPORT.
Matson: THE OTHER THING THAT WE DISCOVERED IN OUR RESEARCH
IS THAT ONE OF THE REASONS THEY WEREN'T TRYING THE NEW PRACTICE
IS THAT THE CREDIT UNIONS
,THEIR CREDIT UNIONS
WERE TELLING THEM NOT TO.
THE CREDIT UNIONS CAN RECOMMEND
WHAT KIND OF PRODUCTION

PRACTICES SHOULD OCCUR
SO THAT THE CHANCES IN
SUCCESS AT BEING PAID BACK
ARE THE HIGHEST.
AND SO ALTHOUGH WE HAVE
BEEN RECOMMENDING
REDUCTIONS IN FERTILIZER USE
THE CREDIT UNIONS ARE OFTEN
RECOMMENDING
INCREASED FERTILIZER USE.
Narrator: THE RESEARCH TEAM
BEGAN SEARCHING FOR AN
APPROACH
THAT COULD BE ADAPTED FOR
EACH FARMER.
ORTIZ-MONASTERIO
COLLABORATED
WITH DR. BILL RAUN AT
OKLAHOMA STATE UNIVERSITY
WHO HAD BEEN DEVELOPING A
HANDHELD RADIOMETER
CALLED A GREENSEEKER.
THIS DEVICE CAN ASSESS
NUTRIENT NEEDS IN REAL TIME
AND HELP FARMERS OPTIMIZE
FUTURE NITROGEN
APPLICATIONS.
THE INSTRUMENT CALCULATES
TOTAL AVERAGE BIOMASS
AND THE AMOUNT OF
CHLOROPHYLL IN THE LEAVES
DATA LINKED TO THE OVERALL

HEALTH OF THE PLANTS.
ARMED WITH THESE REAL-TIME MEASUREMENTS
ORTIZ-MONASTERIO HELPED DEVELOP
A MANAGEMENT STRATEGY FOR NITROGEN ENRICHMENT.
ON EACH PLOT, THE FIRST STEP IS TO ESTABLISH A
NITROGEN-RICH STRIP
A FEW HECTARES THAT HAVE ENOUGH EXTRA NITROGEN APPLIED
TO GUARANTEE MAXIMUM CROP YIELDS.
THE NITROGEN-RICH STRIP HAS TO REPRESENT
A LEVEL OF NITROGEN THAT DOESN'T HAVE ANY NITROGEN DEFICIENCY.
THAT'S GOING TO BE OUR REFERENCE.
ONCE WE HAVE THE NITROGEN STRIP WELL ESTABLISHED
AROUND 45 DAYS AFTER PLANTING, WE COME ALONG WITH THE SENSOR
AND WE TAKE THE READINGS IN THE N-RICH STRIP
AND THEN WE TAKE THE READINGS IN THE REST OF THE PLOT.

Narrator: THE READINGS ARE
CALLED IN TO A RESEARCHER
WHO CALCULATES HOW MUCH
ADDITIONAL NITROGEN
FERTILIZER
THE FARMER MUST APPLY
SO THIS PARTICULAR FIELD CAN
OBTAIN THE SAME YIELD
AS THE N-RICH CONTROL STRIP.

MUCH TO THE SURPRISE OF SOME
OF THE FARMERS
THE CALCULATIONS OFTEN SHOW
THAT THE PLOT REQUIRES LITTLE
OR NO ADDITIONAL NITROGEN
IN THIS SECOND APPLICATION TO
ACHIEVE MAXIMUM YIELDS.
THESE TECHNIQUES WILL NOT
ONLY REDUCE
THE ENVIRONMENTAL IMPACT OF
EXCESS FERTILIZER
BUT WILL ALSO SAVE THE
FARMERS MONEY
A FACT THAT WAS VERY
APPEALING TO THE CREDIT
UNIONS.
Matson: ULTIMATELY, WHEN THEY
SAW
THAT THE
HANDHELD-RADIOMETER
APPROACH WORKS
AND THAT COULD SAVE THEIR

FARMERS A LOT OF FERTILIZER
AND THUS SAVE THEM A LOT OF
MONEY
THEY DECIDED TO INVEST IN
THEM FOR THEIR MEMBERS.
SO THE CREDIT UNIONS
THEMSELVES BOUGHT THE
HANDHELD RADIOMETERS
FOR ALL OF THEIR MEMBERS TO
USE.
AND THEY BOUGHT IT BECAUSE IT
WAS A MONEY-SAVING DEVICE.
Narrator: WHILE NOT ALL WHEAT
FARMERS IN THE YAQUI VALLEY
HAVE ADOPTED THIS PRACTICE
THE RESEARCHERS ARE MAKING
PROGRESS
IN THIS PIVOTAL YEAR.
Dr. Ortiz-Monasterio: LAST YEAR WE
HAD ONLY SEVEN FIELDS.
THIS YEAR WE JUMPED TO 174.
SO IN MY OPINION, THIS YEAR IS
CRUCIAL.
IF WE ARE SUCCESSFUL
I THINK THIS IS GOING TO
EXPLODE AND BE WIDELY
ADOPTED.
AND I THINK THIS IS A
WONDERFUL EXAMPLE
HOW A TECHNOLOGY LIKE THIS
CAN RESULT IN A WIN-WIN
SITUATION

WHERE THE FARMER BENEFITS AND AT THE SAME TIME THE ENVIRONMENT BENEFITS.

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