



# **Biofortification**

A Sustainable Solution for Hidden Hunger

# Important!

- This module is designed to potentially serve a wide variety of audiences (nutritionists and agronomists, policymakers, extension workers, farmers)
- Not all of the material will be relevant to all audiences
- Please refer to the accompanying Facilitator's Guide for guidance on how to adapt these materials to your audience and facilitation best practices.

# Legend

#### Description

• Xm Expected Duration, minutes

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Quick Review/Survey Questions

**Brainstorming Session** 

**Discussion Session** 

**Group Activity** 

**Animated Slide** 

**End of Animation** 

# Unit 1 Introduction



#### Welcome

During this session, we will be examining the potential of biofortification as a sustainable strategy to address micronutrient malnutrition worldwide.

# **Quick Survey**



By show of hands:

- How many of you are already working with biofortification initiatives or biofortified crops?
- How many of you know what biofortification is, but have yet to get involved?
- How many of you have only a vague idea or no idea what biofortification is and hope to learn more?

# **Objectives**

#### By the end of this session, you should be able to:

- Explain how biofortification can address micronutrient malnutrition among vulnerable populations
- Compare biofortification to other common interventions for micronutrient malnutrition
- Summarize the process that breeders follow to produce biofortified varieties of staple crops
- Outline strategies for promoting biofortified crops to farmers, consumers and partner organizations
- Describe the ways that international, national and local stakeholders can help to make biofortification sustainable over the long term



 Standard "housekeeping" items for session (break times, end time, facilities, meals)

#### Meet the Facilitator

#### Name

- Role, Organization
- Credential(s)
- Fun biographical detail



# **Ground Rules**

- Mobile phones off
- In addition to lecturing, there will be opportunities for discussions and asking questions.
  - To keep things moving, we might have to cut some conversations short and move on to the next topic
  - Not everyone will get to answer every question, but everyone will get multiple chances to speak and be heard throughout the session
  - If one or two people are answering every question, we will politely ask them to give someone else a chance to speak.

## **Ground Rules**

As participants in this learning experience, we need to:

- Share our ideas without fear of criticism, and listen to the ideas of others without criticizing
- Engage in discussions without arguing
- Help other participants and accept help from others
- Create a safe, supportive environment for everyone to learn
- Have fun

# Activity (Groups)



#### **Meet Your Fellow Participants**

- Pair off with another participant (ideally someone you don't already know)
- Talk to each other and find out:
  - Their name
  - One interesting fact about their professional background
  - Something they enjoy outside of work, such as:
    - Hobbies
    - Favorite foods
    - Favorite holiday destination
- Reconvene and have each pair introduce each other to the rest of the class

An Introduction

# Micronutrients and Biofortification

# **Unit Objectives**

#### By the end of this unit, you should be able to:

- List and describe the three types of malnutrition
- Define 'hidden hunger' and explain the importance of micronutrients for good health
- Identify natural sources of micronutrients
- List and describe common interventions for micronutrient deficiency
- Define 'biofortification'
- Compare biofortification to other interventions and summarize its major advantages and challenges
- Differentiate between biofortified crops produced through selective breeding and GMOs

# The Problem of "Hidden Hunger"



# **Brainstorming**

#### Malnutrition



# What do we typically think of when we hear the term "malnutrition"?

# **Key Terminology**

#### Malnutrition

Lack of proper nutrition, caused by

- Not having enough to eat
- Not eating enough of the right things
- The body not being unable to use the nutrients from food that a person does eat



### **The Problem of Malnutrition**

- Serious public health issue in many parts of the world
- Major impediment to equitable economic growth
- In countries with persistently high levels of malnutrition, costs can rise to 16.5 percent of the economy (GDP)



#### Women and Children

- Disproportionately impacts women and children
- Factor in 45% of all child deaths and 20% of maternal deaths (WHO)
- Causes 110,000 deaths during childbirth each year (WFP)
- Malnourished children lag **four years** behind peers in educational achievement





# What are some of the <u>visible</u> symptoms of malnutrition? (What does a malnourished person look like?)

20



#### Types of Malnutrition

- Because of past famines, many people associate "malnutrition" with:
  - Calorie
    Deprivation
  - Protein
    Deficiency
- In extreme cases, these result in visible "wasting" of the body







# How have governments, NGOs and other groups addressed calorie deprivation?





### **Responses to Malnutrition**

 Historically, interventions have focused on providing high-calorie staple foods foods to avoid starvation

- Direct distribution of staple foods during emergencies
- Helping farmers increase production of staple crops

# Brainstorming

#### **Staples**

# What are "staple" foods? Can you give some examples?

# **Key Terminology**

#### Staple

A staple food, or simply a "staple", is a food that

- Is eaten routinely in such quantities that it constitutes a dominant portion of a standard diet for a given people
- Supplies a large fraction of energy needs and generally forms a significant proportion of total nutrient intake.



### **Staples Around the World**

- Popularity of different staples varies around the world
- Depends on availability, traditional preferences, etc.

# **Brainstorming**

#### **Staple Crops**



Based on consumption, which crops would be considered the most important staples in:

- Africa
- Latin America & The Caribbean
- Asia

# **Calories by Staple Crop**

Asia	Africa	Latin America and the Caribbean	World
Rice 55%	Wheat 33%	Maize 35%	Rice 47%
Wheat 35%	Maize 32%	Wheat 32%	Wheat 34%
Maize 5%	Rice 19%	Rice 23%	Maize 12%
Potato 4%	Cassava13%	Cassava 5%	Potato 4%
Cassava 1%	Potato 3%	Potato 4%	Cassava 3%



#### "Green Revolution"

- Improvements in farming have helped
- Increased production of staple crops has reduced incidence of famine
- Global rate of calorie deprivation decreased from 18.6% in 1992 to 10.9% in 2016 (FAO)
  - 1 in 4 people in
    Sub-Saharan Africa
    still calorie-deprived



# What types of nutrients do staples provide? What types of nutrients do staples generally <u>not</u> provide?

#### Types of Nutrients

#### **Macronutrients**

- Carbohydrates, fats and protein
- Need to consume in large amounts to provide energy, build muscle and fat
- Staples contain large amounts carbohydrates, which can help keep people alive





#### Types of Nutrients

#### Micronutrients

- Vitamins and minerals
- Needed in small amounts for body to function properly.
- Most staple foods do not provide sufficient micronutrients for good health, cognition and productivity



#### **Micronutrients**



Can you name some important vitamins and minerals? Can you describe how they are important for human health?

# **Micronutrients and Health**

- Vitamin A (beta-carotenoids) -Eyesight and immune system
- Vitamins B1, B2, B3, B6, B12 Help turn food into energy, produce red blood cells, nervous system function
- Vitamin C Immune system, brain
- Vitamin D Bones, immune system
- Vitamin E Prevents cell damage
- Folate (Folic Acid) Heart health, prevents birth defects, produce new cells (esp. red blood cells)
- Vitamin K Bones, blood clotting
- **Calcium** Bones, muscle development, cell function
- Chromium Regulates sugar
- Copper Blood cells, bone health

- Fluoride Bone health, dental health
- Iodine Regulates hormones
- Iron Carries oxygen through the body in red blood cells
- Magnesium Muscles, nervous system, bones, heart health
- Manganese Bone health, wound healing, process food
- Molybdenum Processes protein
- **Phosphorus** Cell function, bones
- Potassium Nervous system, muscles, regulates water
- Selenium Prevents cell damage
- **Zinc** Immune system, reproductive health, nervous system

# **Three Types of Malnutrition**

When we think of "malnutrition", we need to account for:

- Calorie Deprivation
- Protein Deficiency
- Micronutrient Deficiency



#### Symptoms of malnutrition

# What are the <u>visible</u> symptoms of micronutrient (vitamin/mineral) deficiency?


## "Hidden Hunger"

- Because micronutrient deficiency symptoms are less visible/obvious than macronutrient deficiency symptoms, micronutrient deficiency is called the "Hidden Hunger"
- Far more prevalent than calorie or protein deprivation
- Even mild deficiency, can have serious consequences:

# **Effects of Micronutrient Deficiency**







# What percentage of the world's population are affected by micronutrient deficiencies?





# What percentage of the world's population are affected by micronutrient deficiencies?

Micronutrient deficiencies afflict more than **two billion individuals**, or **one in three people**, globally (FAO et al., 2015).

# **Economic Impact**

Annual losses from micronutrient malnutrition (World Bank)

Country	Losses in GDP
Bangladesh	\$700M
DRC	\$100M
India	\$12B
Nigeria	\$1.5B
Pakistan	\$3B
Rwanda	\$50M
Tanzania	\$289M
Uganda	\$145M
Zambia	\$186M



#### **Vulnerable Groups**



# What groups of people are most vulnerable to micronutrient malnutrition?

### Vulnerable Groups

- Micronutrient deficiency is a health issue for everyone, but disproportionately affects
  - Low-income populations
  - Women of reproductive age
  - Infants and young children





### Vulnerable Groups

- Infants and Children: Micronutrient deficiencies in the early years of life can affect growth and development and cause irreversible damage
- Pregnant and lactating women have much higher micro-nutrient needs than nonpregnant, non-lactating women and men

# **Hidden Hunger Across the Life Cycle**







# Which 4 micronutrients does the WHO consider to be of the highest public health importance?



# Micronutrients of Highest Public Health Significance

The WHO considers four specific micronutrients as being of the highest public health importance:

- Iron
- Vitamin A
- Zinc
- Iodine



#### Iron

- Used throughout body, most critically in blood cells
- Without iron, blood cannot carry oxygen from lungs to other parts of the body
- Deficiency can result in anemia, fatigue, poor growth, and even death

# Vitamin A

- Among other things, it is used in various parts of the eye
- Without Vitamin A, eyes can become clouded, damaged
- Deficiency can result in poor night vision or even blindness
- It is also important for growth, immunity cell development and reproduction





#### Zinc

- Used primarily by the body's immune and reproductive systems
- Deficiency results in stunted growth, hair loss, skin rashes, vulnerability to infections

#### lodine

- Used in body to regulate production of hormones
- Deficiency can result in enlarged thyroid gland (hyperthyroidism / goiter), cognitive impairment, birth defects



# **Micronutrients and Public Health**

The WHO has defined thresholds for when micronutrient deficiency becomes a major problem in a population

Micronutrient	Benefits	Threshold
Vitamin A (beta- carotenoids)	Eyesight and immune system	15%
Iron	Carries oxygen through body in red blood cells	20%
Zinc	Immune system, reproductive health, nervous system	25%
lodine	Regulates hormones	20-50%





# Are you aware of any specific micronutrient deficiencies that impact public health among the communities you work with?



"Micronutrient deficiency" refers to a lack of:

- A. Calories
- B. Vitamins and minerals
- C. Protein
- D. Beneficial microbes in the digestive system





Micronutrient malnutrition is often called "hidden hunger" because...

- A. Lack of micronutrients can cause people to lose their appetite
- B. Many governments deny its existence
- C. It is less prevalent, globally, than macronutrient malnutrition
- D. Its symptoms are less obvious than those of macronutrient malnutrition

55



What are the four micronutrients that the WHO considers to be of the greatest public health importance?

- A. Vitamin A, Iron, Zinc, Iodine
- B. Vitamin A, Vitamin C, Iron, Zinc
- C. Vitamin C, Zinc, Calcium, Iodine
- D. Vitamin C, Calcium, Magnesium, Iodine



#### Alternate

- What is the difference between "macronutrient" versus "micronutrient" malnutrition?
- Why is micronutrient malnutrition called "hidden hunger"?
- What micronutrients does the WHO consider most critical for human health?
- What are some of the consequences of hidden hunger?

# Biofortification: An Intervention for "Hidden Hunger"



58



# Staples and Nutrition

- Vulnerable populations get 60-70% of calories from staple crops
- Staples tend to be grains, root and tuber crops, high in carbohydrates / calories (energy) but lacking in important micronutrients





# What are some things that could be done to help vulnerable populations get more micronutrients?



# **Micronutrient Interventions**

#### **Dietary Diversification**

(Eating a variety of nutritious foods)

**Supplementation** 

(Administering doses of

concentrated micronutrients)



#### **Food Fortification**

(Adding micronutrients during processing/preparation)



#### **Biofortification**

(Increasing micronutrient content of staple crops through selective crop breeding)

These interventions are most effective when used together

### Dietary Diversification

- Food sources of micronutrients are always ideal
- Yet, in some areas, nutritious foods are only available seasonally or are out of reach for poor households
- Education can raise awareness and promote consumption of a variety of micronutrient-rich foods
- Eating from a wide range of foods improves nutritional status



# **Brainstorming**

# Sources of Micronutrients



# What are some natural sources of micronutrients?



### Sources of Micronutrients

Major sources of micronutrients include:

- Animal products (meat, fish, dairy, eggs, liver and oil)
- Fruits & vegetables (esp. dark color)
- Nuts
- Legumes (beans, cowpea, pigeon pea, etc.)



# What a Healthy Diet Looks Like

Use **HEALTHY OILS** (like olive and canola oil) for cooking, on salad, and at the table. Limit butter. Avoid trans fat.

Drink WATER, tea, or coffee (with little or no sugar). Limit milk/dairy (1-2z servings/day) and juice (1 small glass/day). Avoid sugary drinks.

#### **Vegetables**

The more veggies – and the greater the variety – the better. Potatoes and French fries don't count.

# Eat plenty of fruits of all colors.

#### Whole Grains

Eat a variety of whole grains(like whole-wheat bread, whole-grain pasta, and brown rice). Limit refined grains (like white rice and white bread).

#### **Healthy Proteins**

Eat fish, poultry, beans, and nuts; limit red meat and cheese; avoid bacon, cold cuts, and other processed meats.



#### Micronutrient Malnutrition

- Affordability, accessibility and stability are all factors that impact how micronutrient-rich foods reach consumers
- Prices have increased significantly
- Availability is often seasonal
- Rural, low-income populations often lack access to micronutrientrich foods

## **Supplementation**

- Provide doses of highly concentrated vitamins and minerals
  - Capsules, tablets or injections
- Effective for young children esp. in first 2 years of life.
- Requires regular supply of supplements, which often cannot be sourced locally, and appropriate storage





#### Fortification

- Micronutrients added to food during processing (e.g., flour, rice, oils) or sprinkled on food before eating
- Micronutrient powders and oils sold at local markets, esp. in urban areas
- Vulnerable populations often lack access to processed foods, additives

# **The Challenge**

- Staple crops are widely available, but deficient in essential micronutrients
- Supplements, additives, processed foods and nutritious non-staples are not available to many vulnerable populations

#### So...

• Is it possible to make the staple crops that people eat more nutritious?



### **Biofortification**

- Biofortification increases the micronutrients in food crops through plant breeding or agronomic practices, without compromising yield
- Some traditional and wild varieties of certain staples in the biodiversity have higher micronutrient content
- Selective breeding can produce new varieties with significantly higher micronutrient content

# **Selective Breeding**



with best traits of parent varieties

# Are Biofortified Crops GMOs?

#### **Selective Breeding**

- Plants reproduce naturally
- Traits are passed naturally from "parent" plants to offspring
- Breeders control which types of plants cross-breed with each other

#### GMO

- The DNA of a plant is modified artificially
- New traits are artificially added to plants, without any natural precedent

All crops discussed in this course have been produced through **selective breeding** and are <u>**not**</u> GMOs.
# **How Biofortification Works**

- **Researchers** breed new varieties of staple crops with higher micronutrient content
- National partners (governments, private companies, NGOs, etc.) make new varieties available to farmers
- Farmers grow biofortified crops to feed their families and sell at market
- Consumers purchase and eat biofortified crops and foods
- Eventually, as cultivation and consumer demand scale, supply of micronutrient-rich, biofortified staples becomes self-sustaining

## **Major Biofortified Crops**









Zinc Rice Up to 60% of daily zinc

### Yellow Cassava Up to 40% of daily vitamin A beta-carotenoids

### Iron Pearl Millet

Up to 80% of daily iron

### High-Iron Beans Up to 50% of daily iron







Orange-Fleshed Sweetpotato Up to 100% of daily vitamin A (beta-carotenoids)

Zinc Wheat Up to 50% of daily zinc

Pro-Vitamin A Maize Up to 25% of daily vitamin A (beta-carotenoids)

#### Countries where biofortified crops have been released or are being tested



### **Biofortified Crop Distribution**

Biofortified crops released in 30+ countries and currently being tested and grown in additional 30+ countries

### **Biofortified Crop Distribution**

	Hi-Iron Beans	Yellow Cassava	PVA Maize	lron Millet	OFSP	Zinc Rice	Zinc Wheat
Bangladesh							
DRC							
India							
Latin America & Carribean							
Nigeria							
Pakistan							
Rwanda							
Tanzania							
Uganda							
Zambia							

### How much more nutrition?

### Iron Content In Beans (PPM)



Traditional Biofortified

### How much more nutrition?

### Vitamin A (Beta-Carotenoid) Content in Maize (PPM)



### How much more nutrition?

### Vitamin A (Beta-Carotenoid) Content in OFSP



### "Food Basket" Approach

In combination, biofortified crops can address all dimensions of malnutrition.



**Micronutrient Deficiency** 



### **Sustainability**

- Once a biofortified staple is made available, farmers can cultivate it year over year at almost zero marginal cost.
- Goal is for most biofortified crops to become fully integrated into food system and simply taken for granted

"Just crops"

## Brainstorming

### **Comparing strategies**

How is biofortification different from food fortification and supplementation?

*How is biofortification different from dietary diversification?* 

What are some unique advantages of biofortification compared to other strategies?

82



## **Advantages of Biofortification**

Biofortification's primary advantages include:

- Focus on **staple crops** that poor people already cultivate and consume
- Sustainability and cost
- Targets those who need it most

### **Case Studies**

- Orange-Fleshed Sweetpotato Randomized controlled trial of 24,000 households in Uganda and Mozambique from 2006 to 2009
  - In Uganda, introduction of biofortified OFSP over four growing seasons resulted in significantly increased vitamin A (serum retinol) for children with low vitamin A at the beginning of the study
  - In Mozambique, consumption of biofortified OFSP by children under five significantly reduced likelihood of diarrhea, the second leading cause of death in this age group, by 39% and duration of diarrhea episodes reduced by more than 10%

### **Case Studies**

- Study of Provitamin A Maize conducted in Zambia with 5–7-year-old children
  - After three months of consumption, total body stores of vitamin A increased significantly compared with those in the control group
  - Consumption of orange maize has been demonstrated to improve total body vitamin A stores as effectively as supplementation
  - Significantly improved visual function in marginally vitamin A deficient children

### **Case Studies**

- Iron pearl millet proved effective in six-month study of adolescent children in rural Maharashtra, India.
  - For secondary school children who consumed iron pearl millet flat bread twice daily, iron deficiency was significantly reduced and serum ferritin and total body iron were significantly improved after only four months.
  - Children who were iron deficient at beginning were 64% more likely to resolve their deficiency by six months.
  - Improved cognitive performance and levels of physical activity



### Return on Investment

- Development and distribution of orange-fleshed sweetpotato in Uganda cost
  \$15-\$20 USD per Disability Adjusted Life Year (DALY) saved
  - This is considered highly costeffective by World Bank standards

### Return on Investment

 For every dollar invested in biofortification, up to \$17 USD of benefits may be gained (from increased productivity, reduced illness, etc.)





### **Recognition for Biofortification**

- Copenhagen Consensus, a panel of economists including multiple Nobel laureates, prioritized public health interventions
- For overall impact, biofortification ranked #5 out of 30 initiatives surveyed

# S2016 Laureates THE WORLD FOOD PRIZE



### **Recognition for Biofortification**

- 2016 World Food Prize awarded to developers of biofortified Orange-Fleshed Sweetpotato
- Howarth Bouls (IFPRI/HarvestPlus)
- Dr. Maria Andrade (CIP)
- Dr. Robert Mwanga (CIP)
- Dr. Jan Low (CIP)



Which of the following is NOT a common intervention for micronutrient malnutrition:

- A. Supplementation
- B. Food fortification
- C. Nutrient substitution
- D. Dietary diversification
- E. Biofortification



Biofortification focuses on:

- A. Eating a greater variety of nutritious foods, including animal products and non-staple crops
- B. Giving concentrated doses of micronutrients in capsule or injection form
- C. Adding micronutrient powders or liquids during processing/preparation
- D. Breeding varieties of staple crops with higher micronutrient content
- E. All of the above



The biofortified crops that we are studying in this course were produced by:

- A. Genetic modification
- B. Selective breeding
- C. Mixing with supplements during cooking
- D. All of the above



Which of these is **<u>not</u>** an actual biofortified crop?

- A. Pro-vitamin A maize
- B. Calcium wheat
- C. High iron beans
- D. Zinc rice

### Alternate



- What are some common interventions for micronutrient malnutrition?
- What is biofortification?
- How is "biofortification" different from "food fortification"?
- Name some major crops for which biofortified varieties have been bred
- Are biofortified crops GMOs?



We discussed the advantages... what challenges might we anticipate for popularizing biofortified crops as a solution for "hidden hunger" (micronutrient malnutrition)?

### **Major Questions**

- Will a biofortified crop make an appreciable difference in a target population's health?
- Can we breed sufficiently micronutrient-rich varieties?
- Will local partners (governments, private companies) approve and support the crop?
- Will farmers grow the crop?
- Will consumers purchase and eat the crop?
- Can we achieve the necessary scale for a biofortified crop to become self-sustaining within local economies / food systems?
- How can we support biofortification through policy, business models, etc.?

## **Unit Objectives - Review**

### You should now be able to:

- List and describe the three types of malnutrition
- Define 'hidden hunger' and explain the importance of micronutrients for good health
- Identify natural sources of micronutrients
- List and describe common interventions for micronutrient deficiency
- Define 'biofortification'
- Compare biofortification to other interventions and summarize its major advantages and challenges
- Differentiate between biofortified crops produced through selective breeding and GMOs

Unit 3

# Developing Biofortified Crops

## **Unit Objectives**

### By the end of this unit you should be able to:

- Explain how the Biofortification Priority Index (BPI) helps researchers prioritize development of biofortified crops
- Summarize how micronutrient targets are set for biofortified varieties
- List causes for micronutrient losses
- Describe the characteristics that make a variety appealing to farmers and consumers
- Outline the major stages of the breeding process
- Explain why breeders might 'fast-track' the release of certain varieties

# Developing Biofortified Crops to Address Micronutrient Malnutrition



# **How Biofortification Works**

- Researchers breed new varieties of staple crops with higher micronutrient content
- National partners (governments, private companies, NGOs, etc.) make new varieties available to farmers
- Farmers grow biofortified crops to feed their families and sell at market
- Consumers purchase and eat biofortified crops and foods
- Eventually, as cultivation and consumer demand scale, supply of micronutrient-rich, biofortified staples becomes self-sustaining



What criteria could we use to determine which biofortified crops might be most appropriate for addressing micronutrient malnutrition in a particular country?

Which crops do you think would have high potential for the country (or countries) where you work?

# **Identifying Target Crops & Populations**

- The **Biofortification Priority Index (BPI)** ranks suitability of seven staple crops for addressing micronutrient deficiencies across 127 countries, using data from FAO, WHO and USDA
- Identifies top, high, medium, low, and little/no priority countries for investment in each biofortified crop based on:
  - Production subindex: Each country's output of potentially biofortifiable crops
  - Consumption subindex: % of domestically produced crops consumed by the local population
  - Micronutrient deficiency subindex: Prevalence of micronutrient deficiencies in each country which could be addressed by biofortifying domestically produced crops

# The Biofortification Priority Index (BPI)

Iron Beans



• Live link: <a href="http://www.harvestplus.org/knowledge-market/BPI">http://www.harvestplus.org/knowledge-market/BPI</a>

# The Biofortification Priority Index (BPI)

Vitamin A (PVA) Maize



• Live link: <a href="http://www.harvestplus.org/knowledge-market/BPI">http://www.harvestplus.org/knowledge-market/BPI</a>





### What are some advantages for using an index like BPI to decide which crops to focus on for biofortification?



## **Target Crops & Countries**

Overall, the BPI figures show that:

- African countries rank highest for vitamin A (beta-carotenoid)—rich crops
  - Orange-Fleshed Sweetpotato
  - Yellow Cassava
  - PVA Maize
- Asian countries rank highest for zinc-rich cereals
  - Zinc Wheat
  - Zinc Rice
- Several countries in Africa and some in Latin America and the Caribbean rank highly for high-iron beans (HIBs)
- Africa (especially West Africa) and South Asia rank highly for iron-biofortified pearl millet




# What factors must nutritionists consider when they set micronutrient targets?



#### Setting Micronutrient Targets

- Nutritionists evaluate numerous factors
- Requirements for good health
- Ability of body to absorb and retain ingested nutrients (bioconversion and bioavailability)
- Quantities of crop consumed by the target population



## **Targets by Population**

Based on needs of preschool children 4–6 years old and nonpregnant, non-lactating women of reproductive age, nutritionists set the following biofortification targets:

- Iron in iron beans and iron pearl millet = 60% of Estimated Average Requirement (EAR)
- Zinc in zinc wheat and zinc rice = 60–80% of EAR
- Provitamin A (beta-carotenoids) in orange maize and yellow cassava = up to 50% of EAR
- Provitamin A (beta-carotenoids) in orange-fleshed sweetpotato = up to 100% of EAR

## **Targets by Nutrient**

Provitamin A (beta- carotenoids)		OFSP	Maize	Cassava
	Baseline micronutrient content	2	0	0
	Additional content required	30	15	15
	Final target content	32	15	15

## **Targets by Nutrient**

Iron		Beans	Pearl Millet
	Baseline micronutrient content	50	47
	Additional content required	44	30
	Final target content	94	77

## **Targets by Nutrient**

<b>Zinc</b>		Rice	Wheat
	Baseline micronutrient content	16	25
	Additional content required	12	12
	Final target content	28	37





#### Targets must also account for micronutrient losses over time. What might cause crops to lose their nutritional value?





#### **Accounting for Losses**

Targets must account for:

- Losses during storage and processing
- Losses from common methods of preparation





*Of the following methods for preparing maize, which do you imagine would retain the most provitamin A?* 

- Cooking (as flour)
- Boiling
- Frying
- Heating (as popcorn)
- Roasting (without husk)





*Of the following methods for preparing maize, which do you imagine would retain the most provitamin A?* 

- Roasting (without husk) 87%
- Heating (as popcorn) 80%
- Cooking (as flour) 75%
- Boiling 70%
- Frying **65%**

## **Brainstorming**



#### **Other Desirable Traits**

Besides nutrition, what qualities might be of importance to farmers?

What qualities might be of importance to consumers?



#### Other Desirable Traits

#### Farmers

- High yield
- Early maturity
- Tolerance to pests and diseases
- Dry matter content
- Marketability
- Storage durability





#### Other Desirable Traits

#### Consumers

- Taste
- Texture
- Color/appearance
- Ease of preparation (cooking, peeling)
- Cost



Does it seem reasonable to expect breeders to produce staple varieties that meet nutritional targets while satisfying the demands of farmers and consumers? Do you expect there will be some compromise / trade-offs?





The "Biofortification Priority Index" is a system for rating:

- A. The suitability of certain crops for biofortification initiatives in certain countries
- B. The levels of different vitamins and minerals in a biofortified crop
- C. The amount of funding that local governments give to biofortification versus other interventions
- D. The prevalence of biofortified crops as a percentage of all crops grown in a country



Which of these is NOT considered for Biofortification Priority Index?

- A. Transportation Efficiency Subindex
- B. Production Subindex
- C. Consumption Subindex
- D. Micronutrient Deficiency Subindex



Nutritional targets are based on...

- A. The needs of adult males, average price at market per kilogram, plus expected losses
- B. Cost in dollars per additional PPM of micronutrient value, minus expected losses
- C. The needs of women and children, quantity consumed by target population, plus expected losses
- D. Expected losses plus cost of transportation per kilogram

#### Alternate

- What is BPI?
- What three factors does BPI account for?
- What could cause loss of micronutrient content in biofortified crops?
- What qualities do farmers and consumers look for in biofortified crops, other than nutritional value?

126

# **The Breeding Process**



## **Breeding Biofortified Crops**

Steps in process include:

- 1. Screening existing varieties for micronutrient content and agronomic traits
- 2. Breeding new varieties (crosses, selection) with best traits of "parent" varieties
- 3. Laboratory testing to measure micronutrient levels
- 4. At least 3 years of **field testing** to verify crop performance in the target environment
- 5. Submitting promising lines to **national partners** for further testing and release to farmers

## **Breeding Biofortified Crops**

Steps in process include:

- 1. Screening seeds of existing varieties for desirable traits
- 2. Breeding "parent" lines
- 3. Developing tests and identifying genetic markers to confirm the presence of desired traits
- 4. Genome x Environment (GxE) testing i.e., verifying crop performance in the target environment
- 5. Submitting promising lines to **national partners** for further testing and approval



#### Screening

- Breeders screen existing varieties in global seed banks for high micronutrient content and other traits
- Seed banks include wild and cultivated varieties from across the world
- Highest-micronutrient varieties might not be adapted for cultivation/ consumption



## Case Study: CIMMYT Gene Bank

- CIMMYT gene bank in Mexico holds 150,000 wheat seed samples and 28,000 maize samples from 100+ countries
- Landraces (varieties developed by farmers over generations)
- Wild relatives of crops (e.g., teosinte / maize)
- Improved/biofortified varieties



#### Case Study: CIMMYT Gene Bank

- CIMMYT ensures all seed samples meet international phytosanitary standards to avoid spreading seedborne pathogens
- Advices on design of experiments
- Data made available to anyone per openaccess policy

#### Breeding Parent Lines

- Selected varieties cross-bred for even higher nutrient content and other characteristics
  - Agronomic traits desired by farmers (yield, drought tolerance, etc.)
  - Qualities
    preferred by
    consumers (taste,
    color, texture)



## **Breeding for Desired Traits**







#### Once a biofortified variety is developed, how would we confirm that it actually has the desired nutritional and agronomic qualities?





#### Testing

 Developing biofortified crops requires many generations of crossbreeding  Each generation must be tested to determine presence of desired traits, progress to nutritional goals

#### Laboratory Testing

- Thousands of samples tested each season to measure micronutrient content of new varieties
- Faster, more precise, higher-throughput testing methods can reduce time and cost to develop biofortified crops





## **Testing Methods**

- Vitamin A (beta-carotenoids)
  - High-performance liquid chromatography (HPLC)
  - Near-infrared spectroscopy (NIRS)

• Iron / Zinc

- Inductively- coupled plasma (ICP)
- X-ray fluorescence spectroscopy (XRF)

## Genetic "Markers"

- Scientists may identify certain molecular "markers" in plants' DNA that indicate presence of desired traits
- Much faster and easier way to test seeds vs. directly measuring micronutrient content of grain





#### **Field Testing**

- New varieties tested in local farmers' fields
  - Known as "GxE" testing (Genotype x environment)
- Evaluated for yield, tolerance to pests and diseases, nutritional content, etc.
- Tested with/without fertilizer, irrigation
- Compared to the best local varieties



### **Participatory Appraisal**

- During field testing, breeders consult farmers to confirm that crops meet agronomic needs
- Ideally, biofortified varieties perform as well or better than popular varieties, providing farmers incentive beyond nutritional value

#### Approval by National Partners

- Seeds of the bestperforming varieties multiplied and offered to national governments
- Governments test varieties and, upon approval, make them available to farmers, seed companies, etc.





#### **National Partners**



# What are some concerns that national partners might have about biofortified crops?





#### Case Study: Orange-Fleshed Sweetpotato

 Already exceeded Vitamin A (beta carotenoid) target of 32ppm, with biofortified varieties ranging from 36 to 100ppm (traditional varieties have 4 ppm)


#### Case Study: Orange-Fleshed Sweetpotato

- Widely supported by governments, adopted by farmers
- Released in Angola, Brazil, Burkina Faso, China, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nicaragua, Niger, Nigeria, Rwanda, Senegal, South Africa, Syria, Uganda, Zambia.



#### Case Study: Orange-Fleshed Sweetpotato

- Extensive evidence for impact of consuming OFSP on vitamin A intake and status of women and children





## How long would you imagine it takes to develop a biofortified crop then get it out to the public?





## How long would you imagine it takes to develop a biofortified crop then get it out to the public?

Breeding process alone can take **3 to 8 years**, while overall process of breeding, testing and approval can take **6 to 10 years** 



*Is a 6 to 10 year timeframe acceptable for addressing malnutrition?* 

What could potentially be done to accelerate the benefits of biofortification for target populations?

### "Fast Tracking" Crops

To help farmers and consumers benefit from biofortification more quickly, breeders "fast track" release of varieties that, while not meeting the full target, have significantly higher micronutrient content than popular varieties





#### Case Study: PVA Cassava in Nigeria

- 1<sup>st</sup> wave varieties with 6–8 ppm vitamin A (50% of target) released in 2011
- 2<sup>nd</sup> wave varieties with up to 10 ppm (66% of target) released 2014
- 50+ 3<sup>rd</sup> wave varieties with >15 ppm (100%) being tested for agronomic factors for 2018 release

## Activity (Groups)



#### **Explaining Biofortification**

In less than a minute, how might you explain the biofortification process to a typical smallholder farmer or policymaker who might not be familiar with the strategy or the underlying science?

You have 5 min to discuss in your groups



Which of the following steps in the breeding process happens <u>first</u>?

- A. Field Testing
- B. Screening Seeds
- C. Setting nutritional targets
- D. Breeding "parent" lines
- E. Fast-tracking release of promising varieties
- F. Laboratory Testing



Which of the following steps in the breeding process happens <u>last</u>?

- A. Field Testing
- B. Screening Seeds
- C. Setting nutritional targets
- D. Breeding "parent" lines
- E. Fast-tracking release of promising varieties
- F. Laboratory Testing



How long does it take to develop and release a biofortified crop variety?

- 10-15 weeks
- 6-12 months
- 1-2 years
- 6-10 years
- 15-20 years



#### Alternate

- What are the major steps for breeding biofortified crops?
- How long does it take to develop and release a biofortified crop?



## **Unit Objectives - Review**

#### You should now be able to:

- Explain how the Biofortification Priority Index (BPI) helps researchers prioritize development of biofortified crops
- Summarize how micronutrient targets are set for biofortified varieties
- List causes for micronutrient losses
- Describe the characteristics that make a variety appealing to farmers and consumers
- Outline the major stages of the breeding process
- Explain why breeders might 'fast-track' the release of certain varieties

Unit 4

# Fostering Demand for Biofortified Crops

## **Unit Objectives**

#### By the end of this unit you should be able to:

- Identify key stakeholders for biofortification initiatives
- Differentiate between different seed systems, and summarize the advantages and disadvantages of each for biofortification
- Suggest activities to promote farmer adoption of biofortified crops, particularly for your country/region
- Suggest activities to promote consumer adoption of biofortified crops in your country/region
- Develop promotional messaging for different stakeholders and identify the best channels for reaching audiences in your country/region
- Identify partnering opportunities to promote biofortification in your country/region





## Once we have developed a biofortified crop variety, what are the first steps we would take to promote it within a particular country?



## **How Biofortification Works**

- **Researchers** breed new varieties of staple crops with higher micronutrient content
- National partners (governments, private companies, NGOs, etc.) make new varieties available to farmers
- Farmers grow biofortified crops to feed their families and sell at market
- Consumers purchase and eat biofortified crops and foods
- Eventually, as cultivation and consumer demand scale, supply of micronutrient-rich, biofortified staples becomes self-sustaining

## **Steps to Achieve Scale**

- Introduce Encourage adoption of crop among the target groups (farmers, consumers)
- Scale Work with partners to promote crop and achieve necessary market share for long-term sustainability
- Anchor Strengthen support for crop through policy and business models to ensure it remains part of value chain



# Introducing Biofortified Crops



### Introducing Biofortified Crops

- To succeed, biofortification requires:
  - Acceptance among farmers and consumers
  - Support of private and public sector partners
- Begins with initial introduction of seed





### Introducing Biofortified Crops

- 1. Variety release
- 2. Seed production and dissemination
- 3. Direct promotion to farmers, consumers
- 4. Farmer and consumer education
- 5. Engaging partners
- 6. Technical support and research

## Variety Release

- Researchers work with governments, other stakeholders to breed biofortified staples for specific populations
- After breeders meet goals, government conducts additional review/testing
- Government manages release to public
- Researchers provide technical support





## **Seed Production and Dissemination**

- Goal is for biofortified crops to become regular part of farming and food systems
- Best approach for promoting adoption varies by seed systems, local economies

## Seed Systems

- Seed systems refer to how farmers acquire seed for planting
  - Varies by type of crop, local business models
- Types of crops:
  - Vegetatively propagated
  - Self-Pollinated
  - Hybrid
- Distribution models:
  - Primarily commercial private sector (India, Zambia)
  - Mixed public-private (Bangladesh, Nigeria, Rwanda, Uganda),
  - Primarily public sector or informal (DR Congo).



## **Vegetatively Propagated**

- Farmers plant stems, tubers or vines rather than seeds
- Planting materials perishable, must be replanted within days of harvest (no long-term storage)
- Planting materials bulky/expensive to transport



#### **Vegetatively Propagated Biofortified Crops**

Examples of vegetatively propagated biofortified crops:

- Orange-Fleshed Sweetpotato
- Provitamin A Yellow Cassava



Based on their reproductive properties, what sort of seed systems would you expect to develop around vegetatively propagated crops? What are the implications for:

- Farmers
- Private sector seed suppliers

How might this impact our efforts to drive adoption of biofortified varieties?

### Vegetatively Propagated

- Easy and inexpensive for farmers
- Ability to replant, cost of delivery = little incentive for commercial suppliers



### Vegetatively Propagated

- Seed systems are small, informal (e.g., farmer-to-farmer, decentralized vine multipliers / DVMs)
- Lack of commercial suppliers both a challenge (lack of efficient delivery systems) and opportunity (less competition) for biofortified crops



#### Case Study: Decentralized Vine Multipliers

- Program to bolster OFSP dissemination in Mozambique
- Decentralized Vine Multipliers (DVMs) are model farmers who conserve and multiply OFSP vines then distribute to other farmers.



#### Case Study: Decentralized Vine Multipliers

- "Primary" multipliers receive samples and technical support from breeders (CIP) to multiply
- Distribute to "secondary" multipliers for further multiplication





## **Self-Pollinated**

- Plants usually pollinate themselves, with only occasional cross-pollination of different plants
- Seeds generally have same traits as parent, and can be replanted year after year



## Self-Pollinated Biofortified Crops

Examples of self-pollinated biofortified crops:

- Iron beans (Rwanda, DRC)
- Zinc rice (Bangladesh)
- Zinc wheat (India, Pakistan)



Based on their reproductive properties, what sort of seed systems would you expect to develop around self-pollinated crops? What are the implications for:

- Farmers
- Private sector seed suppliers

How might this impact our efforts to drive adoption of biofortified varieties?



#### **Self-Pollinated**

- While farmers need to periodically replace seed to maintain desirable traits, most reclaimed seed is suitable for planting
- Ability for farmers to replant limits incentives for private sector investment



### **Self-Pollinated**

- In many countries, absent commercial suppliers, public sector multiplies and distributes selfpollinated seed
- Informal farmer-tofarmer dissemination also common
- If sufficient demand is created, might spur private sector interest
## Case Study: Zinc Wheat in South Asia

- Delivery of zinc wheat in India and Pakistan began with public sector initiatives, then attracted private sector interest
- In India, zinc wheat is predominantly marketed by the private sector
  - Six private seed companies incorporated zinc wheat into their product lines
  - Advertised as "truthfully labeled seed" (TLS)
    - Uses biofortification as selling point
    - Offers farmers assurance that seeds are actually biofortified varieties
- In Pakistan, delivery through public-private sector partnerships is now underway



## Hybrid

- Cross-pollinate with other plants
- Seeds will not reliably have same traits as parent
- Require highly controlled conditions to produce seed of a specific hybrid variety



#### **Hybrid Biofortified Crops**

Examples of hybrid biofortified crops:

- Provitamin A Maize
- Iron Pearl Millet



Based on their reproductive properties, what sort of seed systems would you expect to develop around hybrid crops? What are the implications for:

- Farmers
- Private sector seed suppliers

How might this impact our efforts to drive adoption of biofortified varieties?

#### Hybrid

- Seed must be replaced each year to ensure same agronomic and nutritional traits
- Need to replace seed incentivizes private sector involvement, commercialization



#### Hybrid

- Private sector delivery good for long-term sustainability, but private sector involvement depends on demand
- To attract investment, biofortification proponents should focus on targeted demand creation among farmers and consumers





What types of seed systems are most prevalent in the communities where you work?

How might that impact efforts to introduce biofortified crops?

## Strengthening Seed Systems

- Multiplication of sufficient, high-quality planting material is a crucial first step towards scaling
  - Without planting material to "prime the pump", there will be no biofortified crops.
- Biofortification proponents have focused on:
  - Strengthening capacity of public and private sector to produce high quality seed
  - Reduce risk by negotiating incentives, working to generate consumer demand
- Biofortified crops must be competitively priced so subsistence and smallholder farmers can afford them
  - Thus far, in cases where biofortified crops are distributed via private sector, cost difference has been negligible



Vegetatively-propagated crops are:

- A. Planted as seeds and pollinate themselves
- B. Planted as stems, tubers or vines rather than seeds
- C. Genetically modified
- D. Always legumes
- E. None of the above



Which of the following statements is true of self-pollinated crops?

- A. Seeds can be replanted with little risk of losing desirable traits
- B. Seeds must be purchased from suppliers every year
- C. They are the most attractive crop type for private sector investment
- D. All of the above



In the early stages of release, the most reliable strategy for driving farmer adoption of biofortified crops is:

- A. Waiting for private sector companies to get involved
- B. Allowing the government to take the lead
- C. Developing consumer demand before engaging farmers
- D. Promoting directly to farmers



#### Alternate

- Who are the major stakeholders to consider in introducing biofortified crops?
- In terms of seed systems, what are the three main types of crops?
- Which type is least attractive to private sector suppliers and why? Which type is most attractive to private sector suppliers and why?

192

## Promoting Farmer Adoption





#### Direct Promotion

- Integration into seed systems takes years
- Necessary to establish demand to attract public/private sector investment
- Biofortification proponents typically promote crops directly to farmers and consumers during early stages of introduction



What incentives might farmers have to plant biofortified crop varieties?

- What reservations might they have about planting biofortified crop varieties?
- How could we address their concerns?

#### Promotion to Farmers

- Farmers are key to biofortification
  - Often part of target population
  - After fulfilling household food needs, sell surplus to larger population via rural and urban retail outlets
- May hesitate to plant crop for which market has not been tested



#### Promotion to Farmers

- Developing crops with desirable agronomic traits (high yield, drought/disease resistance) key to adoption
- Many farmers will adopt biofortified crops simply for agronomic benefits if they outperform other varieties



#### Promotion to Farmers

- Nutritional benefits add additional value:
  - Benefits to farmer's household from eating biofortified crops
  - Potential to use nutritional benefits to drive consumer demand for biofortified crops



#### Private Sector Demand

- Biofortified crops can be used in various commercial products
- Generating demand among processors ensures robust market for surplus grown by farmers





#### **Demonstrations**

Demonstration trials have been key to adoption:

- Local field demonstrations allow farmers to study crops firsthand
- Small promotional seed packs allow farmers to try new variety with minimal risk



# What could be some of the ways to disseminate seeds?

What are the places/ channels we could use? What would be the most effective in your area?

## **Dissemination of Seed**

During initial introduction, seeds disseminated directly to farmers via:

- Local markets
- Schools
- Places of worship
- Health centers
- Extension workers

## Case Study: High Iron Beans in Rwanda

2015 impact assessment of 20,000 farm households in Rwanda found:

- 93% were bean growers
- 29% had planted HIBs since 2010
  - 41% obtained first HIB planting material from the local market
    - Includes buying from market stalls and receiving through direct marketing efforts during initial introduction
  - 33% obtained from social networks (friends/neighbors and farmers' groups)
  - 7% obtained from the Ministry of Agriculture, RAB, or an extension agent

#### Case Study: High Iron Beans in Rwanda

Innovative programs for dissemination:

- "Payback system"
  - Farmers given free HIB seed on condition that they give back portion of grain after harvest
  - Helped to multiply planting material





#### Case Study: High Iron Beans in Rwanda

- "Seed swap"
  - Farmers trade in local seeds for iron rich HIB varieties
  - Gradually
    'flush out' less
    nutritious
    varieties and
    replacing with
    iron rich ones.

## **Evaluating Adoption**

- Farmers' willingness to grow biofortified crops is investigated through various studies including:
  - Farmer field day evaluations
  - Farmer feedback studies
  - Impact assessment studies
  - Impact evaluation studies
- Research suggests that farmers like the various agronomic and consumption attributes of biofortified crops and are generally willing to plant them

#### Case Study: Worldwide Adoption

- HarvestPlus studied biofortified crop adoption in eight target countries (Bangladesh, DR Congo, India, Nigeria, Pakistan, Rwanda, Uganda, and Zambia)
- In all cases studied, rates of adoption and diffusion of biofortified varieties were significant and sustained
- As of the end of 2016, approximately 20 million people in 4 million farming households in these countries were growing and consuming biofortified crops
  - 1.5 million households received biofortified planting material directly from HarvestPlus and its partners in 2016
  - Other 2.5 million households represent continued planting and diffusion from previous years



### **Case Study: Willingness to Pay**

- Study in Tanzania gauged consumers willingness to pay a premium for beans with higher iron levels
- 93% willing to pay 40% more
- 60% willing to pay 66% more
- 26% willing to over 100% more

## Activity (Groups)



#### **Promoting to Farmers**

- Divide into groups
- Each group is to prepare a 2-min presentation to a group of farmers to explain the advantages of planting biofortified crop (can be any biofortified crop – we are just talking about generalities, not specifics of any one crop)

#### • You have 10 minutes

• Once complete, groups will deliver their explanation. Facilitator will play the role of a farmer, and group should be ready to address the farmer's concerns.



Farmers may prefer biofortified crops because they:

- A. Have higher yield
- B. Are more drought/disease resistant
- C. Outperform other varieties on agronomic traits
- D. Often preferred for their taste and cooking characteristics
- E. All of the above

## **Quick Survey**



Which agronomic quality do you think farmers in the communities you work with would find most important?

- A. Yield
- B. Disease/Pest Resistance
- C. Storage Durability
- D. Early Maturity

## **Quick Survey**



Which quality do you think consumers in the communities you work with would find most important?

- A. Taste
- B. Cooking Time
- C. Price
- D. Nutrient Content

#### Alternate

- Why might farmers be interested in biofortified crops?
- Why might they be hesitant to plant them?
- What are some strategies for promoting biofortified crops to farmers?

## Promoting Consumer Demand





#### **Consumer Demand**

- Biofortification cannot counter deficiencies unless consumers regularly purchase and eat biofortified foods
- Consumer acceptance research focuses on:
  - Sensory evaluation
  - Willingness to pay



# When consumers go to the market, how do they select crops?

# What kind of characteristics or qualities are they looking for when evaluating crops?
#### Sensory Evaluation

 May or may not be a detectable difference between biofortified and conventional varieties



# Activity (Whole Group)



#### **Biofortification Sensory Test**

- Participants should examine the samples of biofortified and conventional varieties
- For which crop(s) could you detect an obvious difference?
- For which crop(s) were differences not detectable?



#### Sensory Evaluation

- Vitamin A– biofortified crops change color due to their carotene content
  - Orange-Fleshed
    Sweetpotato
  - Yellow Cassava
- Iron and zincbiofortified crops do not have visible changes



Which do you think would present the greater challenge for fostering consumer demand – crops with visible differences or crops without visible differences?

How can we address these challenges?



#### Consumer Demand

**Consumer-acceptance** research reveals that the different (yellow or orange) color of provitamin A– biofortified crops (i.e., yellow cassava, OFSP, and orange maize) is not a hindrance to consumer acceptance.



### Activity (Groups)



#### **Cooking with Biofortified Crops**

- Divide into groups
- Each group will prepare a different recipe using biofortified ingredients
- Share with the class and discuss the results

# **Nutrition Messaging**





#### **Education**

- Nutrition messaging aimed at farmers and consumers is key to driving demand, achieving public health impacts
- Nutrition information has been shown to increase adoption/ acceptance of all biofortified crops

### Brainstorming

#### **Nutrition Messaging**



What do you think might be some effective methods for delivering nutrition information about biofortified crops?

Which members of a community should we target, specifically?

How much of an impact would you expect nutrition messaging to make on farmer adoption and consumer acceptance?

#### Media

Nutrition information can be delivered via:

- TV
- Radio
- Social marketing
- Public media
- Newspapers
- Face-to-face promotion



### **Impact of Nutrition Information**

- Even <u>without</u> nutritional information
  - Farmers generally preferred biofortified crops for agronomic reasons
  - Consumers liked most biofortified varieties as much as, or more than, conventional ones in sensory tests
- In all cases, providing nutrition information led consumers and farmers to prefer biofortified crops
  - Study in rural Ghana, found that, for consumers who initially preferred dishes made with non-biofortified yellow maize over provitamin A orange maize, provision of nutrition information reversed their preference.

#### **Education**

- Messaging aimed at families ensures that biofortified foods are integrated into child diets
- Messages delivered by community leaders have proven especially effective for increasing demand for biofortified crops





### **Case Study: Messaging in Zambia**

- Study in rural Zambia found that nutritional information produced similar increases in acceptance of biofortified crops regardless of source
- Radio just as effective, but far less expensive, than face-to-face messaging

# Activity (Groups)



#### **Developing Messages**

- Divide into groups
- Each group will be assigned to design one of the following for a particular biofortified crop for a specific audience (farmers, consumers, women, families):
  - 30 to 60-second "radio" message
  - One-page pamphlet
  - Series of three SMS messages
- You have 10 min
- Share your message with the class

### **Quick Survey**



Which of the following do you believe would be the most effective (and cost-effective) means of promoting biofortified crops in the countries/regions where you work?

- A. Filming a TV documentary
- B. Radio
- C. Face-to-face promotion by volunteers, extension workers
- D. Promotion at community events and meetings
- E. Internet / Social Media
- F. Printed leaflets

### **Quick Review**



Which of these factors affect consumer demand?

- A. Sensory qualities
- B. Early maturity
- C. Awareness of nutritional benefits
- D. All of the above
- E. Both A and C

### **Quick Review**

#### Alternate

- Have sensory qualities proven to be an obstacle for consumer acceptance of biofortified crops?
- How does nutritional information impact consumer preferences?
- What media / channels can we use to deliver promotional messaging?

233



# **Engaging Partners**



### **Expanding Partnerships**

- Cooperating with partner organizations and forming multistakeholder platforms can accelerate introduction and scaling of biofortified crops
- Partners might include
  - Local governments
  - Private companies
  - Other participants in value chain
  - Multilateral institutions
  - NGOs

#### Local Governments

- In most countries, government entities are highly supportive of biofortification
- Extension agents help with introduction, scaling efforts
- Biofortification integrated into public health, food policy
- Leaders act as spokespersons in education campaigns





#### Private Companies

- In countries with robust private seed systems, companies are a natural partner
- Hybrid crops have most commercial appeal, but can become interested in self-pollinated crops if sufficient demand exists



### **Reducing Risk of Investment**

 HarvestPlus brokered agreements between companies, NGOs and government to ensure market for seeds

- Technical assistance
- Marketing support
- Limited purchase guarantees

### **Benefits of Private Sector Involvement**

- Involving private sector
  - Shortens the time to market
  - Lays the groundwork for sustainability
  - Contribute to research, testing
- Small and medium-size companies can help create demand for biofortified food even before supply reaches scale
  - Nigerian cassava value chain dominated by small and medium-size food processors
- Multinational companies slower to develop interest, but can have massive impact

### Value Chains

- When scaling up biofortification, reach out to stakeholders across existing value chains.
- A value chain consists of all the activities that add value to an agricultural commodity as it is brought to market.



### **Brainstorming**

#### **Value Chains**



Who are some of the key stakeholders in agricultural value chains, other than farmers and consumers?



### Value Chain Stakeholders

Besides farmers and consumers, value chains may include...

- Input Dealers Includes not only seed companies but makers of fertilizer, pesticides, equipment, etc.
- Aggregators Buy crops from smallholder farmers to resell in bulk to food processors, etc.
- Food processing companies
- Retailers and Market Operators
- Financial Institutions Some offer specialized products for farmers, including smallholders

### **Brainstorming**

#### Value Chains



How could the different types of stakeholders potentially support biofortification?

What incentive(s) might they have for doing so?



#### NGOs

- NGOs have networks to reach most vulnerable communities
- World Vision / HarvestPlus partnership incorporates biofortified crops into existing WV agricultural, health and nutrition programs in 15 countries.

### **Multilateral Institutions**

- Organizations like World Bank, African Development Bank, World Food Programme, World Health Organization, influence policymakers and operational partners
- World Bank implementing several projects supporting biofortification
  - E.g., accelerating the scale-up of orange-fleshed sweetpotato and iron beans in Uganda
- World Food Programme's (WFP) Purchase for Progress program very interested in local purchase of biofortified crops for emergencies



### **Capacity Building**

- Proponents and researchers need to provide capacity building to enable partners to better support biofortification
- Seed companies
- NGOs
- Retailers

- Community Organizations
- Extension agents
- Policymakers



### Which types of organizations would seem like the most natural partners to support biofortification in the communities where you work?



# Technical Support and Research





### **Technical Support and Research**

- Breeders and proponents can advise & assist farmers, partner organizations
- Collect feedback from local stakeholders
- Conduct research, gather data to refine strategy, guide next wave of crop development





#### **Technical Support and Research**

What types of information can we provide to other stakeholders?

What types of information might we want to collect?



### **Quick Survey**



Which of the following do you believe would be the most helpful partners for promoting biofortified crops in the countries/regions where you work?

- A. Government
- B. Private seed companies
- C. Aggregators, food processors, banks and other nonfarmer/consumer stakeholders in the value chain
- D. NGOs
- E. Multilateral organizations

### **Quick Review**

# ?

#### Alternate

- Who might we partner with to promote biofortified crops?
- Which types of partners do you think would be most helpful in the countries/regions where you work?
## **Unit Objectives - Review**

#### You should now be able to:

- Identify key stakeholders for biofortification initiatives
- Differentiate between different seed systems, and summarize the advantages and disadvantages of each for biofortification
- Suggest activities to promote farmer adoption of biofortified crops, particularly for your country/region
- Suggest activities to promote consumer adoption of biofortified crops in your country/region
- Develop promotional messaging for different stakeholders and identify the best channels for reaching audiences in your country/region
- Identify partnering opportunities to promote biofortification in your country/region

Unit 5

# **Scaling Biofortification**

## **Unit Objectives**

#### By the end of this unit you should be able to:

- Describe the major challenges for scaling and anchoring biofortified crops within national food systems
- Recognize the potential impact of policies and regulations on promotion of biofortified crops
- Evaluate the potential to support biofortification through trade
- Summarize the importance of integrating biofortification into international standards

# **How Biofortification Works**

- **Researchers** breed new varieties of staple crops with higher micronutrient content
- National partners (governments, private companies, NGOs, etc.) make new varieties available to farmers
- Farmers grow biofortified crops to feed their families and sell at market
- Consumers purchase and eat biofortified crops and foods
- Eventually, as cultivation and consumer demand scale, supply of micronutrient-rich, biofortified staples becomes self-sustaining

# **Achieving Scale**

- Introduce Encourage adoption of crop among the target groups (farmers, consumers)
- Scale Work with partners to promote crop and achieve necessary market share for long-term sustainability
- Anchor Strengthen support for crop through policy and business models to ensure it remains part of value chain





## **Scaling Up Operations**

- Goal is for biofortified crops to reach sustainable market share in order to ensure long-term supply
- Scale back direct support/financing, allow demand among farmers and public to sustain biofortification

### Virtuous Cycle

**Demand** drives **scale**, which can make biofortification more **cost-effective** and **sustainable** 



#### **Strategic Goals**

- Mainstream biofortified varieties into crop pipeline
- Achieve critical level of demand / market share
- Transfer ownership to public and private sector partners
- Reduce need for specific funding for biofortified crop development



#### **Strategic Goals**

 Encourage other organizations, governments to make biofortified traits a matter of standard practice (or regulatory requirement) for all breeding programs



## **Major Activities**

- Strengthen partnerships
  - Advise government agencies on policy, regulation
  - Attract private sector investment
- Strengthen seed markets
  - Capacity building
  - Product innovation
  - Certification and quality assurance mechanisms
- Incentivize private sector participation
- Mass media and grassroots promotion
  - Educate public, drive demand

#### Value Chains

- When scaling up biofortification, reach out to stakeholders across existing value chains.
- A value chain consists of all the activities that add value to an agricultural commodity as it is brought to market.



# **Brainstorming**

#### Value Chains

Who are some participants in agricultural value chains?

How could the different types of stakeholders potentially support biofortification? What incentive(s) might they have for doing so?

#### Value Chain Stakeholders

Besides farmers and consumers, value chains may include...

- Input Dealers Includes not only seed companies but makers of fertilizer, pesticides, equipment, etc.
- Aggregators Buy crops from smallholder farmers to resell in bulk to food processors, etc.
- Food processing companies
- Retailers and Market Operators
- Financial Institutions Some offer specialized products for farmers, including smallholders



## **Reducing Risk of Investment**

 Proponents broker agreements between companies, NGOs and government to ensure market for seeds

- Technical assistance
- Marketing support
- Limited purchase guarantees



#### **Commercial Food Processors**

- Using biofortified crops in processed foods can increase nutritional value
- Developing interest in biofortification among commercial food processors can ensure market for surplus crops



#### **Multilateral Institutions and NGOs**

- Can incorporate biofortified seed, crops into existing food programs
- Promote adoption
- Help with distribution
- Create market for surplus

#### Discussion



- In your own experience, how long does it take for new crops and agricultural practices to go from new/novel to mainstream?
- What could we do to accelerate mainstreaming of biofortification?
- How long do you imagine it might take in the communities where you work?

# Anchoring

- Introduce Encourage adoption of crop among the target groups (farmers, consumers)
- Scale Work with partners to promote crop and achieve necessary market share for long-term sustainability
- Anchor Strengthen support for crop through policy and business models to ensure it remains part of value chain





#### Ensuring Sustainability

Once scale is achieved, need strategic-level support to ensure sustainability

- Policy
- Regulation
- Trade



What could a local government do to support adoption of biofortified crops?

What kind of policies and regulations could be introduced / modified to help adoption of biofortified crops?

# Policy

- Help local and national government to enact policies and support mechanisms for continued engagement in biofortification as a solution for malnutrition
  - Government-sponsored biofortification programs in Brazil, China, India, Bolivia, Colombia, Guatemala, Haití, Nicaragua, Nigeria, Panama. Rwanda, Tanzania and Zambia
- Incorporate biofortification into regional, global initiatives
  - African Union's Comprehensive Africa Development
    Programme and the Scaling Up Nutrition movement
  - HarvestPlus Latin American and Caribbean (LAC) program led by the Brazilian Ministry of Agriculture's Research Corporation (EMBRAPA)
- Add biofortification as a requirement for future variety releases by private suppliers, other research organizations

#### Regulation

- Food labeling
  - Standardize
    labeling, health
    claims
  - Reduce false claims
- Develop official standards
  - Add minimum micronutrient levels to agronomic requirements for new crop release
- Proponents, breeders can assist certification authorities







# **Codex Alimentarius**

 Efforts underway to integrate biofortification standards into "Codex Alimentarius"

- Food standards maintained jointly by WHO and FAO
- Recognized by World Trade Organization (WTO) as its reference organization

#### Trade

- Profitable business environment and viable business models along biofortification value chain will ensure sustainability
- Important to not only strengthen domestic supply and demand, but also facilitate international trade
- Incorporating biofortification in national, regional and international agreements and standards can facilitate crossborder marketing
- Voluntary standards developed by the multinational food companies can also contribute to the spread of biofortification
- Regional agreements for the testing and release could reduce trade barriers, allow spread of biofortified seeds and crops into new countries



How amenable do you think the governments that you work with would be to adopting and enforcing biofortification standards?

What opportunities are there for trade in the regions where you work?



#### **Strengthening Partnerships**

- Sustainability requires strong relationships, credibility and trust with international, national and local partners
- Build on relationships formed with public, private, NGO sectors during earlier phases of implementation

# Activity (Groups)



#### Labeling

- Divide into groups
- Each group should design a label for biofortified products
  - Convey essential information for consumers as succinctly as possible
  - Give sense of benefits
  - Include an appropriate, distinctive symbol
- You have **15 min**

## Implementation

- Introduce Encourage adoption of crop among the target groups (farmers, consumers)
- Scale Work with partners to promote crop and achieve necessary market share for long-term sustainability
- Anchor Strengthen support for crop through policy and business models to ensure it remains part of value chain



## Implementation

- 3-stage approach is not a "master plan"
  - Not everything can be figured out before starting delivery operations
  - Continue to adapt approach while learning more about farmer and consumer preferences, market conditions, etc.
- Stages build on each other
  - Successful introduction of biofortified varieties necessary condition for scaling up / reaching market penetration
  - Successful scaling / achieving market penetration lays foundation for incorporation of biofortification into policy, regulatory and business frameworks



Which of these is **NOT** a strategic goal of biofortification efforts?

- A. Mainstream biofortified varieties into crop pipeline
- B. Achieve critical level of demand / market share for biofortified crops
- C. Provide intensive support and promotion to foster demand, indefinitely
- D. Transfer ownership of biofortified crop production and distribution to public and private sector partners
- E. Reduce need for specific funding for biofortified crop development



What is Codex Alimentarius?

- A. A UN commission regulating genetically modified products
- B. Food standards maintained jointly by WHO and FAO and a reference organisation for WTO
- C. An international high court protecting consumer rights
- D. An online library of scientific studies on biofortification



Breeders and advocates can help to "anchor" biofortified crops by:

- A. Providing direct, permanent subsidies to farmers over the long term
- B. Offering technical assistance as local stakeholders assume greater responsibility
- C. Demanding that national partners and regional institutions impose tariffs on non-biofortified varieties
- D. Setting a specific date for completely withdrawing support, to ensure local stakeholders take responsibility

# ?

#### Alternate

- What are some of the strategic goals for biofortified crops?
- What could local and national governments do to support biofortified crops adoption?
- What is Codex Alimentarius? Why is it important to biofortification initiatives?

285



## **Unit Objectives - Review**

#### You should now be able to:

- Describe the major challenges for scaling and anchoring biofortified crops within national food systems
- Recognize the potential impact of policies and regulations on promotion of biofortified crops
- Evaluate the potential to support biofortification through trade
- Summarize the importance of integrating biofortification into international standards

# Unit 6 Conclusion

## **Biofortification: Results**

#### 15+ years of studies confirm:

- Increasing nutrients in staple crops through biofortification can alleviate micronutrient deficiencies in real-world (non-experimental) conditions
- Crop breeding can increase nutrient levels enough to improve human nutrition without reducing yield
- Farmers are willing to grow biofortified crops and consumers are willing to eat them, as much or more than conventional popular varieties
- Biofortified crops can reach rural populations with limited access to diverse diets or other micronutrient interventions
- Biofortification is cost-effective per World Bank standards
## **Future Development**

- Continue to develop and release new varieties with even higher micronutrient content
- Introduce biofortified crops in new countries while working to lower international trade barriers
- Integrate biofortification into international and national crop-development programs, crop and food value chains, and national policies and standards
- Develop biofortified varieties of secondary staple crops (sorghum, lentil, cowpea, potato and banana)
- Promote combinations of biofortified crops providing different micronutrients as part of a 'food basket' approach
- Use biofortified raw products in food processing, which can then be further enhanced through fortification



- Biofortification offers a cost-effective solution for the complex problem of micronutrient deficiency
- In combination with other interventions, biofortification can alleviate malnutrition for millions of people





Zinc Rice Up to 60% of daily zinc

Yellow Cassava Up to 40% of daily vitamin A beta-carotenoids





Iron Pearl Millet Up to 80% of ds daily iron

High-Iron Beans Up to 50% of daily iron







Orange-Fleshed Sweetpotato Up to 100% of daily vitamin A (beta-carotenoids)

Zinc Wheat Up to 50% of daily zinc

Pro-Vitamin A Maize Up to 25% of daily vitamin A (beta-carotenoids)

- Biofortification involves breeding varieties of staple food crops with higher micronutrient content
- Accomplished through selective breeding (not GMO)

- Biofortification requires the support of farmers, consumers and local/international partners to succeed
- Developing crops with good agronomic and sensory qualities can drive adoption
- Nutrition messaging is key





- During initial introduction, direct, intensive support is critical
- Long-term sustainability requires scale / market share to anchor biofortified crops in national food systems

# **Objectives (Recap)**

#### You should now be able to:

- Explain how biofortification can address micronutrient malnutrition among poor populations
- Compare biofortification to other common interventions
- Summarize the process that breeders follow to produce biofortified varieties of staple crops
- Outline a strategy for promoting biofortified crops to farmers, consumers and partner organizations
- Describe the ways that various international, national and local stakeholders can help to make biofortification sustainable over the long term





# How might you apply the information presented in this training to your own work?

Any other questions?

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    <u>f</u>

### Building Nutritious FoodBaskets

Combating hidden hunger though nutritious food baskets

The Building Nutritious Food Baskets: Scaling up Biofortified Crops for Nutrition Security seeks to reduce hidden hunger by catalyzing sustainable investment for the production and utilization of biofortified crops (Orange-fleshed sweetpotato (OFSP); vitamin A (yellow) cassava, vitamin A (orange) maize and high iron/zinc beans) at scale. The project is implemented in Nigeria and Tanzania, to demonstrate how biofortified crops can be scaled up through a multi-crop ("food basket") approach. BNFB draws on complementary expertise for scaling up through a partnership between CGIAR centers and programs, regional organizations and other public and private sector agencies to create a movement that will eventually reach the target populations. BNFB's hypothesis is that scaling up is dependent on supportive policy environment, strong institutional capacities and availability of proven technologies.



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