HOKKAIDO UNIVERSITY

Virus Disease Management in Sustainable Agriculture

: Role of Academia in Research and Fostering Human Resources

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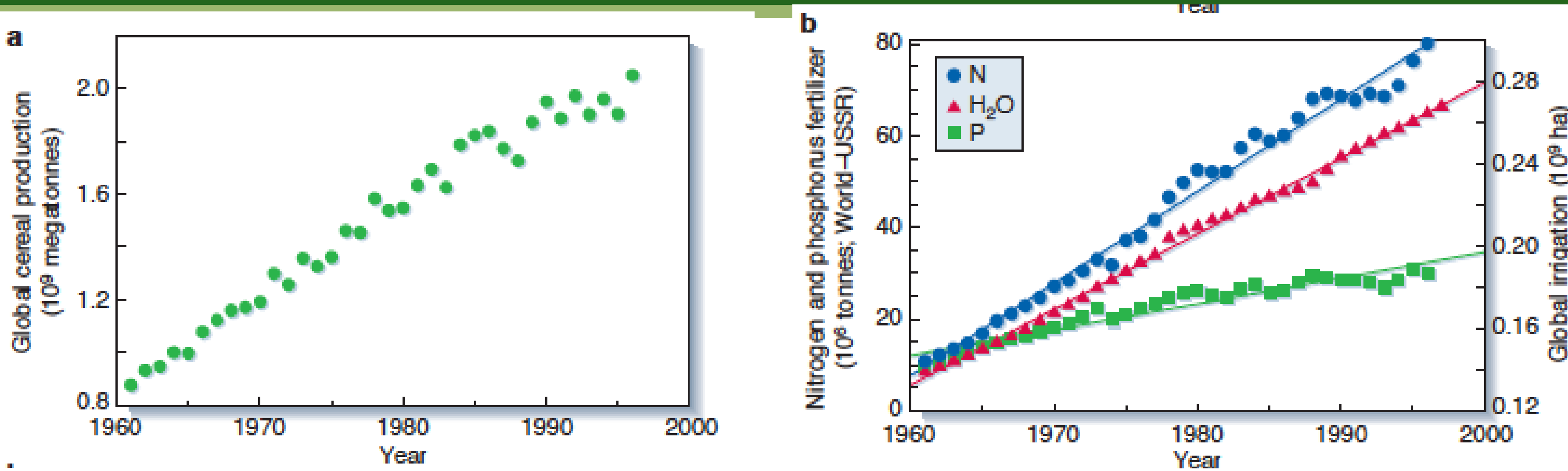
Introduction



Green revolution: Cereal production has more than doubled

- Greater input of fertilizer, water and pesticides
- Crop breeding
- New cultural practices and mechanization

By 2050, global population is projected to be 9 billion, 30% larger than 7 billion at present, and global grain demand is projected to double. It is a big challenge to feed world population in the future.

(D. Tilman et al, Nature 418:671, 2002)

Introduction

Can we continue to do it as we have done in last 50 years?

The answer is NO.

Sustainable agriculture as practices that meet current and future societal needs for food and fibre, for ecosystem services, and for healthy lives. Development of sustainable agriculture must accompany advances in the sustainable energy use, manufacturing, transportation, and other economic sectors that also have significant environmental impacts.

Green revolution

Nitrogen and phosphorus applied can be detrimental to environment.

Pesticide application may harm human health and ecosystem.

(Nature 418:671, 2002)

Disease control is a must for sustainable agriculture

Instead of expanding cultivated lands, crop yield increase per acre is expected.

In order to do so, biotechnologies and precise agricultural practices are needed.

Management is defined as limiting damage from diseases or pests. Reducing the use of pesticides is a desirable goal, but it depends on continued and increased investments in research on alternatives.

Crop yield Losses due to pathogens, pests and weeds are;

Wheat 14~35%, Rice 30~50%, Maize 21~38%, Potato 24~50%, Soybean 28%

(R. James Cook et al, BioScience 45:354 1995)
(EC. Oerke and HW. Dehne, Crop Protection 23:275 2004)

Disease occurrence inevitable

Wild species vs. cultivated crops

Taste comes first, disease resistance later

Wild species → Cultivated crops

Disease resistance → Susceptible

Agricultural techniques
- Breeding
- Fertilizer
- Agricultural chemicals

Agronomy

New variety is genetically vulnerable to pathogens and not ready to combat with diseases in a new environment

Risk of newly introduced variety

Diseases not previously a problem becomes a problem

Case of wheat yellow mosaic virus of wheat in Hokkaido island, Japan

Developed as a variety resistant to several fungal diseases with other good characteristics.

Field trial revealed dwarf and yellowing 100% in one area.

Found to be infected with wheat yellow mosaic virus.

35% grain yield reduction comapred to those in non-infested soil

Intrinsic weakness of Industrial Agriculture to diseases 2

Disease occurrence inevitable

Wild Ecosystem vs. Monoculture and large scale planting

Biodiversity is low in Agriculture
Under a favorable environment, nothing prevent pathogens from prevailing in a field.

Precision Agriculture: Obtain full capacity of the crop varieties

Integrated pest management based on scientific evidence.

The pursuit of sustainable agriculture will also require substantial increases in knowledge-intensive technologies that enhance scientifically sound decision making at the field level. (Nature 2002) Therefore extension plays an important role.

IPM require advanced technologies and human-social implementing system

Integrated pest management

Sustainable disease management

Develop disease resistant crops

- Use of natural genetic resources
- GMO: genetically modified organisms

Use of disease-free seeds and plants

Control Vector species

- Effective for virus disease control

Precise cultural practices

- Forecasting diseases / Minimum application of agricultural chemicals
- Cut disease perpetuation in a disease cycle

Natural resistance gene resources

Natural resistance gene is a first choice to adopt. However pathogens often break the crop resistance by frequent mutations.

Arm race of a host resistance gene and a new emerging race of a pathogen that overcomes the resistance

@ Resistance to viruses often broken by a single point mutation of viral genome.

@ Resistance to rice blast is often broken by emergence of a new race of rice blast fungus.

Natural resistance gene resources

Combating against emerging new races

Mixed planting of multiple race-specific disease resistance isogenic lines

Concept comes from

Browing and Frey, Annu. Rev. Phytopathol. 7:355 (1969)

Application in rice blast in 1980's in Japan and a induce resistance mechanism is proposed

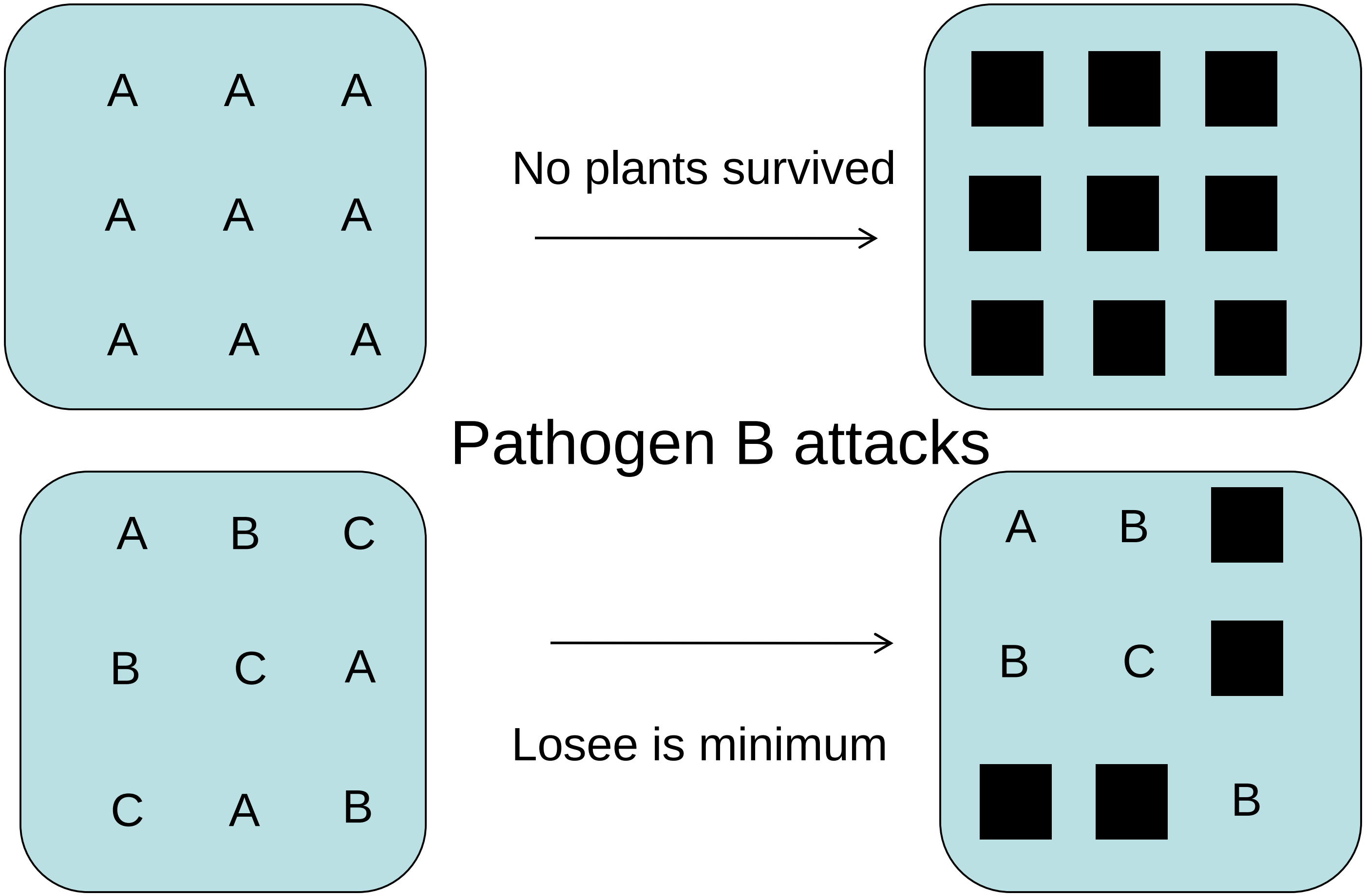
Nakajima et al, Ann. Phytopathol. Soc. Japan 62:360 (1996)

Good evidence of practical application in rice: suppress yield loss, reduced pesticide application

Zhu et al., Nature 406:718 (2000)

Natural resistant gene resources

Mixed planting of multiple race-specific disease resistance isogenic lines



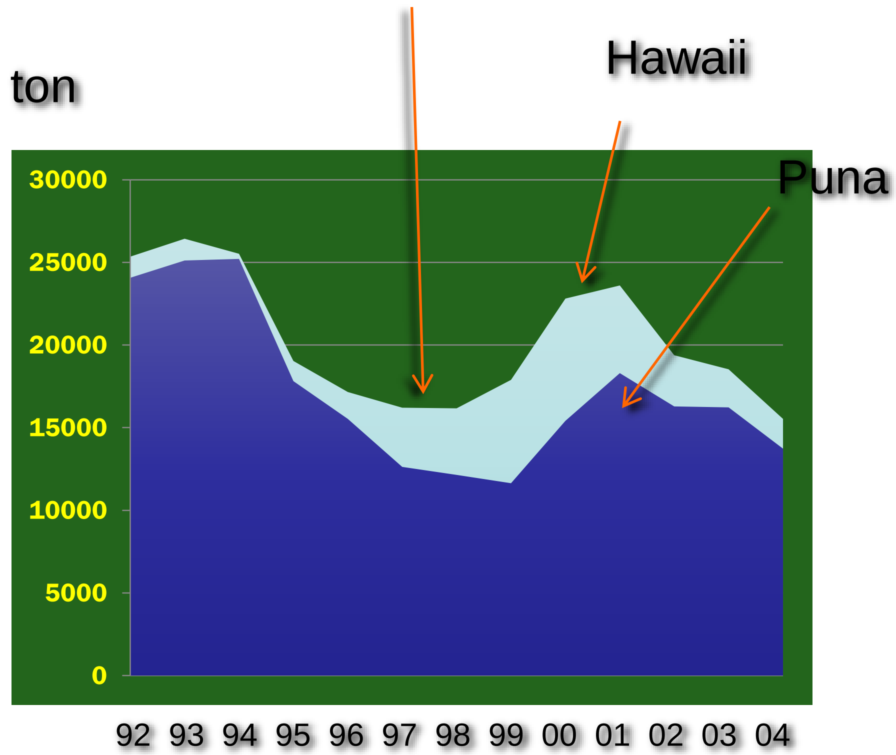
GMO

Good practice of GMO
Case of the transgenic papaya in Hawaii

1996: the transgenic line was deregulated by USDA

1998: Licenses to commercialize transgenic papaya were obtained by Papaya Administrative CommitteeFree distribution of seeds to growers

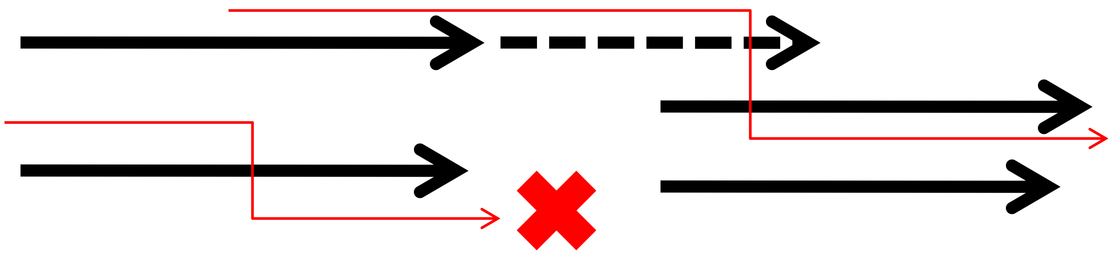
Of the 92 farmers who qualified to receive transgenic papaya seeds, 90% obtained them, 76 planted them, and 19% actually harvested frouits a year after distribution



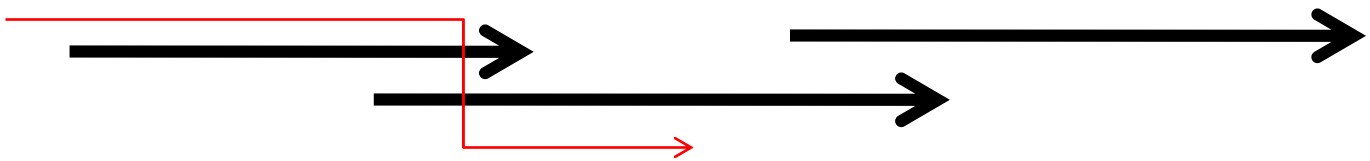
Production in Hawaii and the Puna dis. 1992 - 2004

Cultural practices : Cut disease cycle

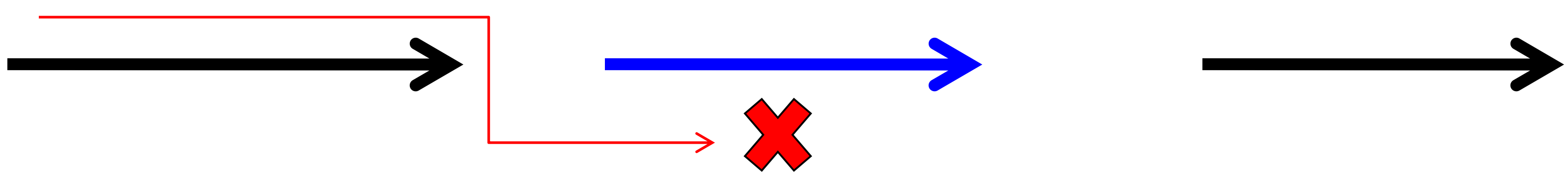
Eradication of previous year's remain (sanitation)



Avoid overlapping seasonal cultivation of a single crop



Crop rotations



Role of Academia in Technology Transfers

Academic societies

Universities
Agricultural University
Faculty of Agriculture

Joint Research

National Research Institutes

Training program

Joint Research

Technology Transfer

Molecular marker assisted breeding

Disease diagnosis technologies

Training program

Joint Research

Key organizations

Regional agricultural experiment stations, Extension Centers

Agricultural Cooperative Associations

Food companies, Agricultural And chemical companies

Farmers

Role of academia in policy making

Academic Societies

Science Council of Japan

Close association

Committee for Agriculture
Committee for Food science

Japanese Society of Breeding
Japanese Society of Soil Science and Plant Nutrition
The Phytopathological Society of Japan

Reports and recommendations to government

Public lectures

Issues such as
Food safety and security

Training program

Public lectures

Technology transfers and
Other agricultural issues

Stakeholders

Researchers

Administrators and government officers

Introduction


Thank you