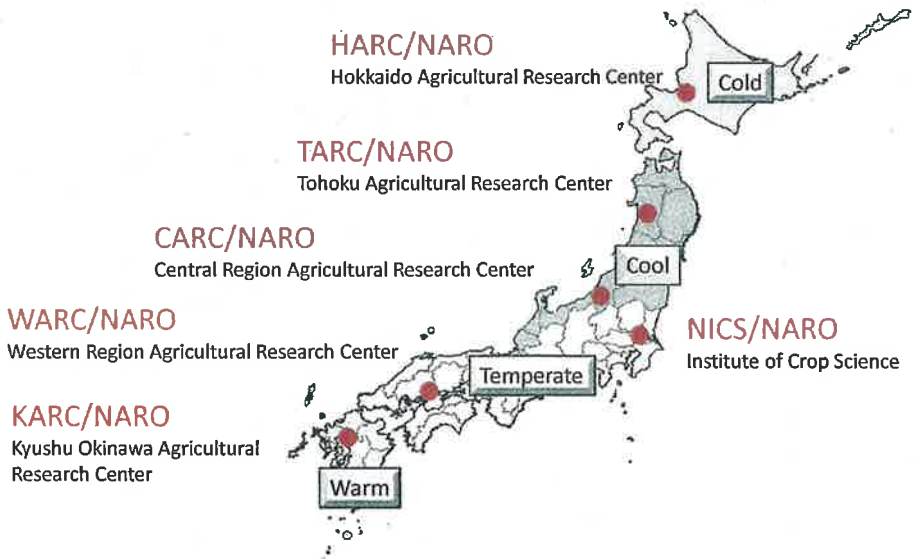
Rice Breeding in Japan

Rice breeding unit, Institute of Crop Science, NARO
Takuro Ishii

Rice breeding stations in NARO

NARO



Present focus of rice breeding research

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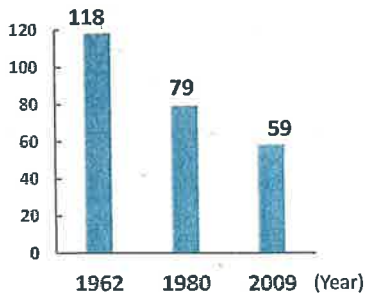
1. Commercial rice & Rice flour
   (for use of the Food industry) 外食的米.
2. Forage rice lodging, 100 kg/ha nitrogen.
3. Adaptation to *Global Warming*

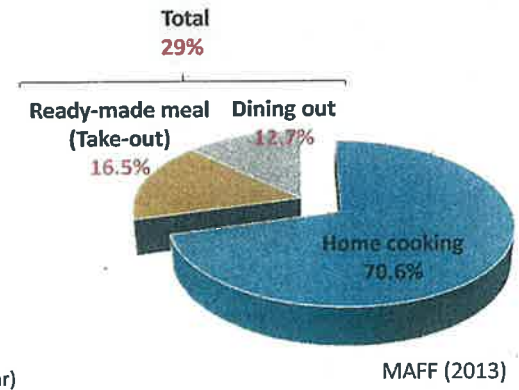
1. Commercial rice & Rice flour

NARO

Background

(Kg/capita/year)





MAFF (2013)

Food industry.

1. Rice consumption has been decreasing.
2. Home cooking is also decreasing .
(Total 29% of rice is consumed in the food service).

1. Commercial rice & Rice flour

NARO

The 1st objective of the rice breeding for use of the Food industry

Development of high-yielding varieties with tolerance to environmental stresses is the most important, because price is their top priority.


Lunch box


Beef bowl


Rice ball


Rice flour noodle


Sushi-bar

Frozen food

Rice flour bread

1. Commercial rice & Rice flour

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Varieties suitable for commercial use

non-stickiness

"Toyomeki"

- High yielding(8.1t/ha)
- Lodging resistance
- Eating quality of the frozen rice is good.

AJINOMOTO FOODS
(Commercial product)

冷凍 -18°C
4°C

"Tachiharuka"

- High yielding (6.9t/ha)
- Blast resistance
- Stripe Virus resistance
- Lodging resistance
- Cooked rice is used for food delivery service and lunch box.

"Eminokizuna"

- Stickiness of the cooked rice is low .
- Eating quality of the Sushi is good.

1. Commercial rice & Rice flour

NARO

Varieties suitable for rice flour

"Mizuhochikara"

- High yielding (7.2t/ha)
- Lodging resistance
- Suitable for bread (Good swelling)

Mizuhochikara Koshihikari

Rice flour (Commercial product)

"Koshinokaori"

- High-amylose content
- Suitable for noodle (non-sticky)

Koshinokaori (High-amylose)

Rice noodle (Commercial product)

Shunyo (Medium amylose)

1. Commercial rice & Rice flour

NARO

Conclusions

1. To increase consumption of rice, we try to breed varieties for use of the Food industry.
2. Breeding objectives of such varieties;
   1) High-yielding
   2) Tolerance to insects & diseases } Low cost production
   3) Grain qualities suited for the commercial products.

2. Forage rice

NARO

Background

Japan's food self-sufficiency ratio on a calorie supply basis is low level . (Total 39% and Forage 26%)

From the view point of "self-sufficiency ratio ", the demand of breeding for forage rice has been increasing since *00s*.

2000

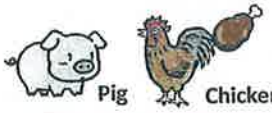
2. Forage rice

NARO

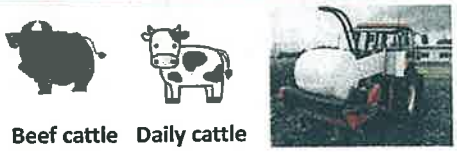
2 types of forage rice

1.Grain feed

rough rice
brown rice



2.Whole crop silage (WCS)



Rice is harvested at the yellow ripening stage, because total digestible nutrients (TDN) is highest at this stage.

2. Forage rice

NARO

Objectives of the rice breeding for forage under low-cost production

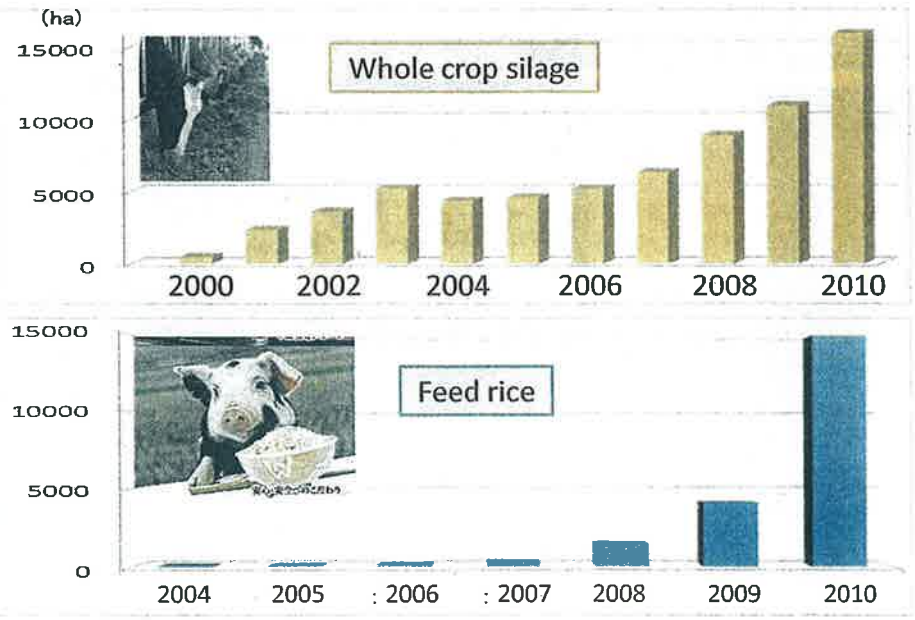
Grain feed type

1. High grain yield (over 10t/ha brown rice base)
2. Multiple-resistance for insects and diseases

WCS type

1. High biomass yield (Total dry weight: 22t/ha, TDN : 13t/ha)
2. Multiple-resistance for insects and diseases
3. Lodging resistance

Expansion of forage rice in Japan



2. Forage rice

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Rice cultivation area for WCS and grain feed

Year	2009	2010	2011	2012	2013
WCS	10,203	15,939	23,086	25,672	26,600
Grain	4,129	14,883	33,955	34,525	21,802
Total	14,332	30,822	57,041	60,197	48,402

(ha)

「タカナリ」と「たちすがた」

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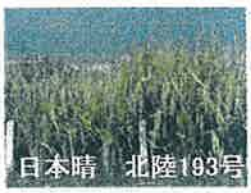
Feed rice varieties

Feed rice varieties in Japan

For cold region
「Kitaaoba」

For cool region
「Bekoaoba」

For cool and warm region
「Hokuriku193」

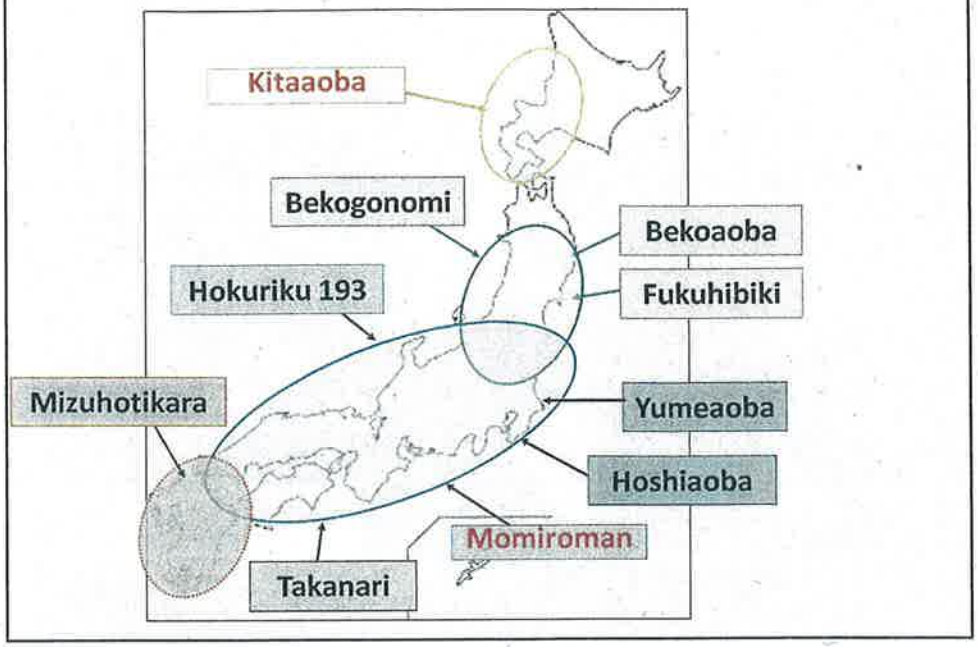


For warm region
「Momiroman」

For waram region
「Hoshiaoba」

For hot region
「Mizuhochikara」

Released High yielding Varieties

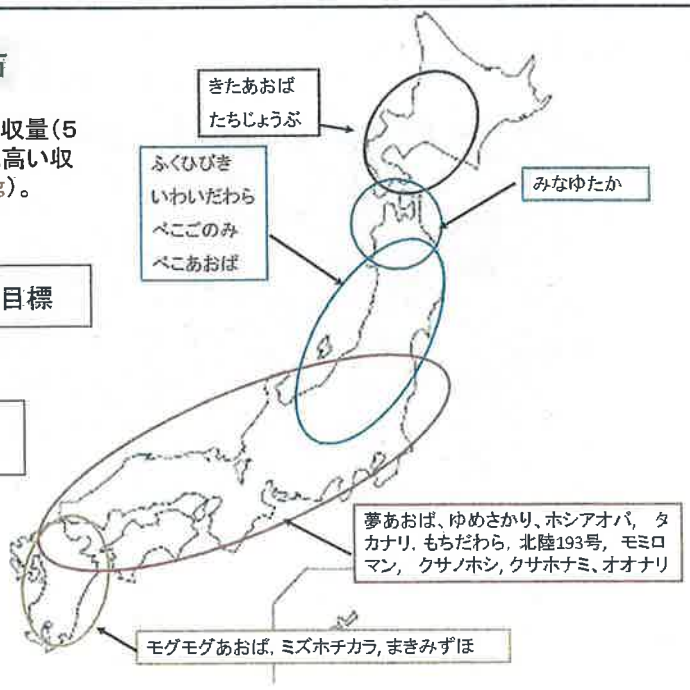


栽培適地の分布

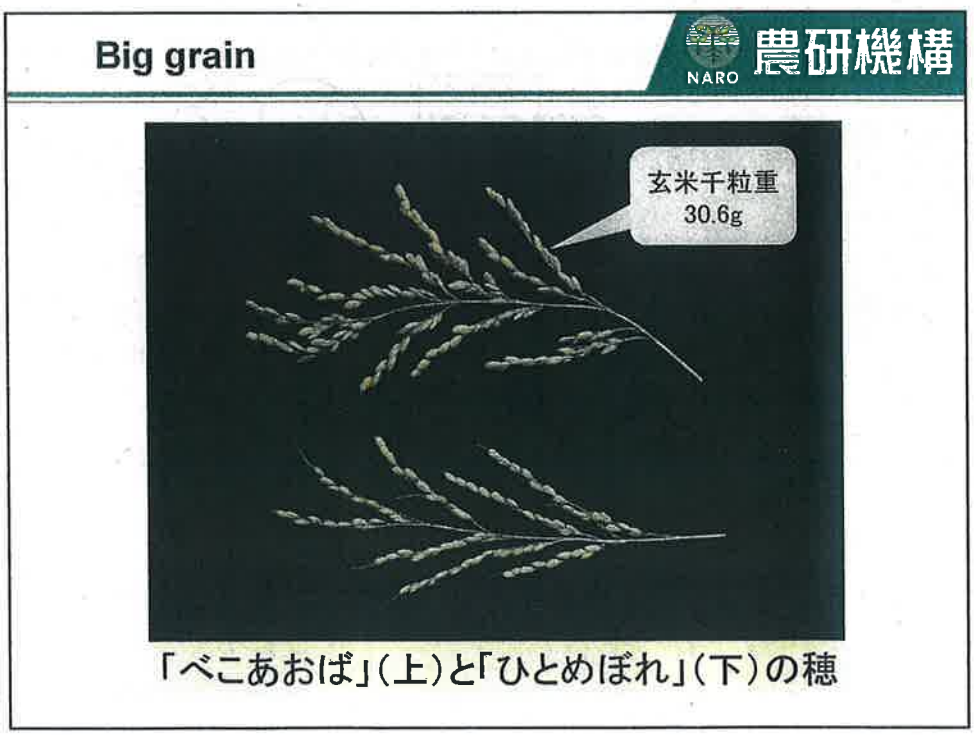
平成24年産水稲平年収量(530kg)に比べ、大幅に高い収量(概ね700～800kg)。

飼料用米の育成目標

玄米収量
1t/10a




Long panicle (籾数が多い)
北陸193号
日本晴
日本晴の穂の籾数は100程度ですが、北陸193号の穂には200～300の籾が着きます。しかも、優れた登熟力が特徴です。
19

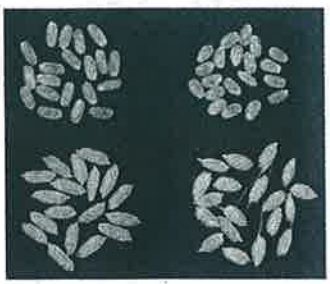

Big grain
NARO
農研機構
玄米千粒重
30.6g
「べこあおば」(上)と「ひとめぼれ」(下)の穂

Lodging resistance

High yielding variety in Warm area 「Hokuriku 193」

兼用

- インド型品種で、収穫期は「日本晴」より遅い。
- 一穂籾数が多く、粗玄米収量は780kg/10a（新潟県上越市）で、「日本晴」より18%多収。
- 稈は極めて太く、非常に倒れにくい。
- 種子の休眠性が強いため、休眠打破処理を行う必要がある。



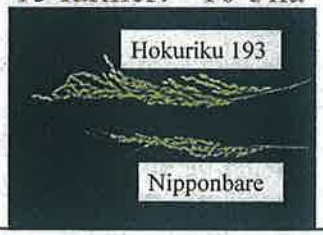
北陸193号　日本晴　22

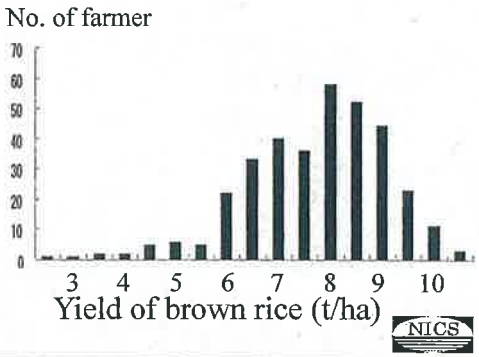
High yielding variety "Hokuriku 193"

Average yield in Experimental Station (2006-2008)
7.14 ～ 9.11 t/ha (Brown rice)

Yield Record of "Hokuriku 193" in farmer's field, 2008
【344 farmer, 301ha】

- ◆Total average: 7.81 t/ha
- ◆Highest record: 10.9 t/ha
- ◆15 farmer: >10 t/ha





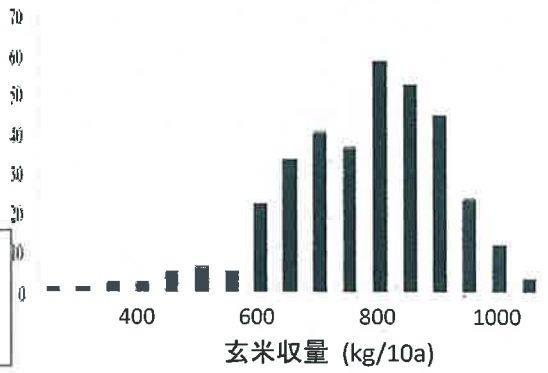
北陸１９３号

新潟県でバイオエタノール素材として利用

2006年～2008年の試作収量 ：714 ～ 911 kg/10a

2008年生産体制
- ◆農家数 344戸
- ◆栽培面積301 ha

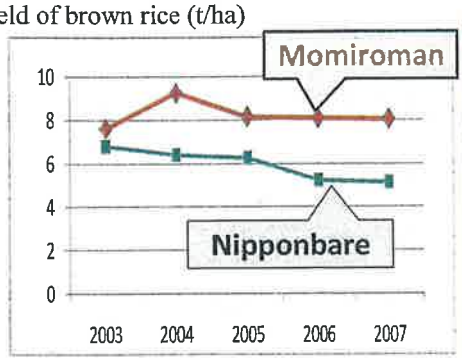
平均収量: 780kg/10a
最高収量: 1090kg/10a
1tを越えた農家: 15戸



(農研機構 中央農研北陸センター)

High yielding variety "Momiroman"

Yield of brown rice (t/ha)



Yield ability in NICS, Tsukuba, Japan.

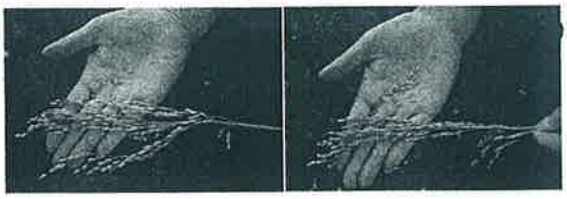
"Momiroman" is selected from the combination between New plant type rice and Japanese panicle weight type rice. This variety is mainly used as feed rice.

NICS

関東以西向き 「Oonari」

- γ線照射によって、インド型品種「タカナリ」の脱粒性を改良。
- 「タカナリ」よりも約7%多収。
- 除草剤 ベンゾビシクロンに感受性。

品種	出穂期 月.日	成熟期 月.日	稈長 cm	穂長 cm	穂数 本/m²	玄米収量 kg/a	同左 比率%
オオナリ	8.06	9.22	83	26.2	336	94.0	107
タカナリ	8.05	9.22	82	25.7	322	87.7	100
日本晴	8.11	9.27	96	20.3	502	62.1	71



（左：「オオナリ」、右：「タカナリ」）

25

Rice varieties for whole crop silage

イネWCS用専用品種の特徴

農研機構 NARO

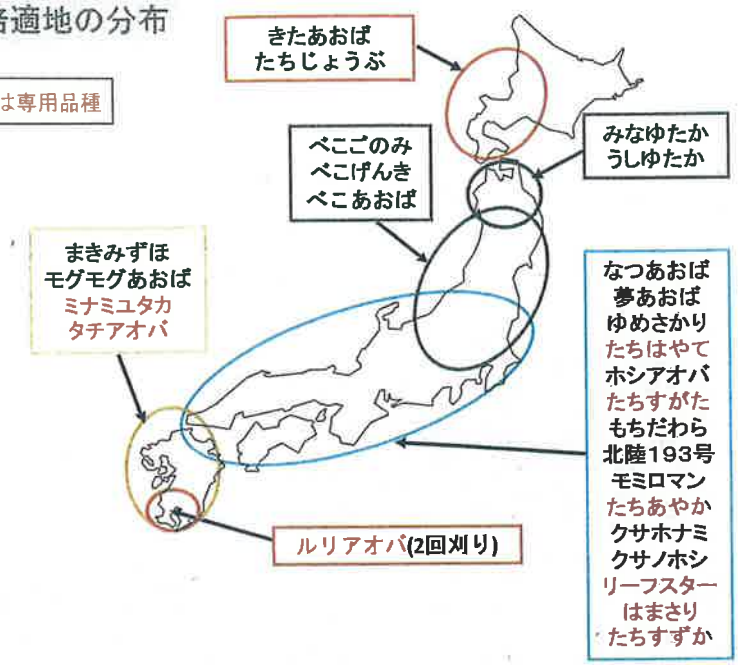
○茎葉多収型である。稈長が長い (long culm, high total weight)。

○強稈で耐倒伏性に優れる (resistant to lodging)。

○玄米収量は高くない (grain yield is not so high)。

栽培適地の分布

赤字は専用品種



関東以西向き「Tachisugata」

- 関東では中生熟期。
- 茎葉の繁茂が良く、高い地上部全重収量とTDN収量を示す。
- 直播栽培でも高い地上部全重収量を示す。

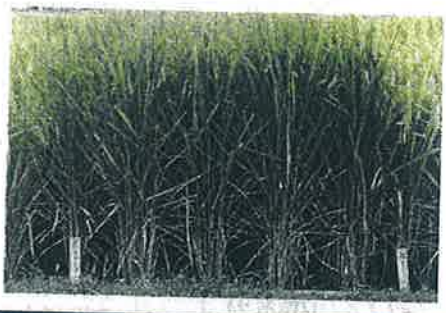
左:タカナリ、右:たちすがた

品種名（一般品種）	出穂期（月．日）	成熟期（月．日）	稈長（cm）	耐倒伏性	風乾全重（t/10	乾物全重（t/10	玄米重（t/10	推定TDN含量(%)	推定TDN収量(	推定TDN収量比率(%)
たちすがた	8.11	10.05	109	強	2.19	2.02	0.6	59.6	1.20	118
(日本晴)	8.16	9.27	90	やや強	1.85	1.75	0.56	58.0	1.01	100

2006

関東以西向き 「Leafstar」

- 関東では極晩生の熟期。
- 茎葉が良く繁茂し、高い地上部全重収量とTDN収量を示す。
- 稈質が強く、耐倒伏性に優れる。



品種名（一般品種）	出穂期（月．日）	成熟期（月．日）	稈長（cm）	耐倒伏性	風乾全重（t/10）	乾物全重（t/10）	玄米重（t/10）	推定TDN含量（%）	推定TDN収量（t/10）	推定TDN収量比率（%）
リーフスター	8.31	10.16	109	強	2.14	1.92	0.42	61.0	1.17	111
はまさり	8.31	10.08	96	強	1.92	1.73	0.51	60.7	1.05	100

関東以西向き 「Tachisuzuka」

- 茎葉が多収で牛が消化しにくい籾が少ない。
- 発酵に必要な糖を多く含み、収穫適期を過ぎても倒れにくい。

品種	出穂期 月．日	稈長 cm	全乾物重 kg/a	同左 比率%	茎葉重 kg/a	籾重 kg/a	黄熟期の糖含量%	耐倒伏性	TDN※ %
たちすずか	9.02	121	187	105	164	23	10.1	極強	58.3
クサノホシ	8.29	110	178	100	106	72	1.7	やや強	53.0

2. Forage rice

NARO

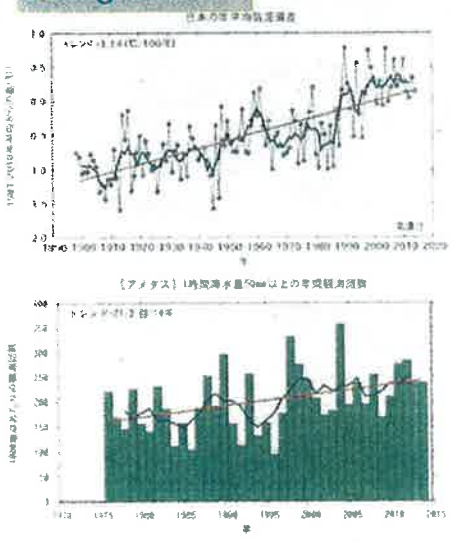
Conclusion

1. To increase the food self-sufficiency ratio, breeding of forage rice was conducted in the last two decades.
2. Two types of forage rice varieties were bred; grain feed type for pig and chicken and WCS for cattle.
3. The most important breeding objectives of forage rice is "high yielding" to accomplish the low cost production, because the international rice price is more cheap than that of ours.

3. Adaptation to *Global Warming* (GW)

NARO

Background



MAFF (2016)

1. Temperature in Japan has been increasing for the last century; 1.14°C/100 Years.
2. In future (2100), temperature will be 1.1- 4.4°C higher than in now (2014).
3. Frequency of Heavy rain (>50mm/hour) in Japan has been also increased.

↓ *Global Warming (GW)*

In Japanese paddy field, Heat damages, diseases and insects are frequently observed.

3. Adaptation to *Global Warming* (GW)

NARO

What damages and How to adapt?

2-1. Adaptation to Heat damages

Chalky grain

Cracked rice
(Fissured grain)

High-temperature sterility

2-2. Adaptation to Diseases and Insects exacerbated by GW

Brown plant hopper

Bacterial grain rot

Brown spot

3. Adaptation to *Global Warming* (GW)

NARO

What damages and How to adapt?

So, genetic information is....

2-1. Adaptation to Heat damages

Chalky grain

Cracked rice
(Fissured grain)

High-temperature sterility

2-2. Adaptation to Diseases and Insects exacerbated by GW

Brown plant hopper

Bacterial grain rot

Brown spot

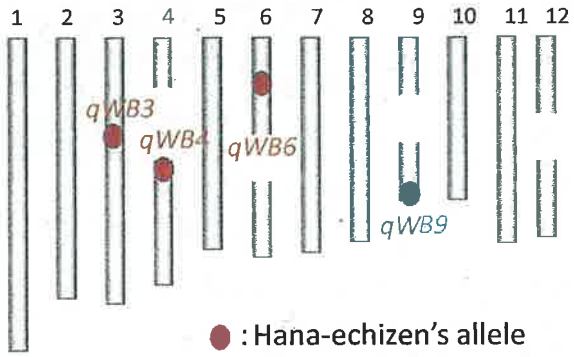
3-1. Adaptation to Heat Damage (Chalky grain)

NARO

QTLs for reducing chalky grain

Hana-echizen (resistant)
Niigata-wase (susceptible)

1) 4 QTLs were detected on the chromosome 3,4,6 and 9.
2) Additive effect of a major QTL (*qWB6*) is more than 30%.



● : Hana-echizen's allele
● : Niigata-wase's allele

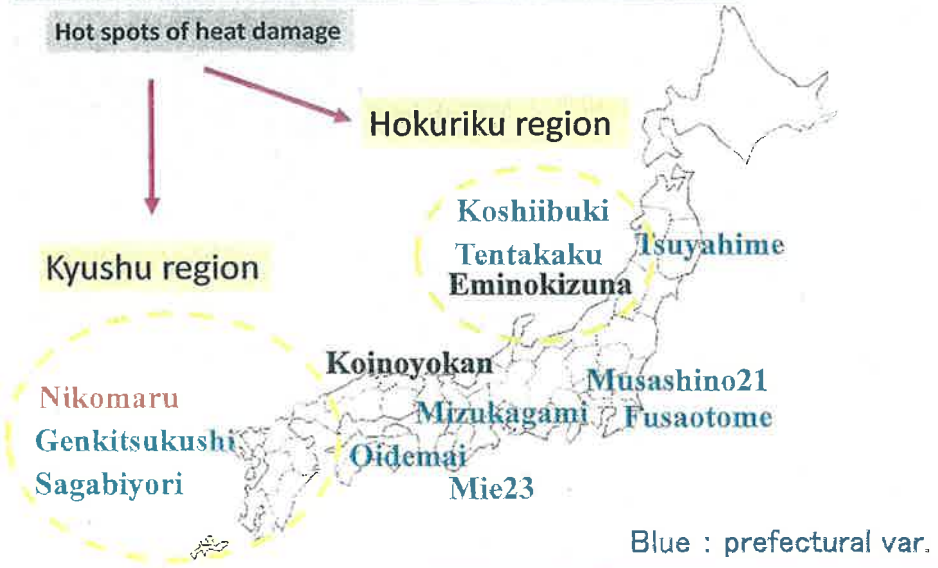
Kobayashi et al. (2008)

3-1. Adaptation to Heat Damage (Chalky grain)

NARO

Heat damage Resistant varieties in 2014

Hot spots of heat damage



3-1. Adaptation to Heat Damage (Chalky grain)

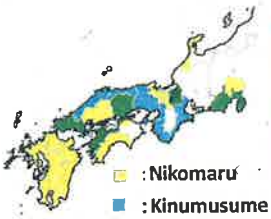
NARO

Varieties reducing chalky grain

"Nikomaru" and "Kinumusue"

Good grain appearance under high-temperature

Good eating quality as same as that of Koshihikari



Planted area in 2015
Nikomaru : 10,000ha
Kinumusume : 12,000ha

3-2. Adaptation to Diseases and Insects exacerbated by GW

NARO

Brown plant hopper resistance variety①

Kanto BPH1

Near isogenic line of Hinohikari with the BPH resistance gene, *Bph11*

Hinohikari　　Kanto BPH1

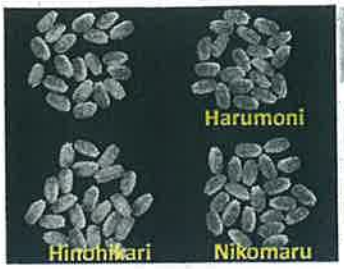
Degree of BPH resistance in field
(Resistance Var. is unknown)

3-2. Adaptation to Diseases and Insects exacerbated by GW

NARO

Brown plant hopper resistance variety②

Harumoni



Good grain appearance under high-temperature

Additionally, wich harboring 3 resistance genes (*Pb1*, *bph11* and *Stvb-i*)

blast

Brown plant hopper

Stripe virus

Hopperburn observed in 'Harumoni' (2013)

Now, the effect of *bph11* to the present biotype of insect is limited. It is necessary to pyrimidine other resistance genes.

3-2. Adaptation to Diseases and Insects exacerbated by GW

NARO

QTLs for Bacterial grain rot resistance

Two QTLs are used for breeding.

QTLs for Brown spot resistance

A major QTL, *qBSfR11* from Tadukan, is used for breeding.

Get more information from the Review written by our research group!

Mizobuchi et al. Rice (2016) 9:23

REVIEW Open Access

QTLs for Resistance to Major Rice Diseases Exacerbated by Global Warming: Brown Spot, Bacterial Seedling Rot, and Bacterial Grain Rot

Ritsuko Mizobuchi, Shuichi Fukuoka, Seiya Tsushima, Motohiko Yano and Hiroyuki Sato*

Varieties with the resistance QTLs are now breeding

3. Adaptation to *Global Warming* (GW)

NARO

Conclusion

1. It is necessary for us to breed resistant varieties under progressing of global warming.
2. Basic researches are also necessary to get the genetic information concerning with high-temperature sterility and cracked rice (in future works).