Weed Management and Weed Genetics: Jointed Goatgrass: Case Study for Gene Flow

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Wheat will form hybrids with jointed goatgrass in the field.

Background

- Research started in 1991 with the discovery that hybrids had produced viable seeds
- Experiments were conducted over 17 years to answer questions concerning the potential for gene flow between wheat and jointed goatgrass
- This research took on more importance with the development of herbicide resistant wheat

Initial questions addressed:

- What was the source of seed on the hybrids?
- How common are the hybrids?
- Would backcrossing occur in the field?
- Would additional generations of backcrossing occur?
- Would self-fertility be restored; if so in what generation?

tetraploid

hexaploid

CC**DD**

AABB**DD**

JGG

X

Wheat

F_1 Hybrid

2n = 35

ABC**DD**

BC_1 to JGG

2n = 30-49

BC_1 to wheat

2n = 39-56

Advanced backcross hybrid

2n = ~28

2n = ~42

Source of seed on hybrids

- Initial research demonstrated that the seed on the hybrid plants was due to backcrossing to either wheat or jointed goatgrass
- While the hybrids are male-sterile, they are partially (~ 2%) female- fertile
- The common D genomes are a probable explanation for the partial female fertility
- Wheat x jointed goatgrass hybrids crossed to either wheat or jointed goatgrass at the same frequency

Cross	% Seed Set
Hybrid x JGG	2.2
Hybrid x Wheat	2.0

Fertility restoration

- Chromosome number in the backcrosses decreased with each cycle of backcrossing, approaching that of the recurrent parent jointed goatgrass (28)

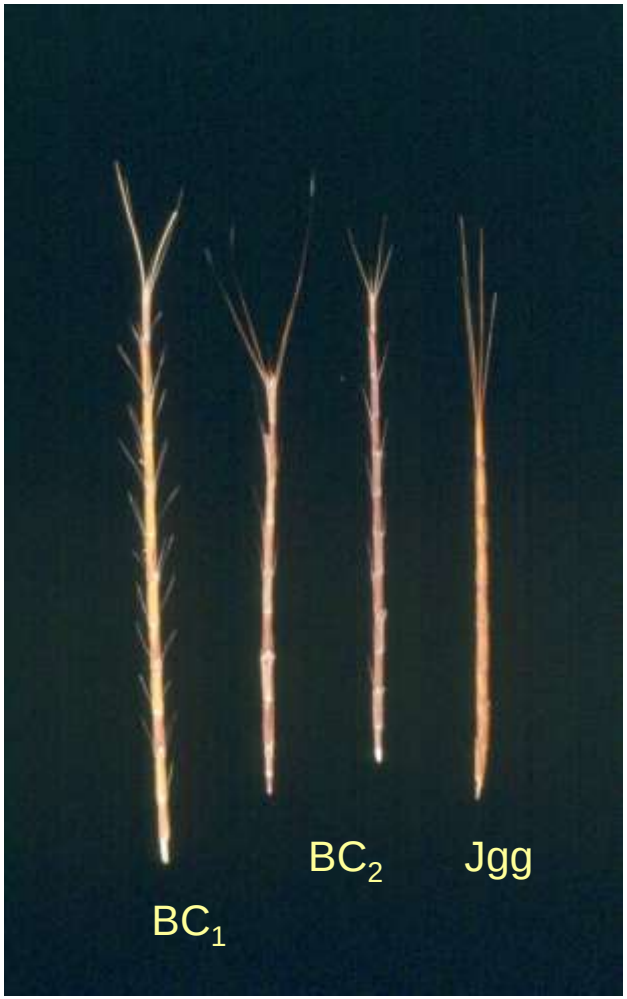
- The increase in homologous chromosome pairs in later backcross generations helps explain the increase in female fertility and the restoration of self-fertility

How many hybrids are out there?

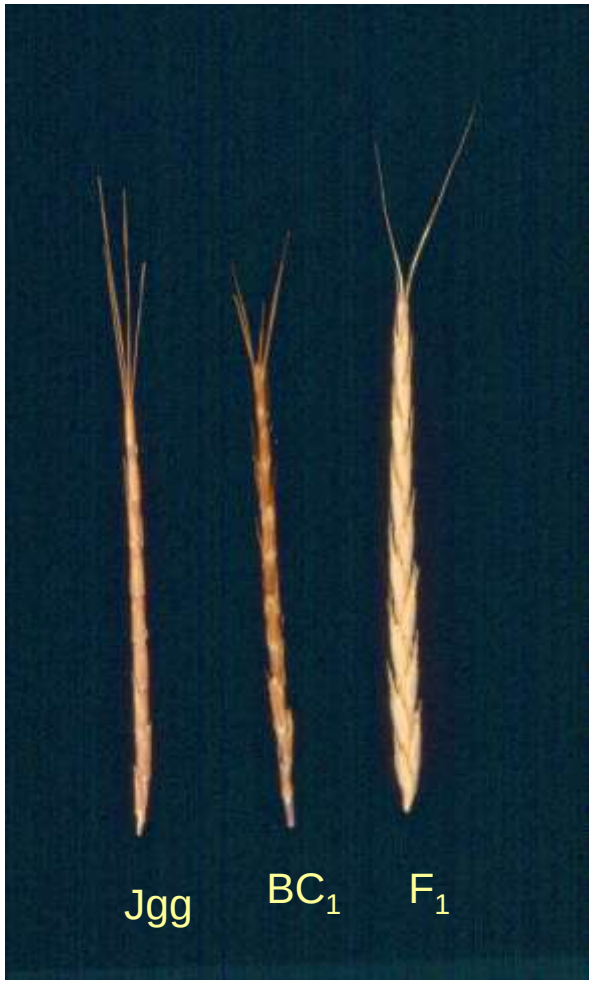
Oregon hybrid collection

Year	Total plants	Fertile plants	Total seed	Fertile spikes	Sterile spikes	Total spikes
1998	86	42	222	165	753	918
1999	269	129	504	400	1834	2280
2000	399	157	502	335	1984	2319
Total	754	328	1228	900	4571	5517

Jointed goatgrass-like backcross hybrids



Experimental



Wheat-field

BC_1

BC_2

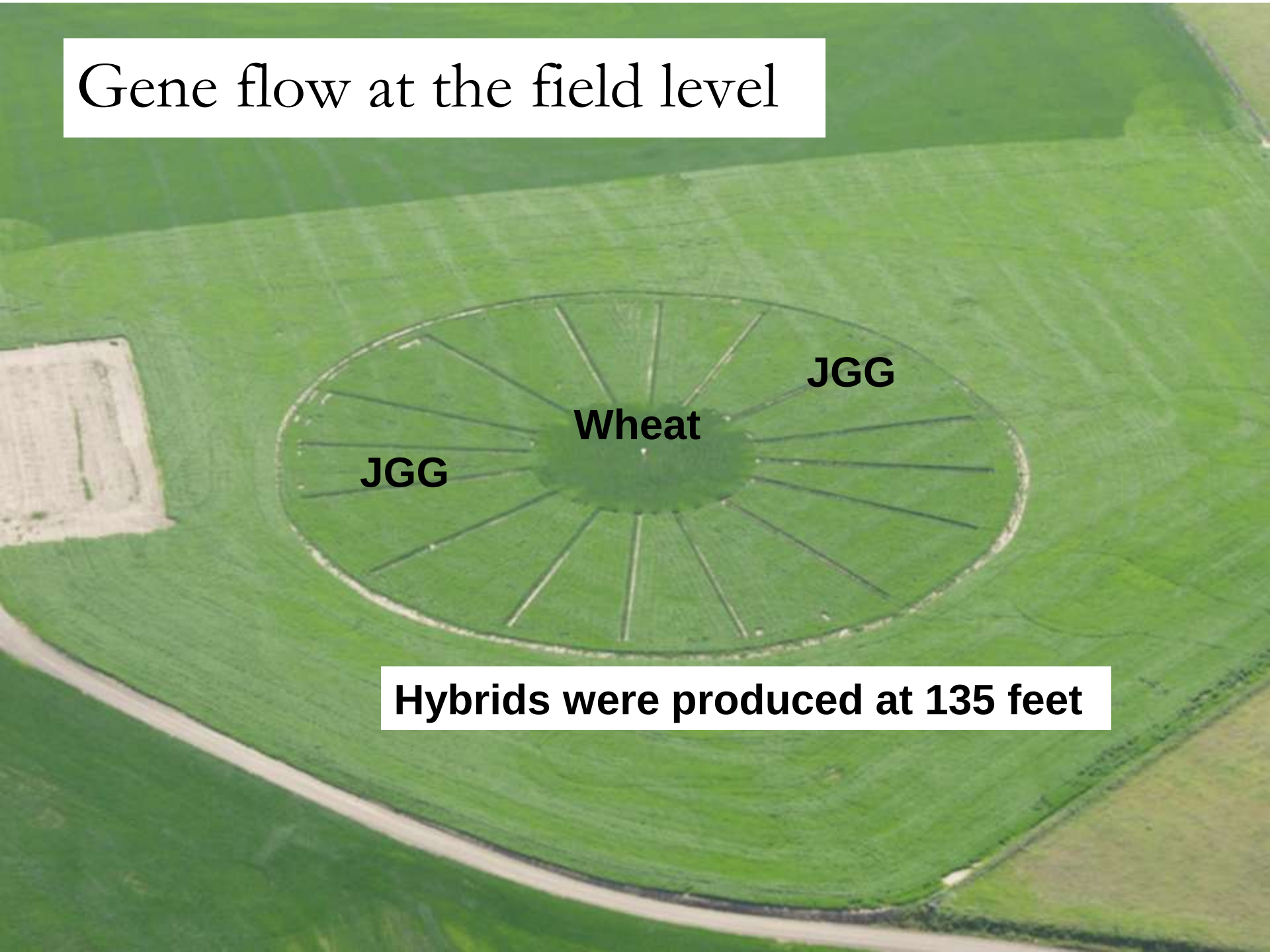
In greenhouse studies:

- Average female fertility in the BC_1 generation increased from 4.4% - 5.1% (range 0.0 to 20.3%)
- Fertility increased in the BC_2 generation with partial restoration of self-fertility from 6.9% to 20.9% (range 0 to 73.2%)

Backcrossing under field conditions

Hybrids and BC_1 plants planted in the field with jointed goatgrass backcrossed at a similar frequency as was observed in the greenhouse

Gene flow at the field level



Hybrids were produced at 135 feet

Results led to additional questions

- Could we determine the direction the crosses were occurring?
- Does gene introgression occur?
- Could genome placement of a resistance gene prevent gene introgression?

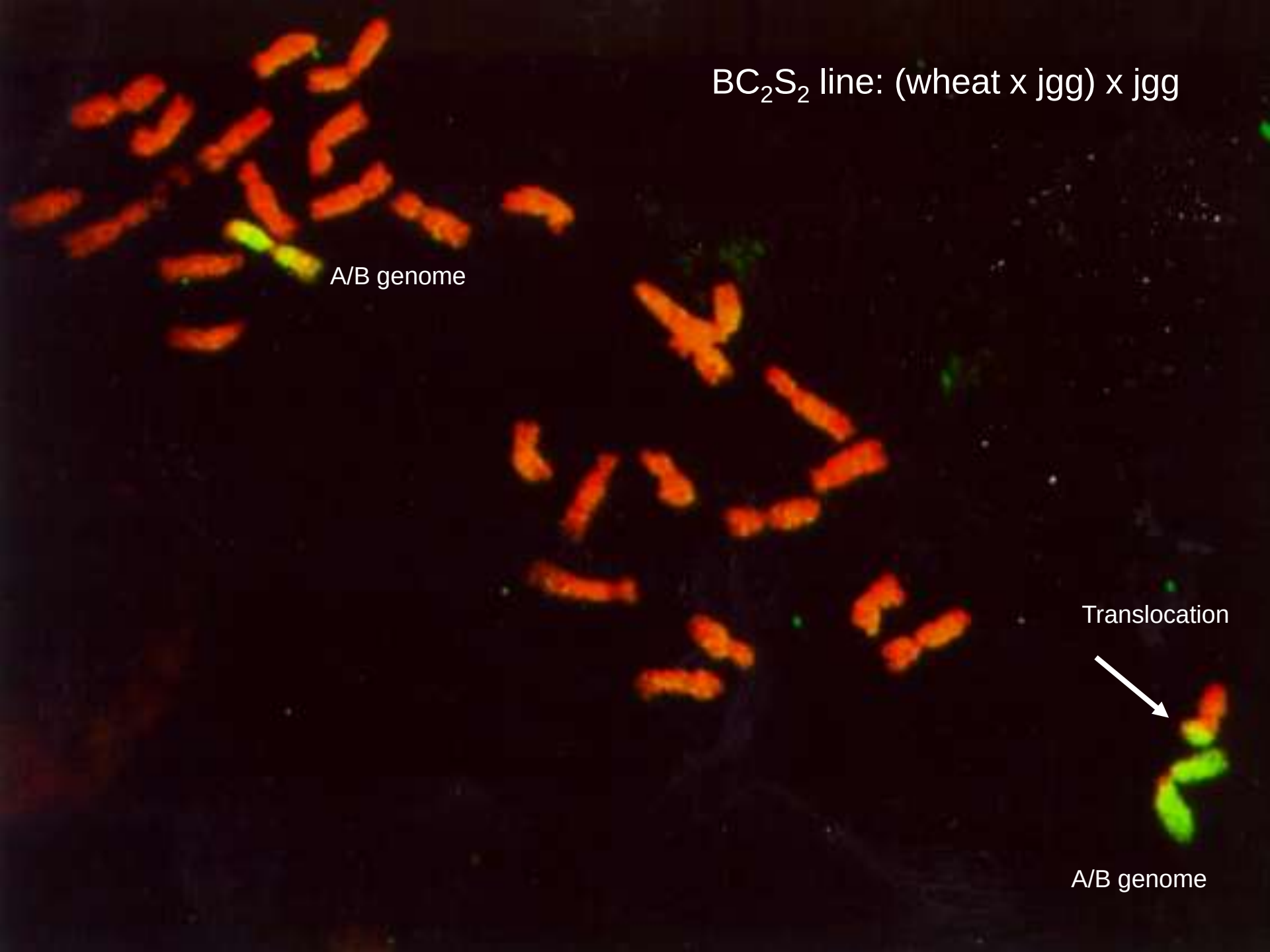
Determination of parentage

- Methods were developed to determine the parentage of the backcrosses found in the field.

- These methods included:
  - high molecular weight glutenin
  - genomic in-situ hybridization (GISH)
  - molecular markers

Determination of parentage

- Use of GISH allowed for determination of:
  - recurrent backcross parent
  - chromosome retention
  - chromosome introgression

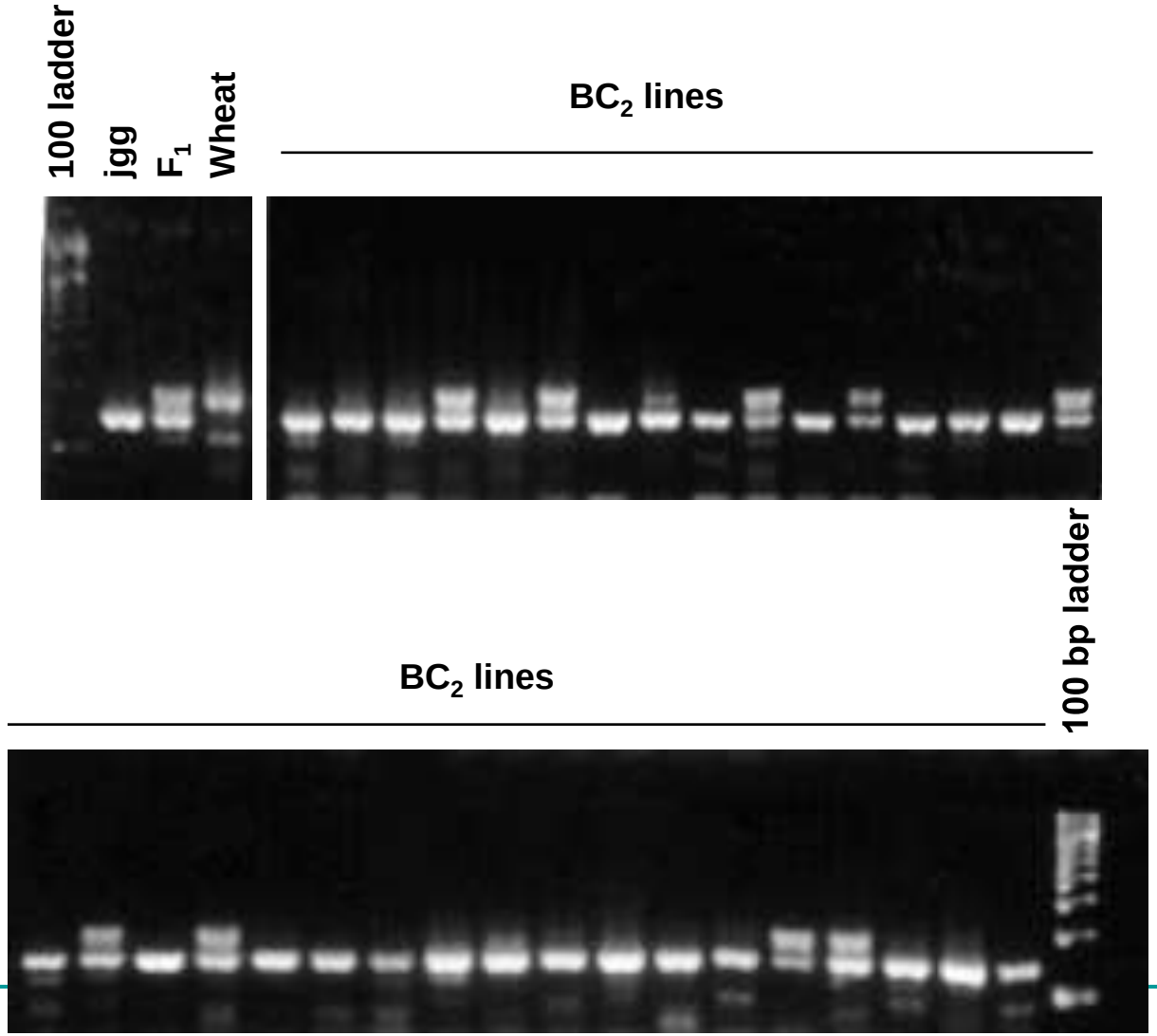

BC_2S_2 line: (wheat x jgg) x jgg
A/B genome
Translocation
A/B genome

Introgression did occur

- Molecular markers confirmed introgression of wheat chromatin and wheat genes into BC_2 plants that had jointed goatgrass as a recurrent parent

- Wheat chromatin was retained at the expected Mendelian frequencies

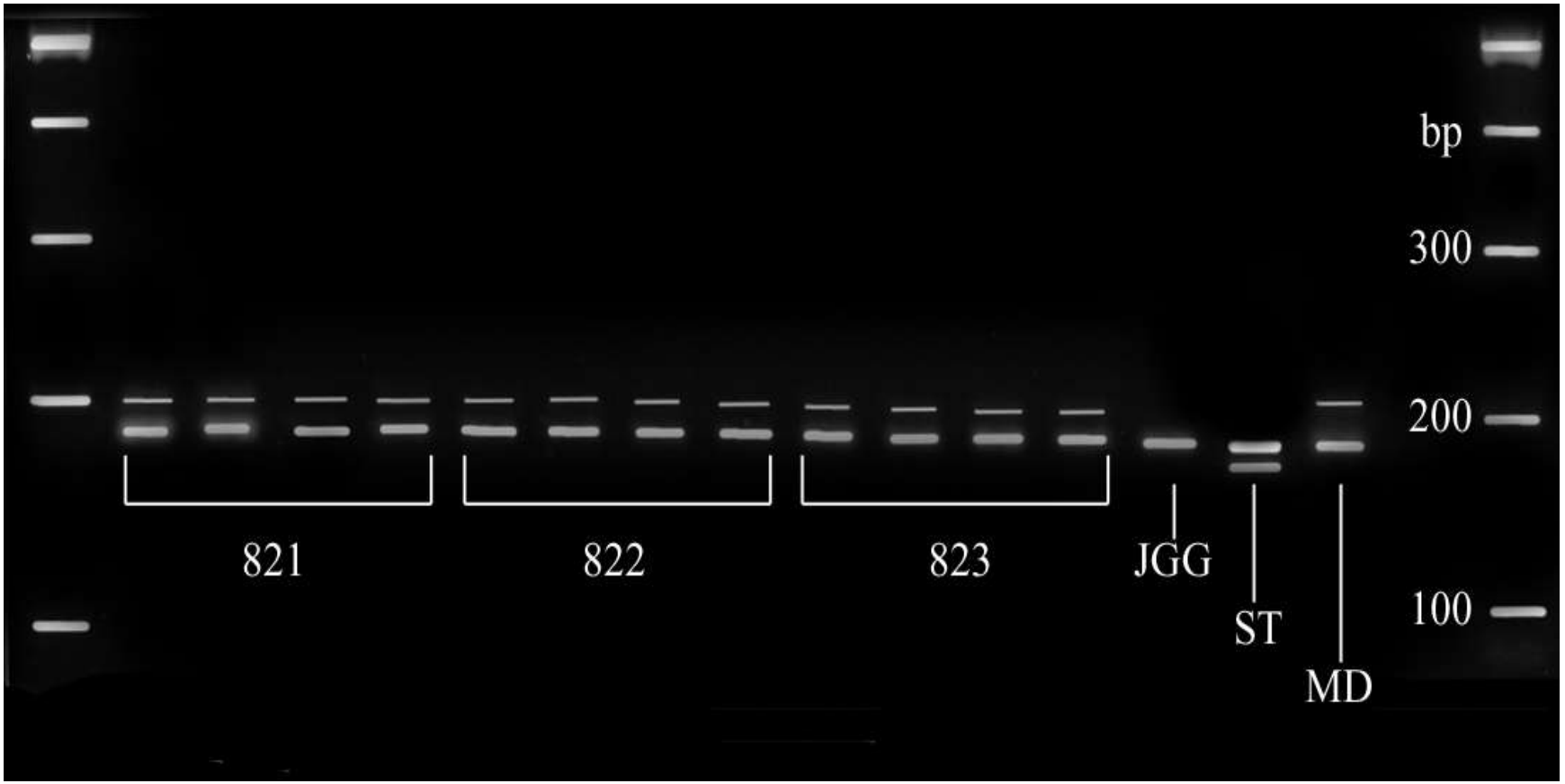
PCR amplification of the wheat microsatellite gwm44



Expression of traits

- Gene introgression and expression was confirmed:
  - *Imi1* gene for imidazolinone resistance on chromosome 6D
  - *Pch1* gene for Cercosporella foot rot resistance on chromosome 7D
- Plants have 28 chromosomes and are both imidazolinone and foot rot resistant

Foot rot resistance marker *Xorw1*



Does genome placement matter?

- Based on our results, movement of a gene located on the D genome from wheat to jointed goatgrass would not be difficult

- **Hypothesis:** More difficult to move gene from A or B to wheat because those genomes are not shared

- To test the hypothesis, the herbicide resistance gene for glyphosate was used

To test the hypothesis:

- Wheat carrying glyphosate resistance on the A, B or D genome was crossed to jointed goatgrass

- A second aspect of this study was to determine the impact of selection pressure on gene migration and retention
  - the BC_1 generation was split into two sub-populations - sprayed and unsprayed

Comparison Gene Transmission (1D-BC_2)

Wheat X JGG	Wheat X JGG
F_1 100% resistance X JGG	F_1 100% resistance X JGG
BC_1 (sprayed) x JGG Resistance = 74% Germination = 56 %	BC_1 (unsprayed) x JGG Resistance = 64% Germination = 40%
BC_2 Resistance = 75% Germination = 10%	BC_2 Resistance = 54% Germination = 60%

Comparison Gene Transmission (6A-BC_2)

Wheat X JGG	Wheat X JGG
F_1 100% resistance X JGG	F_1 100% resistance X JGG
BC_1 (sprayed) x JGG Resistance = 81% Germination = 63 %	BC_1 (unsprayed) x JGG Resistance = 84% Germination = 71 %
BC_2 Resistance = 100% Germination = 36%	BC_2 Resistance = 42% Germination = 77%

Comparison Gene Transmission (4B-BC_2)

Wheat X JGG	Wheat X JGG
F_1 100% resistance X JGG	F_1 100% resistance X JGG
BC_1 (sprayed) x JGG Resistance = 60% Germination = 71 %	BC_1 (unsprayed) x JGG Resistance = 59% Germination = 47 %
BC_2 Resistance = 96% Germination = 36%	BC_2 Resistance = 50% Germination = 69%

Genome placement – not the solution

- These results indicate that genome placement would not prevent gene flow from wheat to jointed goatgrass

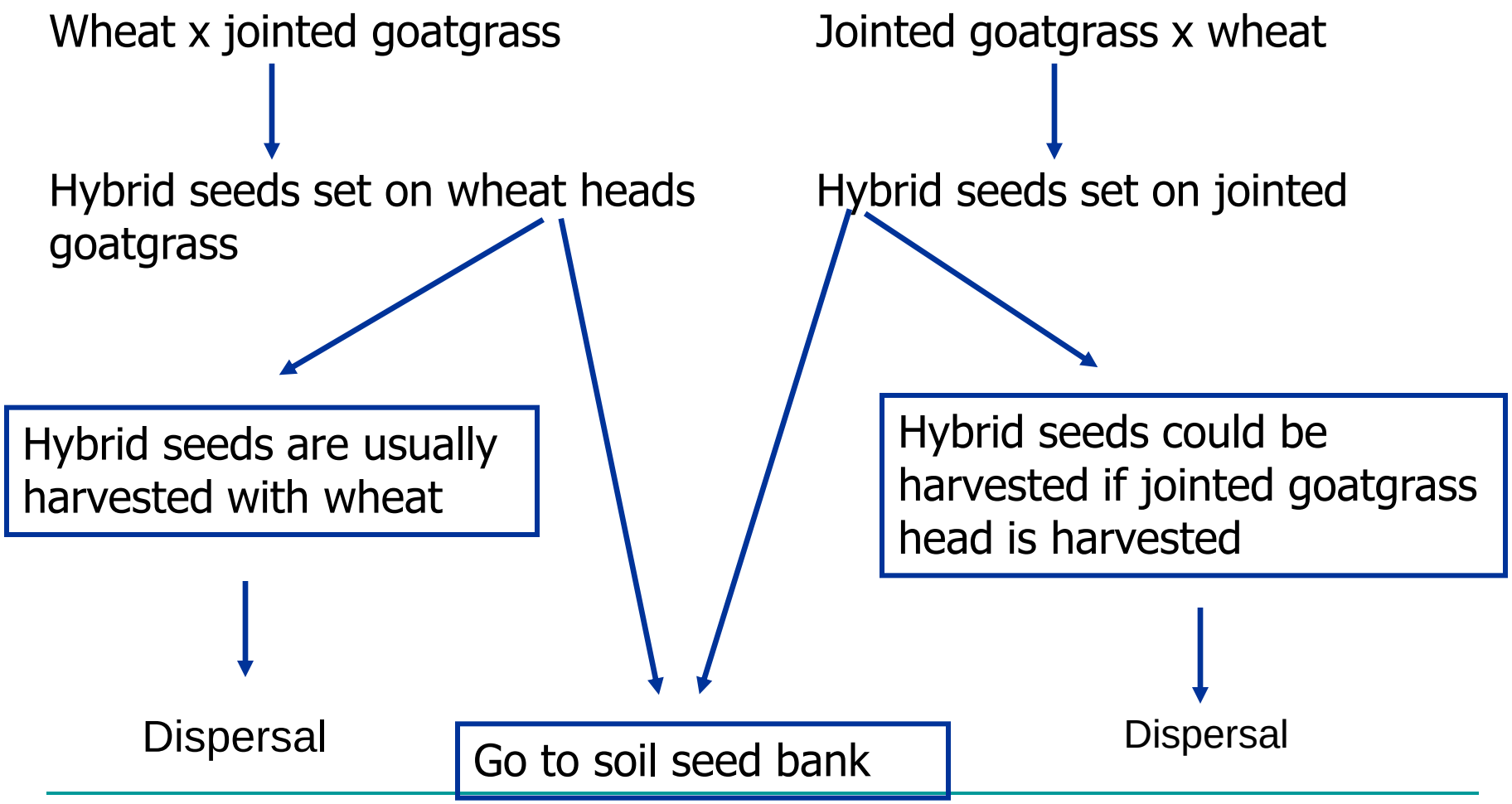
- When glyphosate was applied, gametic selection occurred that decreased the number of BC_2 plants produced but increased the number of BC_2 plants carrying the resistance gene

Can gene migration be prevented?

- The key to reducing the potential for gene flow between wheat and jointed goatgrass is to reduce or eliminate hybrids and the BC_1 generation in the field

- Preventing the BC_2 generation will prevent restoration of self-fertility, thus preventing gene flow

Wheat x Jointed Goatgrass Seeds in Wheat Fields



2008 – Clearfield Wheat Field With Imazamox Resistant Hybrids

OSU/UI jointed goatgrass program

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Publications:

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6 MS students
7 PhD students
2 in press
3 in preparation