Estimation of outcrossing rate in *Hordeum spontaneum* and barley landraces from Jordan

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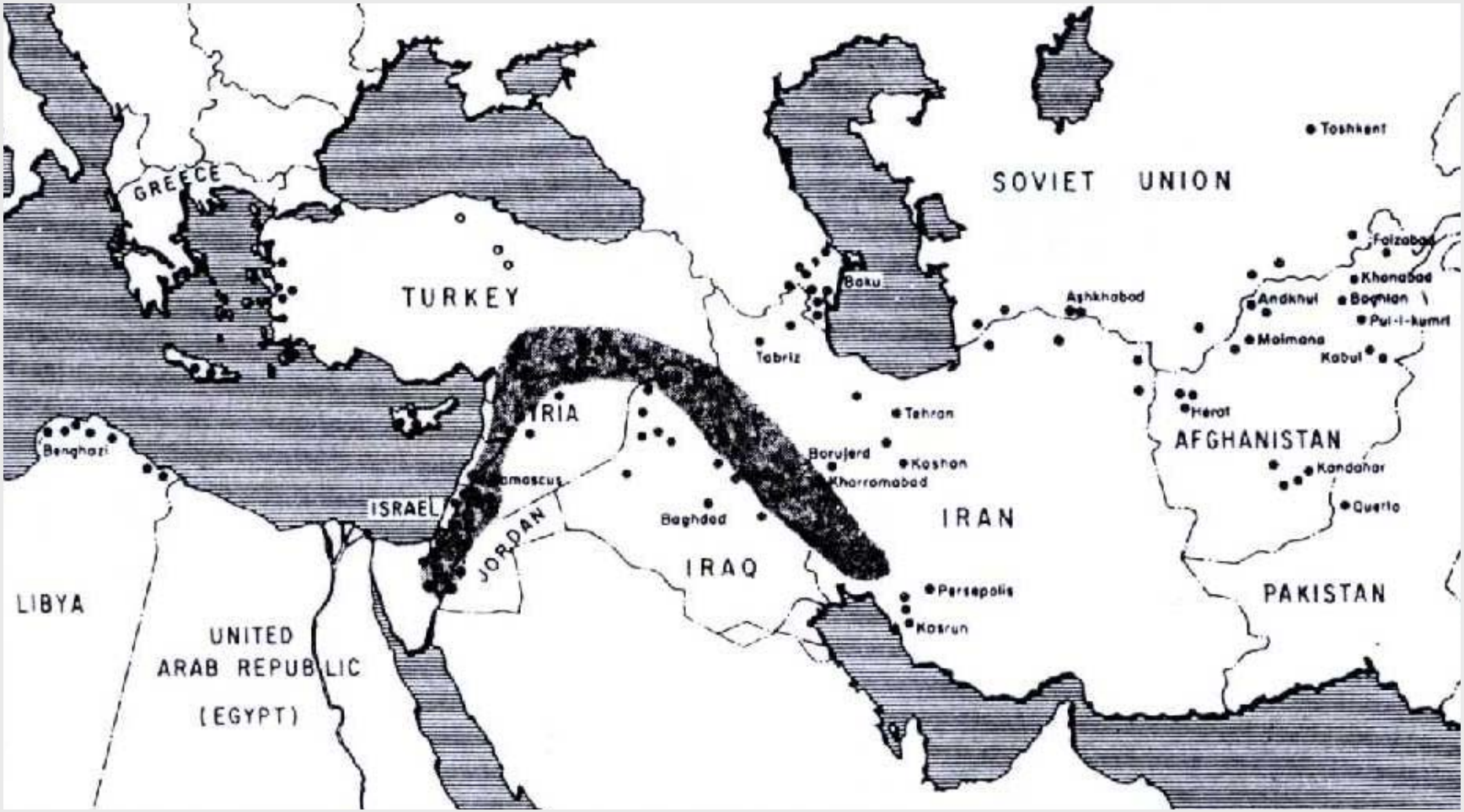
The Fertile Crescent



Barley landrace Arabi Abiad

Barley landrace Arabi Aswad

H. spontaneum, wild barley

H. spontaneum grows in mountains, between rocks

H. spontaneum from marginal areas (<200mm annual rainfall)

Average grain yield (kg/ha) of barley in some countries in West Asia and North Africa (WANA) compared to central Europe

Region	1996	1997	1998
West Asia	743	597	575
North Africa	1149	596	781
Central Europe	5802	5068	5518

Source: Production year book, FAO statistics, 1999

Relative effects of heterozygosity (%) on grain yield at four locations in north Syria

Location	Season	Annual precipitation (mm)	Heterozygosity effect (%)
Tel Hadya	1994/95	405	-1.2
Breda	1994/95	360	16.7**
Tel Hadya	1995/96	313	17.3**
Breda	1995/96	224	45.6**

**Significant at 0.01 probability levels

Einfeldt, C. H. P. 1999 (Dissert. Univ. Hohenheim)

⇒ Development of synthetic variety with high outcrossing rate

Objectives of this study

- To characterize the genetic structure of barley landraces and *H. spontaneum* populations collected from various semi-arid localities in Jordan using Simple Sequence Repeat (SSR) DNA markers. To obtain reliable estimates of the amount and variation of outcrossing in this germplasm,

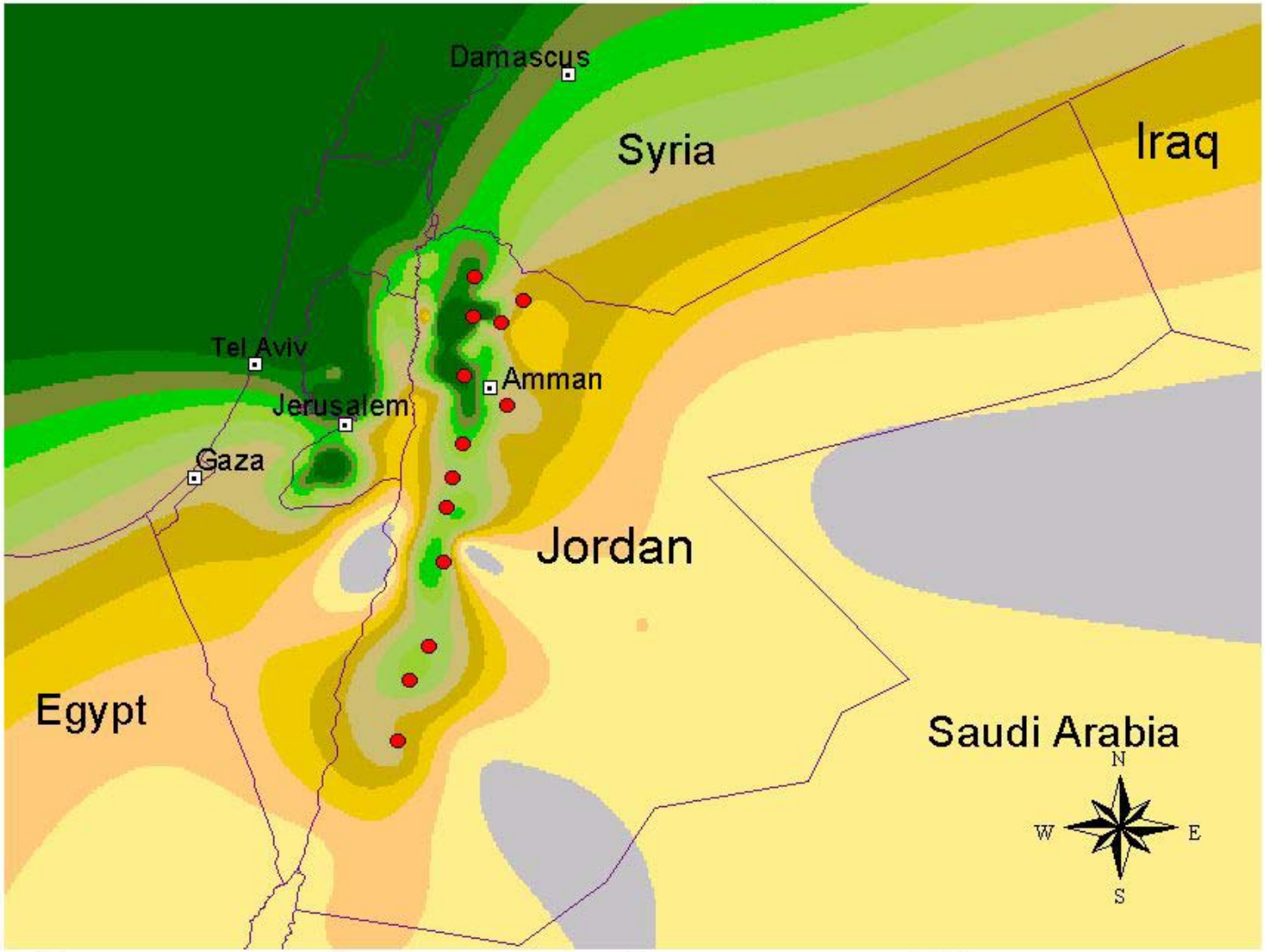
- To estimate the possible effect of climatical conditions on outcrossing rate

Genetic material

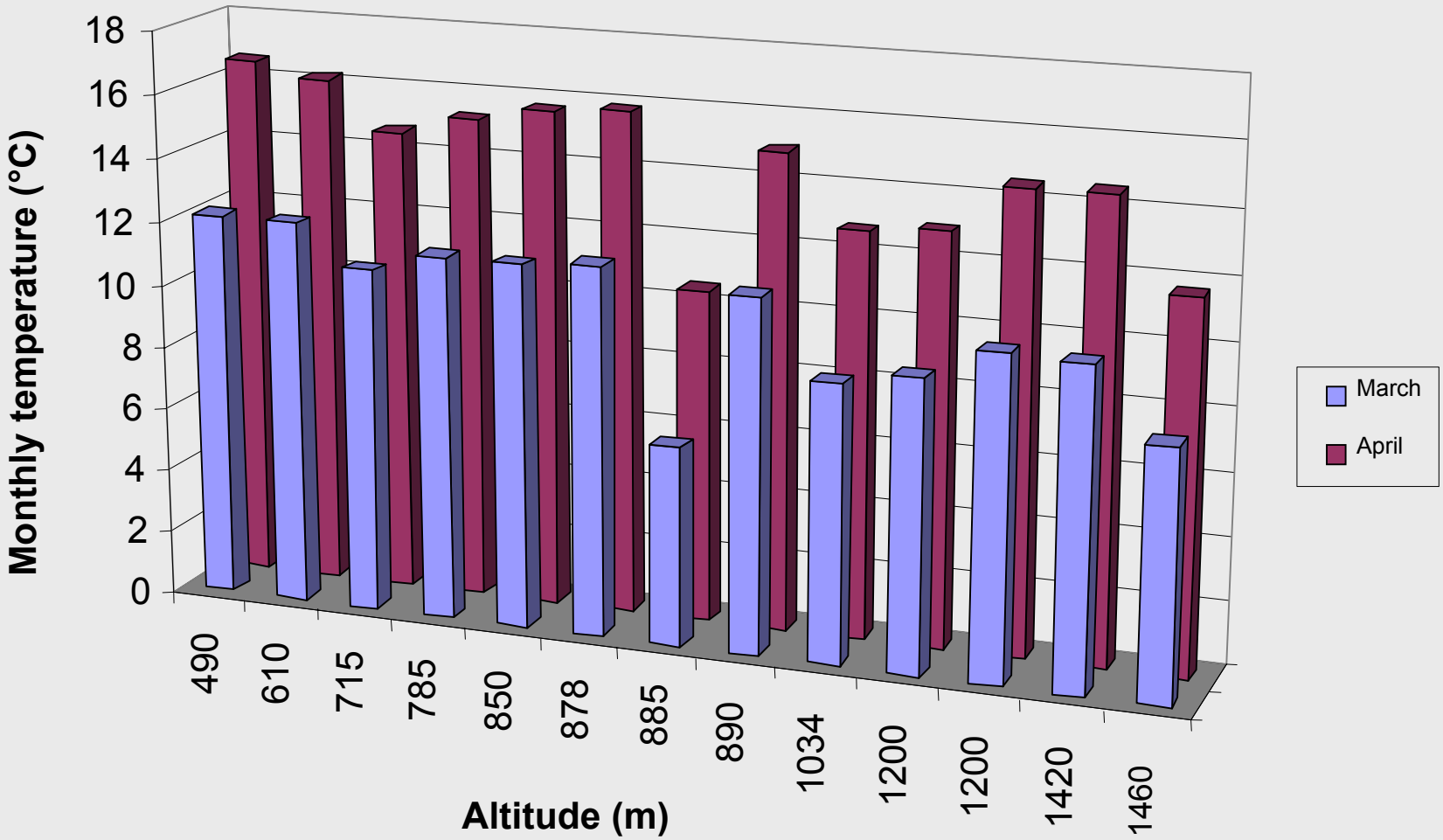
- Number of Populations : 12 barley landraces, 13 *H. spontaneum* populations, and 2 local barley varieties

- Sample size: 50 individual spikes per population

Rainfall distribution and sampling sites in Jordan



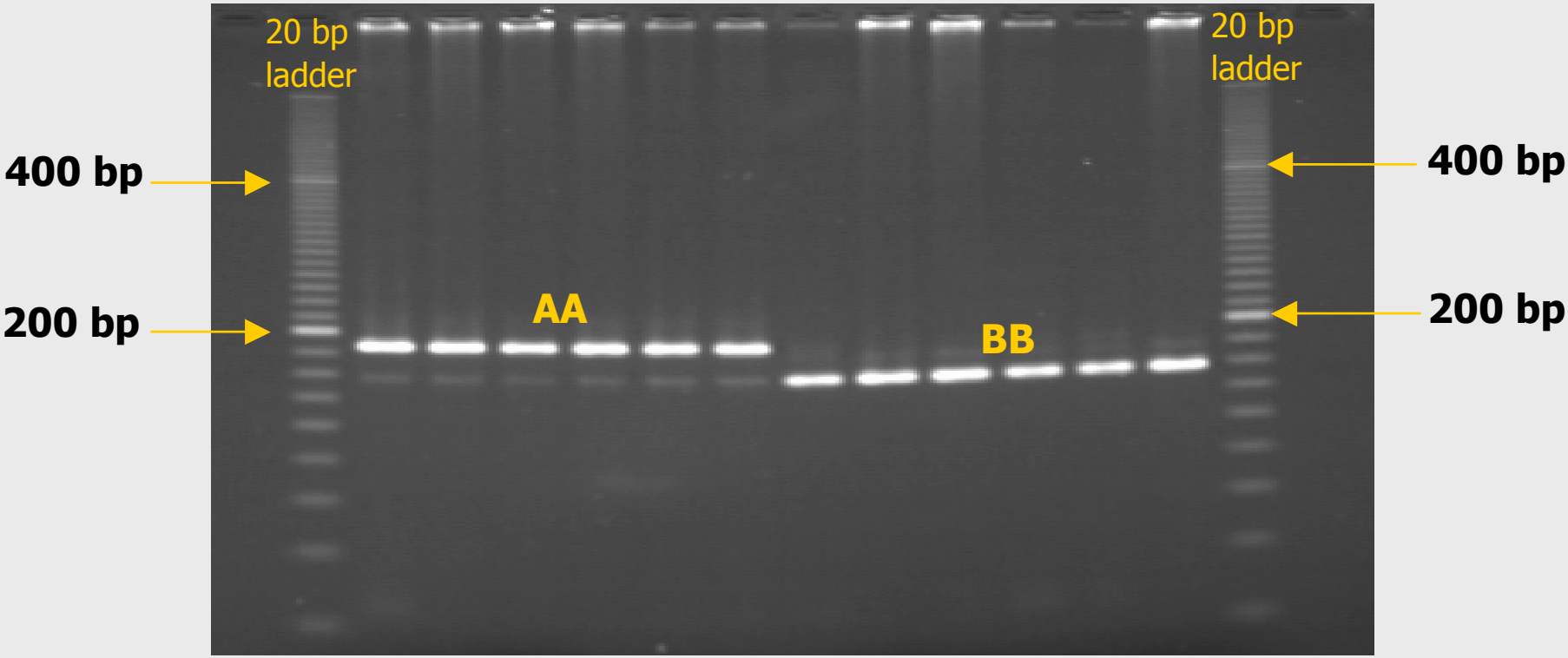
Variation of monthly temperature during March and April among collecton sites



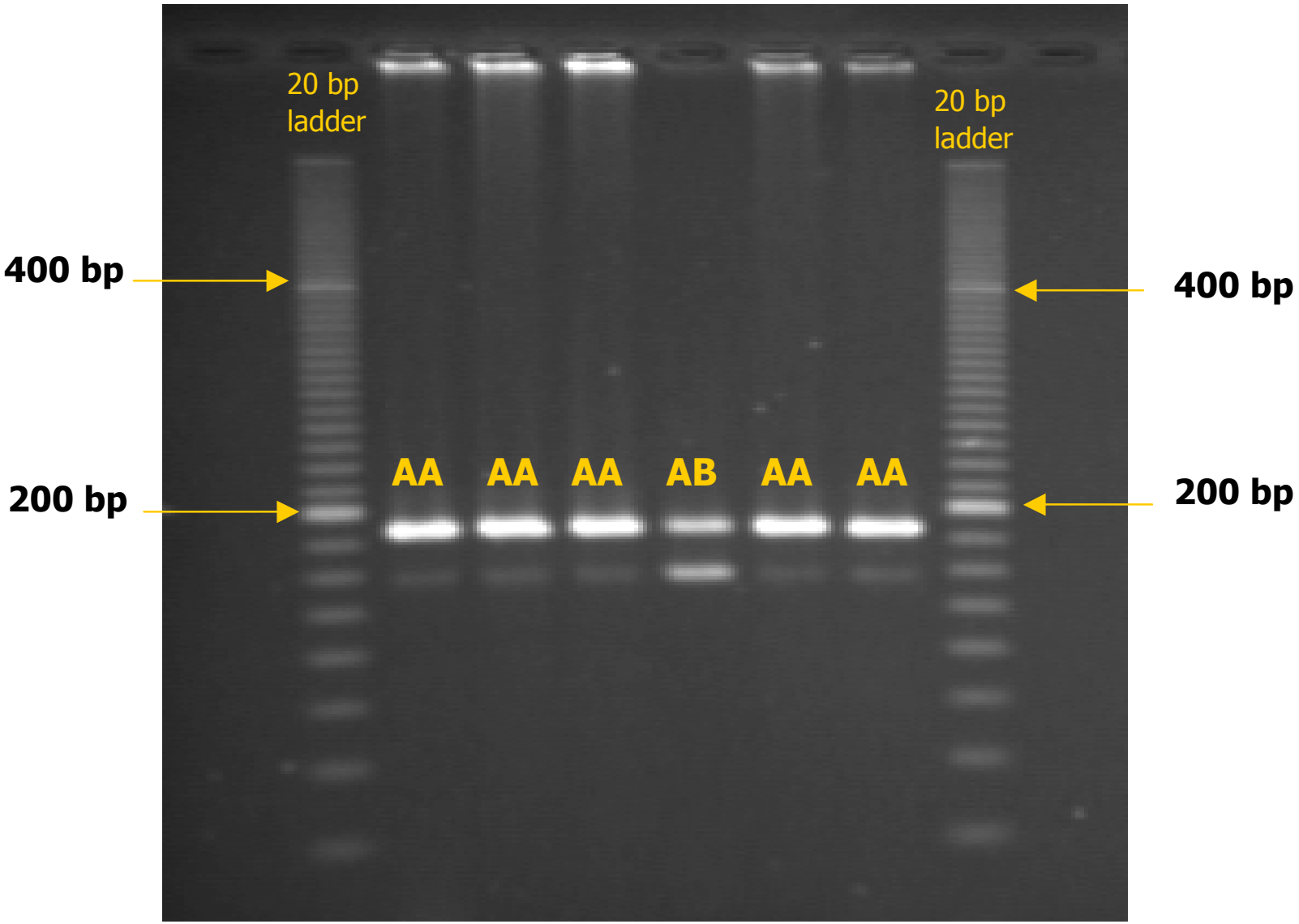
Microsatellite SSR primer sequences, repeat motifs, expected product sizes, and chromosomal locations considered for marker analyses

SSR designation	Chromosomal location	Repeat motif
Bmag0125	2H	$(AG)_{19}$
Bmag0353	4H	$(AG)_{21}$
Bmag0222	5H	$(AC)_{9}(AG)_{17}$
WMC1E8	1H	$(AC)_{24}$

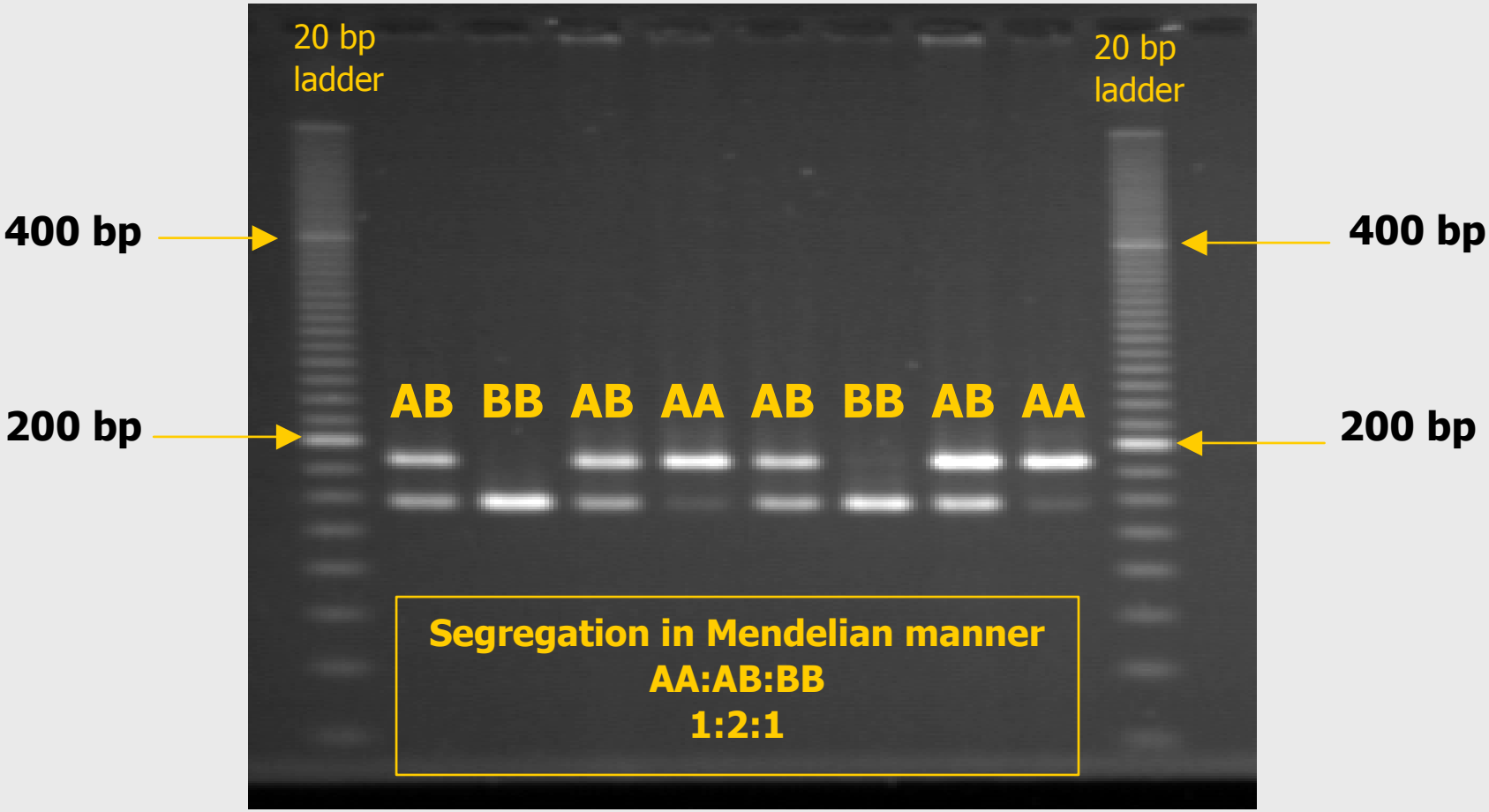
Two homozygous uniform families for SSR marker WMC1E8



One individual within a homozygous family fertilized foreign pollen



Segregating family



Estimation of outcrossing rates

- Outcrossing rates were estimated using the maximum likelihood method and the mixed mating model (Ritland and Jain, 1981)

- Analyses were performed with the MLTR computer program (Ritland, 1997)

Estimates of outcrossing rate (t%) for barley landraces and *H. spontaneum* populations collected from different localities in Jordan

Region	Barley Landraces		*H. spontaneum*	
	Total no. of individuals	Outcrossing rate (%)	Total no. of individuals	Outcrossing rate (%)
Irbid	173	**0.0**	143	**0.0**
Ajloun	175	**0.6**	154	**1.3**
Jarash	172	**0.6**	181	**0.6**
Mafaraq	176	**0.0**	148	**0.0**
Amman	196	**0.5**	172	**0.0**
Salt	167	**0.6**	167	**1.8**
Ma'ddaba	184	**0.0**	184	**0.6**
Dieban	175	**0.0**	159	**0.0**
Karak1	181	**0.6**	138	**0.0**
Karak2	179	**0.0**	176	**1.8**
Tafila	187	**0.0**	129	**0.0**
Shoubak	270	**0.0**	270	**0.0**
Maán	-	-	129	**0.0**
Mean	186	**0.24 ±0.30**	165	**0.47 ±0.71**

Estimates of outcrossing rate (t%) for barley landraces and *H. spontaneum* populations collected from different localities in Jordan

Population type	**t (%)**
Landraces	0.24
Local varieties	0.30
H. spontaneum	0.47
Mean	**0.34 ± 0.12**

Contrasting expression of anther extrusion:

(A) *H. spontaneum* with many extruded anthers

(B) Barley landrace spikes without extruded anthers

Mean estimates of outcrossing rate (t%) for regions differing in annual precipitation

Annual rainfall (mm)	Barley landraces	*H. spontaneum*
>400 mm	0.4 ± 0.93	1.03 ± 0.35
400-200	0.2 ± 0.64	0.40 ± 0.29
<200 mm	0.0 ± 0.00	0.00 ± 0.00

Coefficient of correlations (r) between outcrossing rate and three climatic characteristics

Germplasm	Annual precipitation	Mean temperature in March	Relative humidity in March
Barley landraces	0.47	-0.14	0.22
H. spontaneum	0.78**	-0.60**	0.48

**Significant at 0.05 probability level

Under severe drought, plants are stunted and spikes remain in the flag sheet thus preventing outcrossing

Drought conditions seem to favour selfing

- Stable seed production through self-pollination to secure survival under extreme heat and drought stress may be more important than vigor.

- Cleistogamy may be considered as an effective mechanism to warrant pollination even in drought-stunted plants with non-dehiscent spikes and prolong pollen viability.

Under moist and cool conditions, spikes emerge from flag sheets and start flowering

Moist and cool conditions seem to enhance outcrossing

- Because survival is less important under moderate weather conditions

- Cool moist conditions may extend pollen grain viability, and thus increase the rate of outcrossing

Conclusions

- Low outcrossing rates were found in cultivated barley and its wild relative *H. spontaneum* ranging among local populations from 0-1.8% with a mean of 0.35%.

- Somewhat higher, though not significant, outcrossing rates were observed in *H. spontaneum* than *H. vulgare* populations under high rainfall conditions (>400 mm annual rainfall).

Conclusions

- High precipitations and cool temperatures during flowering may enhance outcrossing in cultivated and wild barley populations.

- The rather low levels of outcrossing indicate that increased vigor due to heterozygosity has not been a major force in the evolution and domestication of *H. spontaneum* and *H. vulgare*, respectively.

Outlook

- Yet ICARDA's (International Center for Agricultural Research in the Dry Areas) gene bank contains a number of drought-adapted accessions showing various degrees of open-pollination. This material is presently being evaluated for its outcrossing behavior. It is considered a valuable genetic resource for increasing the level of heterozygosity in actual barley gene pools for increasing yield potential without loosing drought tolerance.

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