# Supplemental Material

# Parallel adaptation to highland climate in maize domesticated populations

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**Supplemental Table 1 List of maize landraces used in this study**

| ID[a] | USDA ID | Population | Landrace | Locality | Latitude | Longitude | Elevation | Origin |
|---|---|---|---|---|---|---|---|---|
| **RIMMA0409** | PI 478968 | Mexico | Tepecintle | Chiapas, Mexico | 15.4 | -92.9 | 107 | USDA |
| RIMMA0410 | PI 478970 | Lowland | Vandeno | Chiapas, Mexico | 15.4 | -92.9 | 107 | USDA |
| **RIMMA0433** | PI 490825 | | Nal Tel ATB | Chiquimula, Guatemala | 14.7 | -89.5 | 457 | USDA |
| **RIMMA0441** | PI 515538 | | Coscomatepec | Veracruz, Mexico | 19.2 | -97.0 | 1320 | USDA |
| **RIMMA0615** | PI 628480 | | Tuxpeno | Puebla, Mexico | 20.1 | -97.2 | 152 | USDA |
| **RIMMA0619** | PI 645772 | | Pepitilla | Guerrero, Mexico | 18.4 | -99.5 | 747 | USDA |
| **RIMMA0628** | PI 646017 | | Tuxpeno Norteno | Tamaulipas, Mexico | 23.3 | -99.0 | 300 | USDA |
| **RIMMA0696** | Ames 28568 | | Tuxpeno | El Progreso, Guatemala | 16.5 | -90.2 | 30 | Goodman |
| **RIMMA0700** | NSL 291626 | | Olotillo | Chiapas, Mexico | 16.8 | -93.2 | 579 | Goodman |
| **RIMMA0701** | PI 484808 | | Olotillo | Chiapas, Mexico | 16.6 | -92.7 | 686 | Goodman |
| **RIMMA0702** | Ames 28534 | | Negro de Tierra Caliente | Sacatepequez, Guatemala | 14.5 | -90.8 | 1052 | Goodman |
| **RIMMA0703** | NSL 283390 | | Nal Tel | Yucatan, Mexico | 20.8 | -88.5 | 30 | Goodman |
| **RIMMA0709** | Ames 28452 | | Tehua | Chiapas, Mexico | 16.5 | -92.5 | 747 | Goodman |
| **RIMMA0710** | PI 478988 | | Tepecintle | Chiapas, Mexico | 15.3 | -92.6 | 91 | Goodman |
| **RIMMA0712** | NSL 291696 CYMT | | Oloton | Baja Verapaz, Guatemala | 15.3 | -90.3 | 1220 | Goodman |
| **RIMMA0716** | Ames 28459 | | Zapalote Grande | Chiapas, Mexico | 15.3 | -92.7 | 91 | Goodman |
| **RIMMA0720** | PI 489372 | | Negro de Tierra Caliente | Guatemala | 15.5 | -88.9 | 39 | Goodman |
| **RIMMA0721** | Ames 28485 | | Nal Tel ATB | Chiquimula, Guatemala | 14.6 | -90.1 | 915 | Goodman |
| **RIMMA0722** | Ames 28564 | | Dzit Bacal | Jutiapa, Guatemala | 14.3 | -89.7 | 737 | Goodman |
| **RIMMA0727** | Ames 28555 | | Comiteco | Guatemala | 14.4 | -90.5 | 1151 | Goodman |
| **RIMMA0729** | PI 504090 | | Tepecintle | Guatemala | 15.4 | -89.7 | 122 | Goodman |
| **RIMMA0730** | Ames 28517 | | Quicheno Late | Sacatepequez, Guatemala | 14.5 | -90.8 | 1067 | Goodman |
| **RIMMA0731** | PI 484137 | | Bolita | Oaxaca, Mexico | 16.8 | -96.7 | 1520 | Goodman |
| **RIMMA0733** | PI 479054 | | Zapalote Chico | Oaxaca, Mexico | 16.6 | -94.6 | 107 | Goodman |
| **RIMMA0416** | PI 484428 | Mexico | Cristalino de Chihuahua | Chihuahua, Mexico | 29.4 | -107.8 | 2140 | NA |
| **RIMMA0417** | PI 484431 | Highland | Azul | Chihuahua, Mexico | 28.6 | -107.5 | 2040 | USDA |
| **RIMMA0418** | PI 484476 | | Gordo | Chihuahua, Mexico | 28.6 | -107.5 | 2040 | USDA |
| **RIMMA0421** | PI 484595 | | Conico | Puebla, Mexico | 19.9 | -98.0 | 2250 | USDA |
| **RIMMA0422** | PI 485071 | | Elotes Conicos | Puebla, Mexico | 19.1 | -98.3 | 2200 | USDA |
| **RIMMA0423** | PI 485116 | | Cristalino de Chihuahua | Chihuahua, Mexico | 29.2 | -108.1 | 2095 | NA |
| **RIMMA0424** | PI 485120 | | Apachito | Chihuahua, Mexico | 28.0 | -107.6 | 2400 | USDA |
| **RIMMA0425** | PI 485128 | | Palomero Tipo Chihuahua | Chihuahua, Mexico | 26.8 | -107.1 | 2130 | USDA |
| **RIMMA0614** | PI 628445 | | Mountain Yellow | Jalisco, Mexico | 20.0 | -103.8 | 2060 | USDA |
| **RIMMA0616** | PI 629202 | | Zamorano Amarillo | Jalisco, Mexico | 20.8 | -102.8 | 1800 | USDA |
| **RIMMA0620** | PI 645786 | | Celaya | Guanajuato, Mexico | 20.2 | -100.9 | 1799 | USDA |
| **RIMMA0621** | PI 645804 | | Zamorano Amarillo | Guanajuato, Mexico | 21.1 | -101.7 | 1870 | USDA |
| **RIMMA0623** | PI 645841 | | Palomero de Jalisco | Jalisco, Mexico | 20.0 | -103.7 | 2520 | USDA |
| **RIMMA0625** | PI 645984 | | Cacahuacintle | Puebla, Mexico | 19.0 | -97.4 | 2600 | USDA |
| RIMMA0626 | PI 645993 | | Arrocillo Amarillo | Puebla, Mexico | 19.9 | -97.6 | 2260 | USDA |
| **RIMMA0630** | PI 646069 | | Arrocillo Amarillo | Veracruz, Mexico | 19.8 | -97.3 | 2220 | USDA |
| **RIMMA0670** | Ames 28508 | | San Marceno | San Marcos, Guatemala | 15.0 | -91.8 | 2378 | Goodman |
| **RIMMA0671** | Ames 28538 | | Salpor Tardio | Solola, Guatemala | 14.8 | -91.3 | 2477 | Goodman |
| **RIMMA0672** | PI 483613 | | Chalqueno | Mexico, Mexico | 19.7 | -99.1 | 2256 | Goodman |
| **RIMMA0674** | PI 483617 | | Toluca | Mexico, Mexico | 19.3 | -99.7 | 2652 | Goodman |
| **RIMMA0677** | Ames 28476 | | Conico Norteno | Zacatecas, Mexico | 21.4 | -102.9 | 1951 | Goodman |
| **RIMMA0680** | Ames 28448 | | Tabloncillo | Jalisco, Mexico | 20.4 | -102.2 | 1890 | Goodman |
| **RIMMA0682** | PI 484571 | | Tablilla de Ocho | Jalisco, Mexico | 22.1 | -103.2 | 1700 | Goodman |
| **RIMMA0687** | Ames 28473 | | Conico Norteno | Queretaro, Mexico | 20.4 | -100.0 | 1921 | Goodman |

[a] GBS data are available for the accessions in bold font.

**Supplemental Table 1 (continued)**

| ID | USDA ID | Population | Landrace | Locality | Latitude | Longitude | Elevation | Origin |
|---|---|---|---|---|---|---|---|---|
| **RIMMA0388** | PI 443820 | South America | Amagaceno | Antioquia, Colombia | 6.9 | -75.3 | 1500 | USDA |
| **RIMMA0389** | PI 444005 | Lowland | Costeno | Atlantico, Colombia | 10.4 | -74.9 | 7 | USDA |
| **RIMMA0390** | PI 444254 | | Comun | Caldas, Colombia | 4.5 | -75.6 | 353 | USDA |
| RIMMA0391 | PI 444296 | | Andaqui | Caqueta, Colombia | 1.4 | -75.8 | 700 | USDA |
| **RIMMA0392** | PI 444309 | | Andaqui | Caqueta, Colombia | 1.8 | -75.6 | 555 | USDA |
| **RIMMA0393** | PI 444473 | | Costeno | Cordoba, Colombia | 8.3 | -75.2 | 100 | USDA |
| **RIMMA0394** | PI 444621 | | Pira | Cundinamarca, Colombia | 4.8 | -74.7 | 1000 | USDA |
| **RIMMA0395** | PI 444731 | | Negrito | Choco, Colombia | 8.5 | -77.3 | 30 | USDA |
| **RIMMA0396** | PI 444834 | | Caqueteno | Huila, Colombia | 2.6 | -75.3 | 1100 | USDA |
| **RIMMA0397** | PI 444897 | | Negrito | Magdalena, Colombia | 11.6 | -72.9 | 50 | USDA |
| **RIMMA0398** | PI 444923 | | Puya | Magdalena, Colombia | 9.4 | -75.7 | 27 | USDA |
| **RIMMA0399** | PI 444954 | | Cariaco | Magdalena, Colombia | 10.2 | -74.1 | 250 | USDA |
| **RIMMA0403** | PI 445163 | | Pira Naranja | Narino, Colombia | 1.3 | -77.5 | 1000 | USDA |
| **RIMMA0404** | PI 445322 | | Puya Grande | Norte de Santander, Colombia | 7.3 | -72.5 | 1500 | USDA |
| RIMMA0405 | PI 445355 | | Puya | Norte de Santander, Colombia | 8.4 | -73.3 | 1100 | USDA |
| **RIMMA0406** | PI 445514 | | Yucatan | Tolima, Colombia | 5.0 | -74.9 | 450 | USDA |
| RIMMA0407 | PI 445528 | | Pira | Tolima, Colombia | 4.2 | -74.9 | 450 | USDA |
| **RIMMA0428** | PI 485354 | | Aleman | Huanuco, Peru | -9.3 | -76.0 | 700 | NA |
| **RIMMA0462** | PI 445073 | | Amagaceno | Narino, Colombia | 1.6 | -77.2 | 1700 | USDA |
| **RIMMA0690** | PI 444946 | | Puya | Magdalena, Colombia | 8.3 | -73.6 | 250 | Goodman |
| **RIMMA0691** | PI 445391 | | Cacao | Santander, Colombia | 6.6 | -73.1 | 1098 | NA |
| **RIMMA0707** | PI 487930 | | Tuxpeno | Ecuador | -1.1 | -80.5 | 30 | Goodman |
| **RIMMA0708** | PI 488376 | | Yunquillano F Andaqui | Ecuador | -3.5 | -78.6 | 1098 | Goodman |
| **RIMMA0426** | PI 485151 | South America | Rabo de Zorro | Ancash, Peru | -9.1 | -77.8 | 2500 | NA |
| **RIMMA0430** | PI 485362 | Highland | Sarco | Ancash, Peru | -9.2 | -77.7 | 2585 | NA |
| **RIMMA0431** | PI 485363 | (Andean) | Perlilla | Huanuco, Peru | -8.7 | -77.1 | 2900 | NA |
| **RIMMA0436** | PI 514723 | | Morocho Cajabambino | Amazonas, Peru | -6.2 | -77.9 | 2200 | NA |
| **RIMMA0437** | PI 514752 | | Ancashino | Ancash, Peru | -9.3 | -77.6 | 2688 | NA |
| **RIMMA0438** | PI 514809 | | Maranon | Ancash, Peru | -8.7 | -77.4 | 2820 | NA |
| RIMMA0439 | PI 514969 | | Maranon | La Libertad, Peru | -8.5 | -77.2 | 2900 | NA |
| **RIMMA0464** | PI 571438 | | Chullpi | Huancavelica, Peru | -12.3 | -74.7 | 1800 | USDA |
| **RIMMA0465** | PI 571457 | | Huarmaca | Piura, Peru | -5.6 | -79.5 | 2300 | USDA |
| **RIMMA0466** | PI 571577 | | Confite Puneno | Apurimac, Peru | -14.3 | -72.9 | 3600 | USDA |
| **RIMMA0467** | PI 571871 | | Paro | Apurimac, Peru | -13.6 | -72.9 | 2800 | USDA |
| **RIMMA0468** | PI 571960 | | Sarco | Ancash, Peru | -9.4 | -77.2 | 3150 | USDA |
| **RIMMA0473** | PI 445114 | | Sabanero | Narino, Colombia | 1.1 | -77.6 | 3104 | USDA |
| **RIMMA0656** | Ames 28799 | | Culli | Jujuy, Argentina | -23.2 | -65.4 | 2287 | Goodman |
| **RIMMA0657** | NSL 286594 | | Chake Sara | Bolivia | -17.5 | -65.7 | 2201 | Goodman |
| **RIMMA0658** | NSL 286812 | | Uchuquilla | Bolivia | -21.8 | -64.1 | 1948 | Goodman |
| **RIMMA0661** | PI 488066 | | Chillo | Ecuador | -2.9 | -78.7 | 2195 | Goodman |
| **RIMMA0662** | NSL 287008 | | Cuzco | Ecuador | 0.0 | -78.0 | 2195 | Goodman |
| **RIMMA0663** | PI 488102 | | Mishca | Ecuador | 0.4 | -78.2 | 2067 | Goodman |
| **RIMMA0664** | PI 488113 | | Blanco Blandito | Ecuador | 0.4 | -78.4 | 2122 | Goodman |
| **RIMMA0665** | PI 489324 | | Racimo de Uva | Ecuador | -0.9 | -78.9 | 2931 | Goodman |
| **RIMMA0667** | Ames 28737 | | Patillo | Chuquisaca, Bolivia | -21.8 | -64.1 | 2201 | NA |
| RIMMA0668 | Ames 28668 | | Granada | Puno, Peru | -14.9 | -70.6 | 3925 | Goodman |

[a] GBS data are available for the accessions in bold font.

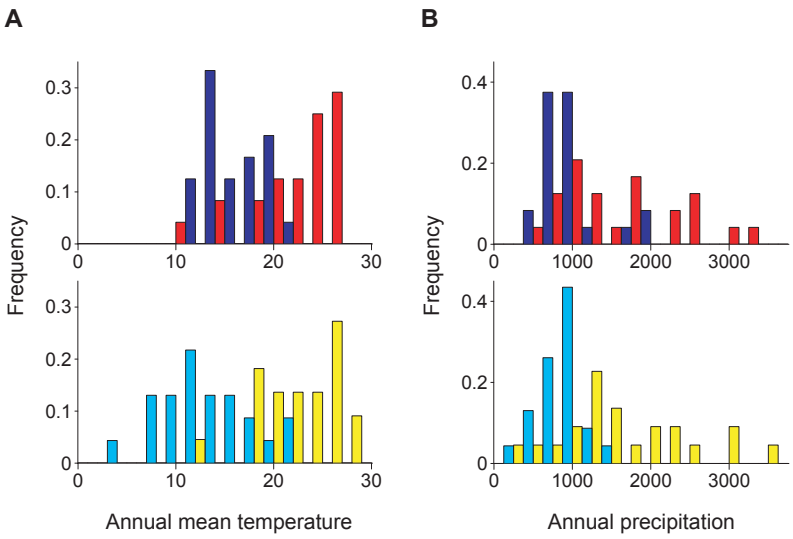
**Supplemental Table 2 Inference of demographic parameters**

| Mexico | Model I | |
|---|---|---|
| | Likelihood | $-3050.84$ |
| | $\alpha$ | 0.99 |
| | $\beta$ | 0.42 |
| | $\gamma$ | 1 |
| | $\sigma$ | 1 |
| South America | Model I | |
| | Likelihood | $-2737.80$ |
| | $\alpha$ | 0.6 |
| | $\beta$ | 0.97 |
| | $\gamma$ | $\geq$55 |
| | $\sigma$ | 1 |

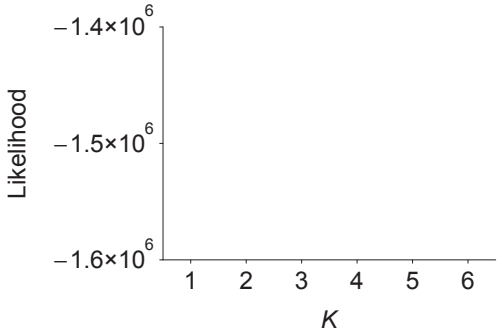
The description of $\alpha, \beta$ and $\gamma$ is in Figure 3.
$\sigma$ is a relative size of $N_B$ to $N_C$ ($N_B = \sigma N_C$).

**Supplemental Table 3 ms command**

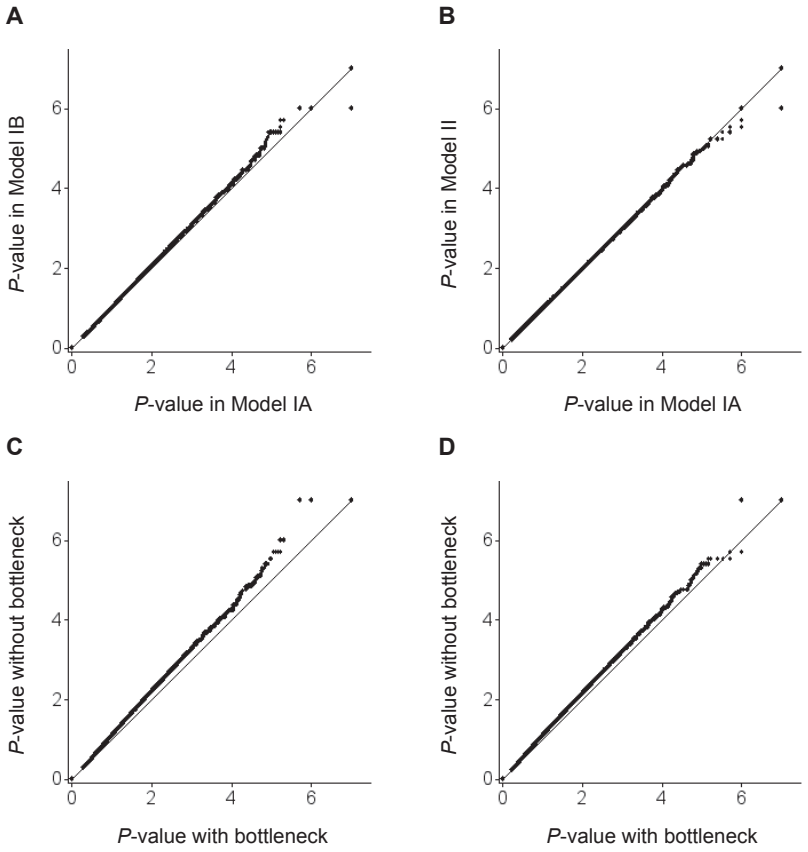
| |
|---|
| Model I for Mexico populations |
| Population 1: Mexico lowland population |
| Population 2: Mexico highland population |
| -I 2 $n_{m1}$ $n_{m2}$ -n 1 0.3496 -n 2 0.5704 -ej 0.01 2 1 -en 0.01 1 0.92 -en 0.0133 1 0.0163 -en 0.015 1 1.0 |
| Model II for Mexico populations |
| Population 1: Mexico lowland population |
| Population 2: Mexico highland population |
| Population 3: *mexicane* population |
| -I 2 $n_{m1}$ $n_{m2}$ -n 1 1.125 -n 2 0.375 -es 0.01 2 0.8 -en 0.01 3 1.0667 -ej 0.01 2 1 -en 0.01 1 1.5 -en 0.0133 1 0.0163 -en 0.015 1 1.0 -ej 0.1 3 1 |
| Model I for SA populations |
| Population 1: SA lowland population |
| Population 2: SA highland population |
| -I 2 $n_{s1}$ $n_{s2}$ -n 1 0.5335 -n 2 0.99 -g 2 614.1517 -ej 0.006667 2 1 -eg 0.006667 2 0.0 -en 0.00667 1 0.55 -en 0.01333 1 0.0163 -en 0.015 1 1.0 |
| Model III for SA populations |
| Population 1: Mexico lowland population |
| Population 2: SA lowland population |
| Population 3: SA highland population |
| -I 3 $n_{m1}$ $n_{s1}$ $n_{s2}$ -n 1 0.64 -n 2 0.342 -n 3 0.99 -g 3 601.1000 -ej 0.006667 3 2 -eg 0.006667 3 0.0 -en 0.006667 2 0.36 -ej 0.01 2 1 |
| -en 0.01 1 1 -en 0.0133 1 0.0163 -en 0.015 1 1.0 |
| Sample size of Mexico lowland, Mexico highland, SA lowland and SA highland populations are denoted by $n_{m1}$, $n_{m2}$, $n_{s1}$ and $n_{s2}$, respectively. |



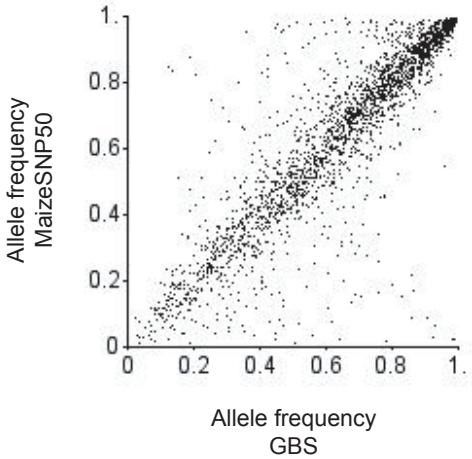

**Supplemental Figure 1** Correlation of allele frequencies between GBS (*x*-axes) and MaizeSNP50 (*y*-axes) data. We used overlapped SNPs with $n \geq 40$ for both data sets. Correlation coefficient is 0.890 ($P < 10^{-5}$ by permutation test with $10^5$ replications).



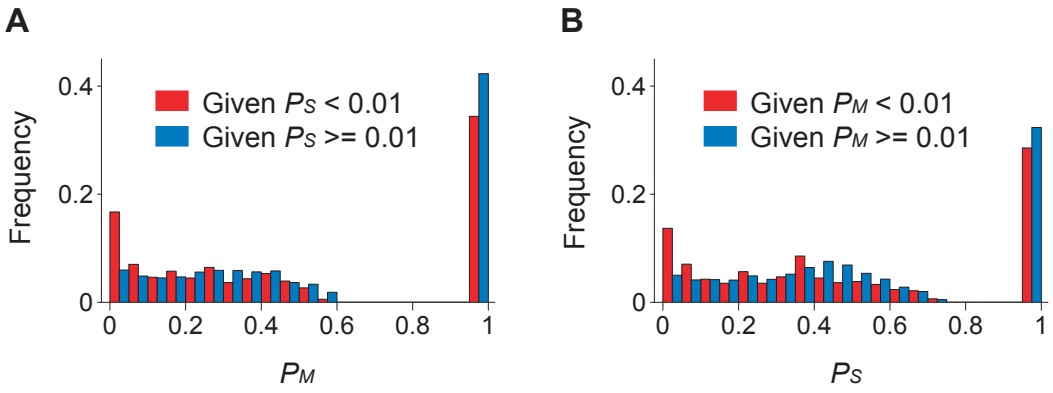

**Supplemental Figure 2** Likelihood of STRUCTURE analysis given $K$. The *x*-axes represents $K$ and the *y*-axes represents likelihood.



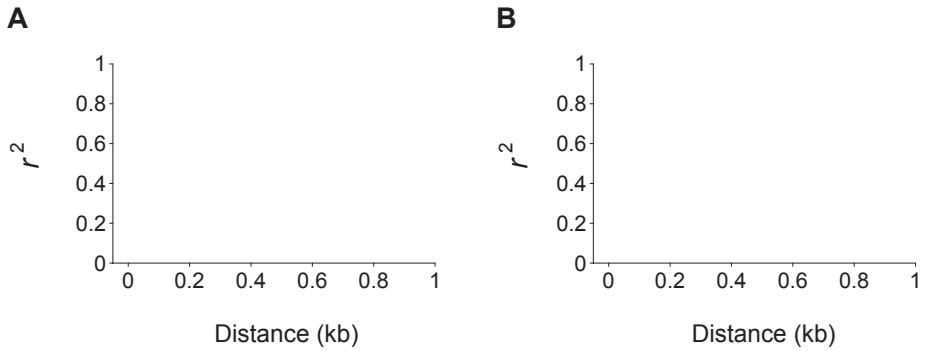

**Supplemental Figure 3** Q-Q plot for $-\log_{10}$-scaled *P*-values of population differentiation between lowland and highland populations. (A) Model IA *v.s.* Model IB in Mexico, (B) Model IA *v.s.* Model II in S. America, (C) Model with *v.s.* without bottleneck in Mexico and (D) Model with *v.s.* without bottleneck in S. America.




**Supplemental Figure 4** Correlation of allele frequencies between GBS (*x*-axes) and MaizeSNP50 (*y*-axes) data. We used overlapped SNPs with $n \geq 40$ for both data sets. Correlation coefficient is 0.890 ($P < 10^{-5}$ by permutation test with $10^5$ replications).




**Supplemental Figure 5** (A) Frequency distribution of $P_M$ given $P_S < 0.01$ and $P_S \geq 0.01$. (B) Frequency distribution of $P_S$ given $P_M < 0.01$ and $P_M \geq 0.01$.




**Supplemental Figure 6** Pattern of decay of linkage equilibrium in Mexico (A) and South America (B). Red and blue dots represent low- and highland population, respectively. $r^2$ values were calculated as a statistics and averaged within 10-bp bins of distance between SNPs. The *x*- and *y*-axes represent distance between SNPs (kb) and average $r^2$ values.