Table 1: R lines and Inbreeds procured from USDA

|  |  |  |
| --- | --- | --- |
| Sl.no | Genotypes | Pedigree |
| 1 | RHA276 | CMS PI343765/HA119//HA62-4-5/2/T66006-2-2-11-3-2 |
| 2 | RHA278 | CMS PI343765/HA119//HA62-4-5/2/T66006-2-2-11-3-2 |
| 3 | RHA293 | 3\*Commander /Mennonite RR |
| 4 | RHA309 | RHA 293 Selection |
| 5 | RHA328 | RHA 294 /3/ R811 // HA 292 / RHA 282 |
| 6 | RHA329 | RHA 298 and 299 / Nonoilseed Composite |
| 7 | RHA330 | RHA 298 and 299 / Nonoilseed Composite |
| 8 | RHA389 | C2 RFSS (DMRRS) |
| 9 | RHA401 | RHA 274/RHA 1185-14-3-4-1 |
| 10 | RHA408 | ROMANIA R-LINE SCL POP-1 |
| 11 | RHA282 | Boneta Giant Manchurian/Mennonite RR |
| 12 | RHA294 | CMS PI 343863 / Bonita Giant-Manchurian / HA61 / Mennonite RR |
| 13 | RHA295 | CMS Mennonite RR- 18-1\*3 / T66006-2 |
| 14 | RHA409 | ROMANIA R-LINE SCL REC CYCLE C2 |
| 15 | RHA299 | CMS P-21 VRI/T70050 T70050=PI343765/HA119 //HA62-4-5/2/T66008-2 |
| 16 | RHA419 | RHA 373 / ARG 1575-2 |
| 17 | RHA427 | RHA 409/R 376\*2/*H.annuus* IMI resistant |
| 18 | RHA325 | R811-3 |
| 19 | RHA326 | RHA 293 / RHA 294 |
| 20 | RHA327 | RHA 294 /3/ R811 // Jumbo Israel / R268 |
| 21 | RHA331 | RHA 298 and 299 / Nonoilseed Composite |
| 22 | RHA332 | RHA 298 and 299 / Nonoilseed Composite |
| 23 | RHA333 | RHA 298 and 299 / Nonoilseed Composite |
| 24 | RHA334 | RHA 298 and 299 / Nonoilseed Composite |
| 25 | RHA340 | HA 89 \**H.argophyllus* 415 |
| 26 | RHA344 | RHA 274 \*2/Pervenets High Oleic |
| 27 | RHA345 | RHA 274 \*2/Pervenets High Oleic |
| 28 | RHA 346 | RHA 274 \*2/Pervenets High Oleic |
| 29 | RHA 347 | RHA 274 \*2/Pervenets High Oleic |
| 30 | RHA 348 | RHA 274 \*2/Pervenets High Oleic |
| 31 | RHA354 | RHA 310 \*2 / Pervenets High Oleic |
| 32 | RHA355 | RHA 310 \*2 / Pervenets High Oleic |
| 33 | RHA358 | RHA 274 \*3/DDR Short height |
| 34 | RHA359 | RHA 274/DDR |
| 35 | RHA436 | RHA340 / RHA344 High Oleic |
| 36 | RHA437 | RHA340 / RHA344 High Oleic |
| 37 | RHA364 | RHA418/RHA 419/3/ RHA801//RHA365/PI 413047 |
| 38 | RHA365 | SELECT |
| 39 | RHA373 | RHA 274/82ROM-R31 |
| 40 | RHA374 | ARG-R43 |
| 41 | RHA376 | RHA 296/RHA 266 |
| 42 | RHA377 | RHA 299//SOREM HT 58/RHA 801 |
| 43 | RHA381 | USDA 1869-3/\*3 RHA 274 |
| 44 | RHA386 | 82 ROM. R-LINE BULK |
| 45 | RHA387 | RHA 274/83 ROM. R-LINE B. |
| 46 | RHA388 | RHA 274/FELIX |
| 47 | RHA395 | C4 RFSS (DMRRS) |
| 48 | RHA454 | RHA 447//RHA440/PSC 8 (High ol.) |
| 49 | RHA398 | RHA 274/BCD LINE BULK |
| 50 | RHA399 | RHA 274/ODESSKIJ 91 |
| 51 | RHA400 | AUSTRALIA 85 R-LINE POP. |
| 52 | RHA415 | RHA 274/2696-1 (HIGH LINOL.) |
| 53 | RHA416 | RHA 274/2696-1 (HIGH LINOL.) |
| 54 | RHA418 | RHA 801/RHA 274 // MYHOCO H-9 |
| 55 | RHA420 | RHA 373 / ARG 1575-2 |
| 56 | RHA428 | RHA 801 // RHA 365 / PI 413157 |
| 57 | RHA438 | RHA340 / RHA344 High Oleic |
| 58 | RHA439 | RHA377/AS3211  Sclerotinia Tolerant |
| 59 | RHA440 | RHA377/AS4379  Sclerotinia Tolerant |
| 60 | RHA443 | RHA426/RHA419//RHA440  Imidazolinone Herbicide Resistant |
| 61 | RHA447 | RHA377/RHA348  High Oleic |
| 62 | RHA450 | RHA 324/Primrose |
| 63 | RHA461 | RHA418/RO 12-13//RHA 274/Dobritch |
| 64 | RHA462 | RHA439/IS PH RES. |
| 65 | RHA463 | RHA440/PSC 8 |
| 66 | RHA455 | RHA440/HO IS R-line (High oleic) |
| 67 | RHA854 | RHA 273 Selection |
| 68 | RHA855 | CMS HA 89/RHA 273 |
| 69 | RHA857 | S310/RHA 297 |
| 70 | RHA858 | P1161/RHA 298 |
| 71 | RHA859 | NSH 43/RHA 299 |
| 72 | ID-LRLYC | Late R-line Yield Composited (33 S4 families) |
| 73 | ID-ERLYC | Early R-line Yield Composited (39 S3 families) |
| 74 | NDBR1 | Impira INTA white \*2/3SP/2/HA89 |
| 75 | NDBR2 | Impira INTA white \*2/3SP/2/HA89. |
| 76 | ND-ERLYS | Early R-line Yield Synthetic |
| 77 | RHA360 | RHA 274/Donskoi |
| 78 | P 93-R |  |
| 79 | RHA 6-D-1 |  |
| 80 | GKVK-1 |  |
| 81 | RHA-1-1 |  |
| 82 | TSG-24 |  |
| 83 | PS 2056 |  |
| 84 | RHA-95-C-1 |  |

Table 2 : CMS lines procured from USDA

|  |  |  |
| --- | --- | --- |
|  |  | PEDIGREE |
| 1 | cmsHA65 |  |
| 2 | cmsHA89 | VNIIMK 8931 Sel |
| 3 | cmsHA112 |  |
| 4 | cmsHA115 |  |
| 5 | cmsHA116 |  |
| 6 | cmsHA208 |  |
| 7 | cmsHA224 | Armavirski 9345(P.I.265102) /HA8 |
| 8 | cmsHA228 |  |
| 9 | cmsHA234 |  |
| 10 | cmsHA236 |  |
| 11 | cmsHA248 |  |
| 12 | cmsHA249 |  |
| 13 | cmsHA250 |  |
| 14 | cmsHA253 |  |
| 15 | cmsHA259 |  |
| 16 | cmsHA286 |  |
| 17 | cmsHA288 |  |
| 18 | cmsHA291 |  |
| 19 | cmsHA302 | Peredovik 304   (P.I. 372173) Sel |
| 20 | cmsHA303 | Voshod             (P.I. 371936) Sel |
| 21 | cmsHA232 |  |
| 22 | cmsHA292 |  |
| 23 | cmsHA64 | VNIIMK 1646 Sel = cm 316 |
| 24 | cmsHA234 |  |
| 25 | cmsARM243 |  |
| 26 | cms2023A |  |
| 27 | cmsHA89A-1 |  |
| 28 | cmsHA300 |  |
| 29 | cms243A |  |
| 30 | cms430A |  |
| 31 | cms124A |  |
| 32 | cms133A |  |

Table 5: Phenotypic traits of the R lines in seven clusters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | R1 (n=5) | | | | R2 (n=16) | | | | R3(n=20) | | | | R4(n=8) | | | | | R5 (n=7) | | | | | R6 (n=6) | | | | | R7(n=17) | | | | | Overall (n=84) | | | | |
| Variable | Mean | SE | Min | Max | Mean | SE | Min | Max | Mean | SE | Min | Max | Mean | SE | Min | Max | Mean | | SE | Min | Max | Mean | | SE | Min | Max | Mean | | SE | Min | Max | Mean | | SE | Min | Max |
| DF | 61.3 | 3.1 | 57 | 73.3 | 59 | 1.3 | 47.7 | 67.7 | 65 | 1 | 58.7 | 74.3 | 61.2 | 1.9 | 53.7 | 68.3 | 64.8 | | 1.3 | 59 | 69.7 | 56.8 | | 1.7 | 52.7 | 62.7 | 63.2 | | 1 | 54.3 | 70.3 | 62.2 | | 0.58 | 47.7 | 74.3 |
| DM | 89.2 | 2.2 | 85.3 | 98 | 88.2 | 1.8 | 71 | 100 | 94.3 | 1.2 | 86.7 | 106.3 | 90.5 | 1.8 | 84.3 | 97.3 | 93.9 | | 1.9 | 87 | 102.7 | 86 | | 1.3 | 82.7 | 90 | 91.9 | | 1.1 | 83.3 | 99.3 | 91.3 | | 0.64 | 71 | 106 |
| PL HT (cm) | 104.6 | 7.7 | 89.5 | 133 | 82.8 | 6.3 | 36.8 | 121.7 | 104.7 | 4.7 | 66.7 | 138 | 83.6 | 2.9 | 69.7 | 97 | 105.6 | | 7.1 | 90.1 | 132.4 | 80.8 | | 7.1 | 54.8 | 104.3 | 93 | | 4.4 | 53.5 | 140 | 94.5 | | 2.34 | 36.8 | 140 |
| HD (cm) | 8 | 1.1 | 5.5 | 10.8 | 8.3 | 1.4 | 5.5 | 28.5 | 9.1 | 2.5 | 4.4 | 56 | 6 | 0.3 | 4.8 | 7.5 | 6.5 | | 0.7 | 5.4 | 10.3 | 5.9 | | 0.3 | 5 | 6.9 | 6.9 | | 0.3 | 4.7 | 9.9 | 7.56 | | 0.65 | 4.4 | 56 |
| PY (gram) | 8.3 | 1.4 | 6.4 | 13.9 | 4.5 | 0.6 | 1.5 | 10.5 | 4.5 | 0.5 | 1.4 | 11.1 | 3.3 | 0.5 | 2.3 | 5.6 | 4.2 | | 1.1 | 1.4 | 10.1 | 3.8 | | 0.5 | 2.5 | 6.2 | 3.2 | | 0.3 | 1.4 | 6.1 | 4.27 | | 0.25 | 1.37 | 13.9 |
| TW (gram) | 3.2 | 0.8 | 1.6 | 5.2 | 2.1 | 0.3 | 0.8 | 4.2 | 1.7 | 0.2 | 0.8 | 3.7 | 1.8 | 0.3 | 1 | 3.2 | 2.7 | | 0.4 | 1.4 | 4 | 2.7 | | 0.2 | 2.2 | 3.8 | 2.4 | | 0.2 | 1 | 4.3 | 2.21 | | 0.1 | 0.8 | 5.2 |
| OC % | 35.3 | 1.1 | 30.1 | 43.1 | 32.1 | 0.6 | 25.8 | 40 | 29.5 | 0.6 | 25.9 | 34.9 | 32.3 | 0.9 | 29.6 | 35.6 | 33.2 | | 1.2 | 29.2 | 37.6 | 30.2 | | 1.1 | 25.9 | 34.2 | 29.4 | | 0.8 | 24.6 | 35.7 | 31.1 | | 135 | 24.6 | 43.1 |

DF= days for 50% flowering, DM=days to 50% maturity; PH (cm)=plant height; HD (cm)=Head diameter; PY(g)=Seed yield/plant; TW (g)=Test weight (100 seed weight); OC (%)=oil content in percentage

N= number of lines in cluster; SE=Standard error; Min=minimum; Max=Maximum

Table 4: Phenotypic traits of the CMS lines in three clusters

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | A1 (n=15) | | | | A2 (n=4) | | | | A1 (n=13) | | | | Overall | | | |
| Variable | Mean | SE | Min | Max | Mean | SE | Min | Max | Mean | SE | Min | Max | Mean | SE | Min | Max |
| DF | 66.4 | 2.2 | 58 | 83 | 67.3 | 3.3 | 60 | 76 | 65.2 | 1.2 | 60 | 74 | 66.0 | 1.1 | 58.0 | 83.0 |
| DM | 96.4 | 2.2 | 88 | 113 | 97.3 | 3.3 | 90 | 106 | 95.3 | 1.2 | 90 | 104 | 96.0 | 1.1 | 88.0 | 113.0 |
| PL HT (cm) | 102.4 | 6.9 | 67 | 128 | 91.4 | 7.5 | 70 | 105 | 105.3 | 5.3 | 68 | 131 | 102.2 | 3.8 | 67.0 | 131.0 |
| HD (cm) | 13.3 | 0.4 | 11.2 | 15.8 | 13.0 | 1.0 | 10.4 | 14.8 | 12.0 | 0.3 | 10 | 13.8 | 12.7 | 0.3 | 10.0 | 15.8 |

DF= days for 50% flowering, DM=days to 50% maturity; PH (cm)=plant height; HD (cm)=Head diameter; PY(g)=Seed yield/plant; TW (g)=Test weight (100 seed weight); OC (%)=oil content in percentage

n= number of lines in cluster; SE=Standard error; Min=minimum; Max=Maximum

Table 3: **Thirty nine sunflower simple sequence repeat (SSR) markers exhibiting linkage groups, major allele frequency, number of alleles, gene diversity and polymorphic information content**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Marker** | **LG** | **Major allele Frequency** | **Allele No** | **Gene diversity** | **PIC** |
| ORS610 | 1 | 0.52 | 6 | 0.64 | 0.58 |
| ORS371 | 1 | 0.60 | 2 | 0.48 | 0.36 |
| ORS837 | 1 | 0.72 | 3 | 0.43 | 0.38 |
| ORS229 | 2 | 0.50 | 3 | 0.52 | 0.40 |
| ORS1065 | 2 | 0.52 | 4 | 0.52 | 0.40 |
| ORS1036 | 3 | 0.74 | 2 | 0.38 | 0.31 |
| ORS924 | 3 | 0.77 | 3 | 0.36 | 0.30 |
| ORS695 | 4 | 0.57 | 3 | 0.50 | 0.38 |
| ORS785 | 4 | 0.72 | 4 | 0.45 | 0.42 |
| ORS505 | 5 | 0.61 | 6 | 0.57 | 0.52 |
| ORS533 | 5 | 0.49 | 7 | 0.68 | 0.63 |
| ORS774 | 5 | 0.46 | 3 | 0.61 | 0.53 |
| ORS381 | 6 | 0.85 | 3 | 0.25 | 0.23 |
| ORS966 | 7 | 0.53 | 3 | 0.61 | 0.54 |
| ORS400 | 7 | 0.72 | 3 | 0.43 | 0.39 |
| ORS456 | 8 | 0.28 | 4 | 0.74 | 0.69 |
| ORS1161 | 8 | 0.46 | 3 | 0.64 | 0.57 |
| ORS299 | 8 | 0.72 | 4 | 0.45 | 0.42 |
| ORS844 | 9 | 0.33 | 5 | 0.73 | 0.68 |
| ORS887 | 9 | 0.62 | 3 | 0.48 | 0.37 |
| ORS437 | 10 | 0.36 | 3 | 0.66 | 0.59 |
| ORS878 | 10 | 0.59 | 3 | 0.50 | 0.40 |
| ORS1146 | 11 | 0.52 | 2 | 0.50 | 0.37 |
| ORS607 | 11 | 0.72 | 4 | 0.44 | 0.41 |
| ORS761 | 12 | 0.72 | 3 | 0.44 | 0.39 |
| ORS778 | 12 | 0.72 | 3 | 0.41 | 0.35 |
| ORS656 | 12 | 0.72 | 3 | 0.43 | 0.38 |
| ORS534 | 13 | 0.65 | 3 | 0.46 | 0.36 |
| ORS707 | 13 | 0.75 | 3 | 0.38 | 0.31 |
| ORS694 | 14 | 0.41 | 4 | 0.69 | 0.63 |
| ORS1180 | 14 | 0.44 | 4 | 0.66 | 0.60 |
| ORS254 | 15 | 0.53 | 2 | 0.50 | 0.37 |
| ORS857 | 15 | 0.54 | 2 | 0.50 | 0.37 |
| ORS996 | 16 | 0.61 | 3 | 0.54 | 0.47 |
| ORS807 | 16 | 0.60 | 3 | 0.49 | 0.39 |
| ORS303 | 16 | 0.72 | 3 | 0.41 | 0.35 |
| ORS561 | 17 | 0.44 | 6 | 0.70 | 0.66 |
| ORS735 | 17 | 0.45 | 4 | 0.64 | 0.56 |
| ORS297 | 17 | 0.44 | 7 | 0.68 | 0.63 |
| **Mean** |  | **0.58** | **3.56** | **0.53** | **0.45** |

Table 4: Allele information on 32 CMS lines using *rep*, *box* and *eric* primers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SSR Primer** | **Major Allele Frequency** | **Allele No** | **Gene Diversity** | **PIC** |
| BOX | 0.06 | 28.00 | 0.96 | 0.96 |
| ERIC | 0.09 | 29.00 | 0.96 | 0.96 |
| REP | 0.19 | 14.00 | 0.88 | 0.87 |
| **Mean** | **0.11** | **23.67** | **0.94** | **0.93** |