**Supplementary data 5:** Markers-traits association revealed by TASSEL and GAPIT analysis for 101 genetic markers and 189 individuals for nutrients accumulation including Zn, Fe, and Cd.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments  | Control  | Cd10  | Zn5  |  | Zn20  |  | Cd10+ | Zn5  | Cd10+Zn20  |
| Markers associated to Zn accumulation  |  |  |  |
|  | marker  |  1 |  | 13.825 |   |  | 10.776 |   |  | 8.981 |   |  | 8.385 |   |  | 7.338 |   |  | 10.562 |   |
|  | marker  |  2  |  | 13.825 |   |  | 10.776 |   |  | 8.981 |   |  | 8.385 |   |  | 7.338 |   |  | 10.562 |   |
| marker 3  | 1.629  | 2.024  | 1.984 |   | 1.159 |   | 1.473 |   | 2.388  |
| marker 4  | 2.055  | 1.677  | 1.113 |   | 0.590 |   | 1.179 |   | 2.710  |
| marker 5  | 0.636  | 0.336  | 2.175 |   | 2.001 |   | 0.562 |   | 0.283  |
| marker 6  | 0.636  | 0.336  | 2.175 |   | 2.001 |   | 0.562 |   | 0.283  |
| marker 7  | 0.052  | 0.460  | 1.117 |   | 0.927 |   | 0.177 |   | 0.210  |
| marker 8  | 0.052  | 0.460  | 1.117 |   | 0.927 |   | 0.177 |   | 0.210  |
| marker 9  | 1.184  | 0.709  | 0.674 |   | 0.927 |   | 0.675 |   | 0.672  |
| marker 10  | 0.331  | 0.076  | 0.365 |   | 0.309 |   | 0.258 |   | 0.242  |
| marker 11  | 0.149  | 0.400  | 0.102 |   | 0.196 |   | 0.336 |   | 0.392  |
| marker 12  | 0.149  | 0.400  | 0.102 |   | 0.196 |   | 0.336 |   | 0.392  |
| marker 13  | 0.171  | 0.465  | 0.192 |   | 0.226 |   | 0.916 |   | 0.484  |
| marker 14  | 0.378  | 0.311  | 0.375 |   | 0.707 |   | 0.244 |   | 0.260  |
| marker 15  | 0.102  | 0.054  | 0.069 |   | 0.058 |   | 0.227 |   | 0.091  |
| marker 16  | 0.462  | 0.064  | 0.252 |   | 0.201 |   | 0.164 |   | 0.098  |
| marker 17  | 6.854  | 4.108  | 5.134 |   | 3.923 |   | 2.625 |   | 3.995  |
| marker 18  | 0.401  | 0.090  | 0.279 |   | 0.364 |   | 0.145 |   | 0.345  |
| Markers associated to Fe accumulation  |  |  |  |
|  | Marker19 |   |  | 10.374 |   |  | 8.980  |  |  | 8.859 |   |  | 9.349 |   |  | 8.017 |   |  | 7.337  |  |
|  | Marker20 |   |  | 10.374 |   |  | 8.980  |  |  | 8.859 |   |  | 9.349 |   |  | 8.017 |   |  | 7.337  |  |
| Marker 21  | 6.767  | 3.295  | 6.675 |   | 6.070 |   | 2.899 |   | 3.366  |
| Marker 22  | 5.731  | 2.850  | 6.258 |   | 6.133 |   | 2.481 |   | 2.825  |
| Marker 23  | 6.264  | 3.496  | 6.720 |   | 6.117 |   | 3.187 |   | 3.645  |
| Marker 24  | 7.894  | 8.281  | 7.400 |   | 7.768 |   | 7.392 |   | 6.602  |
|  | Marker25 |   |  | 10.374 |   |  | 8.980  |  |  | 8.859 |   |  | 9.349 |   |  | 8.017 |   |  | 7.337  |  |
|  | Marker 26 |   |  | 10.374 |   |  | 8.980  |  |  | 8.859 |   |  | 9.349 |   |  | 8.017 |   |  | 7.337  |  |
| marker 27  | 0.086  | 0.163  | 0.107 |   | 0.083 |   | 0.158 |   | 0.126  |
| Marker 28  | 0.086  | 0.163  | 0.107 |   | 0.083 |   | 0.158 |   | 0.126  |
| Marker 29  | 6.593  | 5.937  | 5.663 |   | 5.503 |   | 5.528 |   | 5.373  |
|  | Marker 30 |   |  | 9.971  |  |  | 8.760  |  |  | 8.257 |   |  | 7.966 |   |  | 8.399 |   |  | 7.603  |  |
|  | Marker 31 |   |  | 9.971  |  |  | 8.760  |  |  | 8.257 |   |  | 7.966 |   |  | 8.399 |   |  | 7.603  |  |
|  | Marker 32 |   |  | 9.971  |  |  | 8.760  |  |  | 8.257 |   |  | 7.966 |   |  | 8.399 |   |  | 7.603  |  |
| Marker 33  | 0.594  | 0.131  | 0.360 |   | 0.303 |   | 0.114 |   | 0.065  |
| Marker 34  | 0.117  | 0.104  | 0.030 |   | 0.077 |   | 0.090 |   | 0.103  |
| Marker 35  | 0.118  | 0.038  | 0.046 |   | 0.124 |   | 0.062 |   | 0.128  |
| Marker 36  | 0.164  | 0.230  | 0.177 |   | 0.296 |   | 0.108 |   | 0.087  |
|  | Marker 37 |   |  | 10.374 |   |  | 8.980  |  |  | 8.859 |   |  | 9.349 |   |  | 8.017 |   |  | 7.337  |  |
| Marker 38  | 0.086  | 0.163  | 0.107 |   | 0.083 |   | 0.158 |   | 0.126  |
| Marker 39  | 0.290  | 0.264  | 0.223 |   | 0.296 |   | 0.228 |   | 0.207  |
| Marker 40  | 1.276  | 1.556  | 1.413 |   | 1.223 |   | 1.488 |   | 1.481  |
| Marker 41  | 1.673  | 1.141  | 2.239 |   | 2.987 |   | 1.023 |   | 1.078  |
| Marker 42  | 2.416  | 1.368  | 2.691 |   | 3.375 |   | 1.158 |   | 1.194  |

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| Marker 43  | 2.162  | 2.211  | 1.969  | 1.869  | 2.012 |   | 1.910  |
| Marker 44  | 0.515  | 0.632  | 0.338  | 0.407  | 0.763 |   | 0.530  |
| Marker 45  | 0.508  | 0.277  | 0.215  | 0.218  | 0.443 |   | 0.272  |
| Markers associated to Cd accumulation  |  |
| Marker 46 |   | 0.199  |   |   | 0.403 |   | 0.361  |
| Marker 47  |   | 0.199  |   |   | 0.403 |   | 0.361  |
| Marker 48  |   | 0.199  |   |   | 0.403 |   | 0.361  |
| Marker 49  |   | 0.557  |   |   | 0.436 |   | 0.573  |
| Marker 50  |   | 0.020  |   |   | 0.004 |   | 0.121  |
| Marker 51  |   | 0.469  |   |   | 0.277 |   | 0.331  |
| Marker 52  |   | 0.380  |   |   | 0.182 |   | 0.351  |
| Marker 53  |   | 0.001  |   |   | 0.014 |   | 0.075  |
| Marker 54  |   | 0.001  |   |   | 0.014 |   | 0.075  |
| Marker 55  |   | 0.001  |   |   | 0.014 |   | 0.075  |
| Marker 56  |   | 1.539  |   |   | 0.710 |   | 1.605  |
| Marker 57  |   | 0.961  |   |   | 0.289 |   | 1.326  |
| Marker 58  |   | 0.961  |   |   | 0.289 |   | 1.326  |
| Marker 59  |   | 3.126  |   |   | 3.296 |   | 2.840  |
| Marker 60  |   | 3.126  |   |   | 3.296 |   | 2.840  |
| Marker 61  |   | 3.112  |   |   | 3.345 |   | 2.512  |
|  | Marker 62 |   |   |  | 4.537 |   |   |   |  | 4.531 |   |  | 4.066 |   |
| Marker 63  |   | 0.483  |   |   | 0.082 |   | 0.635  |
| Marker 64  |   | 0.050  |   |   | 0.223 |   | 1.188  |
| Marker 65  |   | 0.400  |   |   | 0.087 |   | 0.974  |
| Marker 66  |   | 0.052  |   |   | 0.097 |   | 0.627  |
| Marker 67  |   | 0.120  |   |   | 0.026 |   | 0.152  |
| Marker 68  |   | 1.210  |   |   | 1.188 |   | 0.284  |
| Marker 69  |   | 0.012  |   |   | 0.046 |   | 0.431  |
| Marker 70  |   | 0.240  |   |   | 0.211 |   | 0.017  |
| Marker 71  |   | 0.471  |   |   | 0.416 |   | 0.163  |
| Marker 72  |   | 3.264  |   |   | 3.397 |   | 2.555  |
| Marker 73  |   | 2.144  |   |   | 2.431 |   | 2.338  |
| Marker 74  |   | 2.848  |   |   | 3.077 |   | 1.937  |
| Marker 75  |   | 1.069  |   |   | 1.367 |   | 0.470  |
| Marker 76  |   | 0.054  |   |   | 0.185 |   | 0.097  |
| Marker 77  |   | 0.287  |   |   | 0.551 |   | 0.143  |
| Marker 78  |   | 0.110  |   |   | 0.126 |   | 0.953  |
| Marker 79  |   | 0.295  |   |   | 0.254 |   | 1.714  |
| Marker 80  |   | 0.031  |   |   | 0.032 |   | 0.681  |
| Marker 81  |   | 0.033  |   |   | 0.012 |   | 0.332  |
| Marker 82  |   | 0.146  |   |   | 0.142 |   | 1.541  |
| Marker 83  |   | 0.226  |   |   | 0.061 |   | 0.053  |
| Marker 84  |   | 0.226  |   |   | 0.061 |   | 0.053  |
| Marker 85  |   | 0.002  |   |   | 0.086 |   | 0.260  |
| Marker 86  |   | 0.863  |   |   | 1.032 |   | 0.434  |
| Marker 87 |   |   | 1.630 |   |   |   | 1.366 |   | 1.365  |
| Marker 88 |   |   | 2.600 |   |   |   | 2.553 |   | 1.894  |
|  | Marker 89 |   |   |  | 4.040 |   |   |   |  | 3.820 |   |  | 3.826 |   |
| Marker 92 |   |   | 0.807 |   |   |   | 0.873 |   | 0.747  |
| Marker 93 |   |   | 0.342 |   |   |   | 0.407 |   | 0.238  |
| Marker 94 |   |   | 0.172 |   |   |   | 0.065 |   | 0.034  |
| Marker 95 |   |   | 0.507 |   |   |   | 0.410 |   | 0.504  |
| Marker 96 |   |   | 0.216 |   |   |   | 0.109 |   | 0.008  |
| Marker 97 |   |   | 1.805 |   |   |   | 1.855 |   | 0.320  |
| Marker 98 |   |   | 2.599 |   |   |   | 2.397 |   | 1.456  |
| Marker 99 |   |   | 2.322 |   |   |   | 2.294 |   | 2.007  |
| Marker100  |  |   | 2.331 |   |   |   | 2.433 |   | 0.981  |
| Marker101 |   |   | 1.811 |   |   |   | 1.993 |   | 1.342  |