

Supplementary table:

Table S1: List of 175 genotypes under study

| S.N. | Pedigree/ Genotypes | S.N. | Pedigree/ Genotypes |
|------|------------------------------|------|---------------------------------|
| 1 | CL1449/HUW585 | 43 | HD2948/HD2894 |
| 2 | DL672/PS6270//DE8 | 44 | PS755/HD29 |
| 3 | HW5015/UP2538 | 45 | PS755/PBW502 |
| 4 | HD2898/HD29 | 46 | CL1705/HD2894 |
| 5 | HD2953/HS365 | 47 | CL1705/HD2894 |
| 6 | CL1449/PBW343 | 48 | HD2851/HD2329 |
| 7 | HD2878/HD29 | 49 | HD2851/HD2329 |
| 8 | CL2636 | 50 | VL610/KUNDAN |
| 9 | PBW343/HD2877 | 51 | PBW343/PICCI LOCAL//RL6080 |
| 10 | 18-HRWYT-214 | 52 | HW3083/HD2639 |
| 11 | 18-SAWYT-303 | 53 | HW3083/HD2639 |
| 12 | HD2448/HW1305 | 54 | HW3083/HD2639 |
| 13 | HW4023/HW5028//HD2932/DW1309 | 55 | HW3083/HD2639 |
| 14 | HD2833/DW538 | 56 | DWG107/RAJ 3765 |
| 15 | 39 th IBWSN-23 | 57 | DWG107/RAJ 3765 |
| 16 | 29 th SAWSN-3145 | 58 | WH542/UP290//DBW72 |
| 17 | CSW 43 | 59 | CL 2596/K9451//CI882/HD2329 |
| 18 | HD2932/UP2425 | 60 | DWG107/HDK-10//C306 |
| 19 | WL462/VCC/KOCL/3/Pes/Me-11 | 61 | DWG107/HDK-10//C306 |
| 20 | UP2425/CL146 | 62 | DWG107/HDK-10//C306 |
| 21 | JOSHI 3 | 63 | HD3239/WR562 |
| 22 | HD2967/DW1350 | 64 | DL5/PBW343//DEEPALI |
| 23 | HD2448/HW1305 | 65 | DL5/PBW343//DEEPALI |
| 24 | HD2878/HD29 | 66 | DL5/PBW343//HD2891 |
| 25 | CL1705/PBW12 | 67 | DL5/PBW343//DEEPALI |
| 26 | CL1705/HD2894 | 68 | DL5/PBW343//HD2891 |
| 27 | HD2824/VL796 | 69 | DL5/PBW343//HD2891 |
| 28 | VL610/KUNDAN | 70 | DL5/PBW343//HD2891 |
| 29 | 31-ESWYT-132 | 71 | DL5/PBW343//HD2891 |
| 30 | 5-EBWYT-519 | 72 | CL2596/K9451//CL882/HD2009 |
| 31 | 43-IBWSN-1006 | 73 | G-9/ MC-10 |
| 32 | 43-IBWSN-1077 | 74 | G-9/MC-10 |
| 33 | 43-IBWSN-1090 | 75 | CL22596/K9451//CL882/HD2329 |
| 34 | 43-IBWSN-1102 | 76 | CP264/CL1633//CNO 63/WELLINGTON |
| 35 | 43-IBWSN-1106 | 77 | CL 2596/K9451//CI882/HD2329 |
| 36 | 43-IBWSN-1153 | 78 | CL2596/K9451/CL882//HD2009 |
| 37 | 43-IBWSN-1182 | 79 | CL2596/K9451/CL882//HD2009 |
| 38 | 43-IBWSN-1187 | 80 | HD2669/HD3016 |
| 39 | 29-SAWN-3028 | 81 | HD2669/HD3016 |
| 40 | HW5028/HD2250 | 82 | HD2967/HUW631 |
| 41 | HW2930/DW1309 | 83 | HD2967/DBW17 |
| 42 | HD2948/HD2894 | 84 | HD2967/DBW17 |

| | | | |
|-----|------------------|-----|-------------------------------|
| 85 | HD2967/HD3024 | 128 | HD 3090 |
| 86 | HD2967/HD3024 | 129 | HD 3059 |
| 87 | HD2967/HD3024 | 130 | HD 3086 |
| 88 | HD2967/DBW54 | 131 | GW 366 |
| 89 | HD2967/DBW56 | 132 | WL 711 |
| 90 | HD2967/K-07-08 | 133 | K 9107 |
| 91 | HD2967/WH1073 | 134 | 43IBWSN-1201 |
| 92 | HD2967/WH1073 | 135 | 28SAWSN-3012 |
| 93 | HD2967/PBW 617 | 136 | 43-IBWSN-1054 |
| 94 | HD2967/PBW 596 | 137 | 43-IBWSN-1187 |
| 95 | HD2967/DT2756 | 138 | 28-SAWSN-3028 |
| 96 | HD2967/HD3024 | 139 | CL1705/HD2894 |
| 97 | HD2967/HD3034 | 140 | HW3083/HD2873 |
| 98 | HD2967/HD3034 | 141 | HD3117 |
| 99 | HD2967/HD3035 | 142 | CSW16 |
| 100 | HD2967/HD3035 | 143 | DL849/YSCN-08 |
| 101 | HD2967/DT2761 | 144 | DL672/P66.270//DE894/3/CUMYN |
| 102 | HD2967/DT2761 | 145 | HD2329/WR544//PBW343/NW2041 |
| 103 | HD2967/DT2761 | 146 | 18SAWYT-311 |
| 104 | HI 1544 | 147 | 18HRWYT-214 |
| 105 | HI1563 | 148 | 18 th SAWYT 36 |
| 106 | HI 1500 | 149 | HD2733/PBW343/HD2733/PBW343 |
| 107 | HI1531 | 150 | WH542/YSCN-10 |
| 108 | RAJ 4120 | 151 | HD2687/HP1896//WH542 |
| 109 | RAJ 3765 | 152 | CSW44 |
| 110 | RAJ 4083 | 153 | PBW12/HW2078 |
| 111 | DBW-14 | 154 | HD2824/VL796 |
| 112 | DBW17 | 155 | HD2402/CPAN4067/HW4022/DW5247 |
| 113 | WH 542 | 156 | UP2425/UP2626 |
| 114 | PBW 621-50 | 157 | HD2733/HD2329 |
| 115 | PBW 596 | 158 | VL849/UP2571 |
| 116 | PBW 590 | 159 | HD2733/PBW343/HD2733/PBW343 |
| 117 | PBW 502 | 160 | IBWSN-06-07 KARNAL |
| 118 | PBW 443 | 161 | HD2877/HS451 |
| 119 | PBW 373 | 162 | CL1591/CL1475 |
| 120 | PBW 343 | 163 | 31 ESWYT121 |
| 121 | HD 2285 | 164 | 6 th EBYT-503 |
| 122 | HD 2894 | 165 | CL1705/HD2687 |
| 123 | HD 2932 | 166 | CL1705/HD2687 |
| 124 | HD 2985 | 167 | CL1705/HD2687 |
| 125 | HD 2987 | 168 | CL264//CL1633/CNO-601 |
| 126 | HD 3043 | 169 | CL264//CL1633/CNO-601 |
| 127 | HD 2329 | 170 | CL264//CL1633/CNO-601 |
| 171 | EGPSN-36/PBW 343 | 174 | CL2596/K9451/CL882//HD2009 |
| 172 | EGPSN-36/PBW 343 | 175 | CL2596/K9451/CL882//HD2009 |
| 173 | EGPSN-36/PBW343 | | |

Table S2: List of 19 subset genotypes screened under hydroponics and pot

| SN | Table S1 | Pedigree/Genotypes | Weight (gm) |
|--|----------|------------------------------|-------------|
| On the basis of mean shoot dry weight | | | |
| 1 | 154 | HD2824/VL796 | 1.88 |
| 2 | 144 | DL672/P66.270//DE894/3/CUMYN | 1.12 |
| 3 | 151 | HD2687/HP1896//WH542 | 1.51 |
| 4 | 152 | CSW44 | 1.195 |
| 5 | 84 | HD2967/DBW17 | 0.195 |
| 6 | 128 | HD 3090 | 0.31 |
| 7 | 5 | HD2953/HS365 | 0.265 |
| On the basis of mean Nitrogen efficient | | | |
| 8 | 86 | HD2967/HD3024 | 0.775 |
| 9 | 78 | CL2596/K9451/CL882//HD2009 | 0.615 |
| 10 | 101 | HD2967/DT2761 | 0.595 |
| 11 | 114 | PBW 621-50 | 0.08 |
| 12 | 51 | PBW343/PICCI LOCAL//RL6080 | 0.11 |
| 13 | 92 | HD2967/WH1073 | 0.11 |
| On the basis of mean root dry weight | | | |
| 14 | 173 | EGPSN-36/PBW 343 | 0.1875 |
| 15 | 171 | EGPSN-36/PBW 343 | 0.1435 |
| 16 | 143 | DL849/YSCN-08 | 0.186 |
| 17 | 89 | HD2967/DBW56 | 0.0165 |
| 18 | 71 | DL5/PBW343//HD2891 | 0.019 |
| 19 | 99 | HD2967/HD3035 | 0.0235 |

Table S3: Clustering pattern of 175 spring wheat genotypes (Table S1) on the basis of morpho-physiological traits for NUE under high nitrogen (HN)

| Cluster | Genotype No. |
|---------|---|
| I (160) | 83, 100, 39, 47, 20, 85, 73, 59, 1, 30, 6, 21, 165, 26, 18, 17, 56, 91, 34, 13, 41, 36, 60, 95, 67, 98, 94, 58, 104, 62, 22, 3, 50, 49, 70, 4, 65, 64, 52, 158, 99, 45, 66, 5 , 106, 11, 87, 108, 14, 24, 10, 71, 156, 75, 74, 93, 168, 25, 53, 103, 92, 76, 48, 63, 136, 15, 8, 27, 28, 123, 51, 72, 54, 42, 61, 82, 43, 81, 33, 55, 101, 46, 77, 90, 111, 102, 35, 2, 130, 96, 16, 29, 148, 164, 114, 89, 88, 84 , 150, 124, 38, 131, 163, 139, 135, 167, 19, 105, 80, 147, 7, 137, 32, 129, 69, 57, 142, 117, 37, 157, 44, 132, 109, 97, 118, 121, 78, 175, 116, 115, 107, 133, 169, 149, 159, 40, 68, 141, 128 , 122, 112, 152 , 144 , 125, 146, 113, 23, 138, 12, 126, 170, 134, 31, 174, 119, 140, 86, 145, 110, 160 |
| II (1) | 127 |
| III (1) | 162 |
| IV (11) | 143, 153, 166, 155, 173, 172, 9, 171, 151 , 161, 120 |
| V (1) | 154 |
| VI (1) | 79 |

() indicate numbers of genotypes accommodated in the cluster

Table S4: Clustering pattern of 175 spring wheat genotypes (Table S1) on the basis of morpho-physiological traits for NUE under low nitrogen (LN)

| Cluster | Genotype No. |
|----------|--|
| I (136) | 74, 106, 65, 118, 39, 11, 169, 141, 29, 167, 164, 128, 109, 175, 163, 138, 165, 18, 69, 143, 131, 75, 146, 156, 105, 129, 149, 113, 45, 134, 104, 132, 71, 8, 10, 44, 145, 117, 33, 25, 84, 107, 130, 35, 37, 171, 111, 68, 12, 127, 172, 159, 115, 27, 13, 5, 120, 90, 126, 40, 160, 123, 152, 137, 155, 7, 153, 124, 34, 157, 147, 170, 60, 108, 26, 89, 173, 135, 20, 116, 17, 62, 53, 2, 16, 9, 77, 148, 32, 59, 52, 67, 73, 6, 158, 64, 70, 142, 61, 22, 21, 43, 31, 144, 122, 139, 30, 125, 46, 47, 63, 24, 42, 133, 51, 92 , 66, 50, 140, 174, 15, 136, 55, 57, 150, 76, 121, 151, 28, 23, 80, 154, 1, 19, 110, 114 |
| II (22) | 41, 161, 79, 94, 98, 85, 103, 88, 101, 78 , 99, 100, 102, 83, 82, 81, 87, 97, 3, 93, 38, 36 |
| III (10) | 56, 58, 54, 166, 72, 168, 48, 162, 96, 14 |
| IV (1) | 119 |
| V (1) | 112 |
| VI (1) | 91 |
| VII (1) | 95 |
| VIII (1) | 49 |
| IX (1) | 86 |
| X (1) | 4 |

() indicate numbers of genotypes accommodated in cluster

Table S5: Average intra and inter cluster D^2 values of different clusters under HN

| Cluster | I | II | III | IV | V | VI |
|---------|-------------|----------|----------|--------------|----------|----------|
| I | 10.9 | | | | | |
| II | 18.21 | 0 | | | | |
| III | 19.26 | 12.45 | 0 | | | |
| IV | 25.94 | 11.91 | 15.01 | 13.22 | | |
| V | 39.44 | 26.79 | 24.27 | 21.86 | 0 | |
| VI | 22.87 | 26.03 | 21.15 | 29.89 | 37.34 | 0 |

Table S6: Average intra and inter cluster D^2 values of different clusters under LN

| Cluster | I | II | III | IV | V | VI | VII | VIII | IX | X |
|---------|-------------|-------------|-------------|----------|----------|----------|----------|----------|----------|----------|
| I | 8.41 | | | | | | | | | |
| II | 17.97 | 9.07 | | | | | | | | |
| III | 13.45 | 25.72 | 10.4 | | | | | | | |
| IV | 12.8 | 13.6 | 22.21 | 0 | | | | | | |
| V | 15.93 | 13.7 | 25.54 | 3.54 | 0 | | | | | |
| VI | 13.18 | 15.02 | 15.77 | 18.38 | 20.83 | 0 | | | | |
| VII | 21.9 | 14.32 | 25.84 | 23.11 | 24.19 | 10.84 | 0 | | | |
| VIII | 18.77 | 24.58 | 15.25 | 27.28 | 30.16 | 10.94 | 18.33 | 0 | | |
| IX | 26.53 | 13.73 | 33.06 | 23.39 | 22.97 | 20.2 | 14.01 | 27.89 | 0 | |
| X | 14.24 | 24.64 | 15.71 | 18.81 | 21.65 | 19.43 | 27.94 | 22.38 | 32.94 | 0 |

Table S7: Eigen vectors for different NUE traits under HN

| | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 | PC8 | PC9 | PC10 |
|------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| SDW | 0.452 | 0.007 | -0.166 | 0.140 | -0.023 | -0.096 | 0.352 | 0.261 | -0.739 | -0.013 |
| RDW | 0.258 | -0.530 | 0.057 | 0.074 | 0.334 | -0.612 | -0.395 | -0.016 | 0.029 | -0.012 |
| MRL | 0.156 | -0.470 | 0.009 | -0.504 | -0.706 | 0.037 | -0.014 | -0.005 | 0.003 | -0.003 |
| PH | 0.184 | 0.262 | -0.291 | -0.792 | 0.428 | -0.015 | -0.036 | 0.018 | 0.008 | 0.001 |
| R:S | -0.076 | -0.595 | 0.206 | -0.071 | 0.453 | 0.518 | 0.344 | 0.012 | -0.026 | 0.012 |
| N% | 0.131 | 0.178 | 0.640 | -0.115 | 0.010 | 0.140 | -0.319 | 0.637 | -0.029 | -0.020 |
| gN | 0.463 | 0.071 | 0.044 | 0.112 | 0.003 | 0.324 | -0.229 | -0.345 | 0.035 | -0.699 |
| NUpE | 0.463 | 0.069 | 0.043 | 0.112 | -0.003 | 0.309 | -0.254 | -0.309 | 0.013 | 0.714 |
| NUtE | -0.123 | -0.182 | -0.635 | 0.164 | -0.007 | 0.348 | -0.459 | 0.435 | -0.013 | -0.016 |
| NUE | 0.452 | 0.006 | -0.162 | 0.150 | -0.025 | -0.069 | 0.413 | 0.348 | 0.670 | 0.008 |

Table S8: Eigen vectors for different NUE traits under LN

| | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 | PC8 | PC9 | PC10 |
|------|--------------|---------------|---------------|---------------|--------------|--------------|---------------|---------------|---------------|---------------|
| SDW | 0.433 | 0.167 | 0.022 | -0.024 | -0.124 | -0.275 | -0.171 | -0.028 | 0.404 | -0.707 |
| RDW | 0.426 | 0.152 | 0.181 | -0.092 | -0.060 | -0.266 | -0.136 | -0.125 | -0.803 | -0.001 |
| MRL | 0.197 | -0.032 | -0.491 | -0.504 | 0.682 | -0.005 | -0.011 | -0.007 | 0.000 | 0.000 |
| PH | 0.126 | 0.229 | 0.114 | 0.743 | 0.605 | 0.029 | -0.027 | -0.002 | 0.001 | 0.000 |
| R:S | -0.020 | -0.075 | 0.844 | -0.376 | 0.333 | 0.077 | 0.026 | 0.017 | 0.151 | 0.000 |
| N% | 0.080 | -0.643 | 0.000 | 0.128 | 0.029 | 0.164 | -0.715 | -0.154 | -0.005 | 0.000 |
| gN | 0.432 | -0.154 | -0.002 | 0.046 | -0.095 | 0.499 | 0.430 | -0.585 | 0.054 | -0.001 |
| NUpE | 0.435 | -0.146 | 0.005 | 0.035 | -0.091 | 0.391 | 0.105 | 0.782 | -0.062 | 0.002 |
| NUtE | -0.082 | 0.635 | -0.020 | -0.155 | -0.079 | 0.584 | -0.462 | -0.069 | -0.009 | 0.000 |
| NUE | 0.433 | 0.167 | 0.023 | -0.024 | -0.124 | -0.276 | -0.170 | -0.032 | 0.402 | 0.708 |

SDW: Shoot dry weight (gm), RDW: Root dry weight (gm), TDW: Total dry weight (gm), R:S: Root- shoot ratio, MRL: Maximum root length (cm), N%: Nitrogen percentage in shoot (%), gN: Gram N in shoot (gm), NUpE: Nitrogen uptake efficiency, NUtE: Nitrogen utilization efficiency, NUE: Nitrogen use efficiency