**Tables**

**Table 1.** Sowing and harvest dates of maize and wheat in 2019-2021.

|  |  |  |
| --- | --- | --- |
| **Items** | **Sowing** | **Harvest** |
| Maize | June 15, 2019 | October 4, 2019 |
| Wheat | October 16, 2019 | June 5, 2020 |
| Maize | June 10, 2020 | October 3, 2020 |
| Wheat | October 15, 2020 | June 5, 2021 |

**Table 2.** Grain yield, yield-scaled NH3 and N2O emissions and NUE in the maize and wheat seasons in 2019-2021.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Yield**  **(t ha-1)** | **Yield-scaled NH3 emissions**  **(kg N t-1)** | **Yield-scaled N2O emissions**  **(kg N t-1)** | **NUE**  **(%)** |
| **2019 maize season** | | | |  |
| CK | 5.6±0.4a | - | - | - |
| CU | 9.7±0.2b | 3.8±0.4a | 0.06±0.00a | 47.4±5.6a |
| OU | 9.4±0.5b | 3.5±0.4a | 0.04±0.00b | 54.2±6.3a |
| UOM | 9.0±0.5b | 2.9±0.3b | 0.02±0.00c | 55.8±7.8a |
| ULOM | 9.1±0.5b | 1.2±0.0c | 0.02±0.00c | 56.2±4.2a |
| **2019-2020 wheat season** | | | |  |
| CK | 3.2±0.3a | - | - | - |
| CU | 5.4±0.4b | 5.4±0.5a | 0.07±0.03a | 29.4±5.1a |
| OU | 6.0±0.5bc | 3.8±0.3b | 0.05±0.02ab | 39.1±4.3a |
| UOM | 6.4±0.5cd | 2.4±0.3c | 0.02±0.00b | 52.1±10.7b |
| ULOM | 6.9±0.3d | 1.4±0.0d | 0.02±0.00b | 63.3±4.1b |
| **2020 maize season** | | | |  |
| CK | 6.7±0.5a | - | - | - |
| CU | 9.3±0.9b | 7.8±1.5a | 0.11±0.00a | 43.6±4.3a |
| OU | 9.0±9.0b | 6.2±0.2b | 0.08±0.01b | 53.5±6.3ab |
| UOM | 10.5±0.4c | 3.5±0.1c | 0.02±0.00c | 63.2±7.7bc |
| ULOM | 10.9±0.3c | 1.3±0.0d | 0.03±0.00c | 74.4±6.3c |
| **2020-2021 wheat season** | | | |  |
| CK | 4.9±0.9a | - | - | - |
| CU | 8.1±0.4bc | 3.3±0.7a | 0.11±0.03a | 29.2±2.7a |
| OU | 7.4±0.8b | 3.0±0.7a | 0.09±0.01a | 38.0±5.2a |
| UOM | 8.7±1.1bc | 1.6±0.3b | 0.02±0.02b | 53.6±7.6b |
| ULOM | 8.9±0.2c | 0.5±0.0c | 0.04±0.01b | 60.6±7.3b |

Notes: different letters in each item of each crop season indicate significant differences between treatments at the 0.05 level.

**Table 3.** N budgets (kg N ha-1) over the 2-year maize-wheat rotations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **CK** | **CU** | **OU** | **UOM** | **ULOM** |
| **2019 maize season** | | | | | |
| **Input** | 144 | 523 | 376 | 337 | 337 |
| Initial Nmin | 132 | 331 | 244 | 205 | 205 |
| Nfer | 0 | 180 | 120 | 120 | 120 |
| Nminer | 12 | 12 | 12 | 12 | 12 |
| **Output** | 105 | 190 | 170 | 172 | 172 |
| N uptake | 105 | 190 | 170 | 172 | 172 |
| **N surplus** | 39 | 333 | 206 | 165 | 165 |
| Residual Nmin | 39 | 166 | 129 | 95 | 104 |
| Apparent N losses | 0 | 167 | 77 | 70 | 61 |
| NH3 emissions | 0 | 37 | 33 | 26 | 11 |
| N2O emissions | 0.1 | 0.4 | 0.3 | 0.2 | 0.2 |
| Other N losses | 0 | 130 | 44 | 45 | 49 |
| **2019-2020 wheat season** | | | | | |
| **Input** | 162 | 560 | 433 | 399 | 408 |
| Initial Nmin | 39 | 166 | 129 | 95 | 104 |
| Nfer | 0 | 270 | 180 | 180 | 180 |
| Nminer | 124 | 124 | 124 | 124 | 124 |
| **Output** | 69 | 149 | 140 | 163 | 183 |
| N uptake | 69 | 149 | 140 | 163 | 183 |
| **N surplus** | 93 | 411 | 293 | 235 | 225 |
| Residual Nmin | 93 | 170 | 108 | 128 | 126 |
| Apparent N losses | 0 | 241 | 185 | 108 | 99 |
| NH3 emissions | 0 | 29 | 23 | 16 | 9 |
| N2O emissions | 0.2 | 0.6 | 0.5 | 0.4 | 0.4 |
| Other N losses | 0 | 212 | 162 | 92 | 89 |
| **2020 maize season** | | | | | |
| **Input** | 206 | 462 | 340 | 360 | 358 |
| Initial Nmin | 93 | 170 | 108 | 128 | 126 |
| Nfer | 0 | 180 | 120 | 120 | 120 |
| Nminer | 112 | 112 | 112 | 112 | 112 |
| **Output** | 144 | 223 | 208 | 220 | 233 |
| N uptake | 144 | 223 | 208 | 220 | 233 |
| **N surplus** | 61 | 240 | 132 | 140 | 125 |
| Residual Nmin | 61 | 79 | 61 | 60 | 61 |
| Apparent N losses | 0 | 161 | 71 | 80 | 63 |
| NH3 emissions | 0 | 72 | 56 | 37 | 14 |
| N2O emissions | 0.3 | 1.4 | 1.0 | 0.6 | 0.6 |
| Other N losses | 0 | 88 | 15 | 43 | 49 |
| **2020-2021 wheat season** | | | | | |
| **Input** | 162 | 450 | 342 | 341 | 342 |
| Initial Nmin | 61 | 79 | 61 | 60 | 61 |
| Nfer | 0 | 270 | 180 | 180 | 180 |
| Nminer | 101 | 101 | 101 | 101 | 101 |
| **Output** | 121 | 200 | 190 | 218 | 230 |
| N uptake | 121 | 200 | 190 | 218 | 230 |
| **N surplus** | 41 | 250 | 152 | 123 | 112 |
| Residual Nmin | 41 | 30 | 44 | 16 | 14 |
| Apparent N losses | 0 | 220 | 108 | 107 | 98 |
| NH3 emissions | 0 | 27 | 22 | 14 | 5 |
| N2O emissions | 0.4 | 1.3 | 1.0 | 0.6 | 0.7 |
| Other N losses | 0 | 192 | 85 | 93 | 92 |

Notes: Initial Nmin represents the initial soil NO3--N in 0-1 m soil; Nfer represents the N fertilizer application rate; Nminer represents the amount of N mineralization; Residual Nmin represents the residual accumulation of NO3--N in 0-1 m soil after harvest.

**Table 4.** Economic changes (%) of each treatment over the 2-year maize-wheat rotations, compared to the conventional N application.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **OU** | **UOM** | **ULOM** |
| **2019 maize season** | | | |
| Input cost | -14.7 | 7.8 | 8.6 |
| Yield profit | -7.6 | -12.9 | -12.0 |
| Net economic benefit | -5.3 | -22.7 | -21.8 |
| **2019-2020 wheat season** | | | |
| Input cost | -5.6 | 2.6 | 3.7 |
| Yield profit | 9.2 | 15.6 | 21.1 |
| Net economic benefit | 21.7 | 26.7 | 34.6 |
| **2020 maize season** | | | |
| Input cost | -14.7 | 7.8 | 8.6 |
| Yield profit | -3.6 | 10.9 | 13.9 |
| Net economic benefit | 0.1 | 12.1 | 15.9 |
| **2020-2021 wheat season** | | | |
| Input cost | -5.6 | 2.6 | 3.7 |
| Yield profit | -9.4 | 6.7 | 9.5 |
| Net economic benefit | -11.6 | 8.8 | 12.3 |