Data on root system architecture of water efficient maize as affected by different nitrogen fertilizer rates and plant density

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**ABSTRACT**

Root system architecture is a resource with untapped potential for agricultural improvements. The presented data describes the root system architecture of water efficient maize lines to different nitrogen fertilizer rates and plant density at two locations in North West Province of South Africa. The experiment was carried out during the 2015/16 and 2016/17 planting seasons. The root system architecture traits brace root angle, brace root number, brace root branch depth, crown root angle, crown root number, crown root branch depth and number of lateral roots were scored with the aid of shovelomics score board. ANOVA was used to analyze the data set and means separated with DMRT ($p \leq 0.05$). The regression analysis was used to determine the relationship among nitrogen fertilizer and root architecture system.

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Specifications table

| Subject | Agricultural and Biological Science: Agronomy and Crop Science |
|---------|---------------------------------------------------------------|
| Specific subject area | Plant physiology, plant biology, plant breeding, crop nutrition and soil fertility |
| Type of data | Table |
| How data were acquired | Root system architecture were assessed using shovelomics score board |
| Data format | Raw data |
| Parameters for data collection | Root system architecture was assessed at tasselling and physiological maturity stages using two uprooted plants from the base at 30 cm in each plot. The root system architecture traits brace root angle, brace root number, brace root branch depth, crown root angle, crown root number, crown root branch depth and number of lateral roots were scored with the aid of shovelomics score board. |
| Description of data collection | Root system architectures were assessed using a shovelomics score board |
| Data source location | The experiment was carried out at the Molelwane, North-West University (NWU) Research Farm (25° 48'S, 45° 38' E; 1012 m asl) and Taung Experimental Station (27° 30'S, 24° 30'E; 1111 m asl) of the Provincial Department of Agriculture Research Station during the 2015/2016 and 2016/2017 planting seasons. Both sites are located in the North West Province of South Africa. |
| Data accessibility | Raw data are attached as supplementary file. |

**Value of the data**

- The data showed the effect of different nitrogen fertilizer rates and plant density on root system architecture.
- The data revealed the effect of soil types of each location on root system architecture.
- The data indicated the effect of interaction of nitrogen fertilizer rates, plant densities and locations on root system architecture.
- The data can be used by plant physiologist, plant breeders, crop nutritionist and general agronomist.

**1. Data description**

The data describes the root system architecture of water efficient maize as affected by different nitrogen fertilizer rates and plant density in two locations of North West Province of South Africa. The experiment was carried out during 2015/16 and 2016/17 planting seasons. The meteorological data of experimental locations (Table 1). Tables 2–4 shows effect of each treatment factors (location, plant density and nitrogen fertilizer rates) on root system architectural trait.

**Table 1**
The meteorological data of experimental locations.

| Months | Molelwane Trial | Taung Trial |
|--------|-----------------|-------------|
|        | 2015/16 planting season | 2016/17 planting season | 2015/16 planting season | 2016/17 planting season |
|        | Temperature (°C) | Rainfall (mm) | Temperature (°C) | Rainfall (mm) | Temperature (°C) | Rainfall (mm) | Temperature (°C) | Rainfall (mm) |
| December | 27.70 | 31.20 | 25.10 | 117.20 | 28.6 | 9.00 | 27.10 | 145.6 |
| January | 26.30 | 62.80 | 23.10 | 147.80 | 27.6 | 85.00 | 23.80 | 241.60 |
| February | 27.10 | 18.60 | 22.30 | 282.80 | 27.6 | 15.20 | 23.60 | 155.40 |
| March | 23.60 | 79.40 | 21.60 | 21.00 | 24.1 | 37.60 | 22.60 | 13.00 |
| April | 21.00 | 37.80 | 19.10 | 77.60 | 20.4 | 61.80 | 18.30 | 42.60 |
| May | 15.90 | 17.20 | 15.60 | 0.00 | 15.7 | 22.60 | 15.20 | 0.60 |
| June | 13.60 | 10.40 | 14.30 | 0.00 | 13.3 | 0.00 | 12.40 | 0.00 |
| Total Mean | 22.17 | 36.77 | 20.16 | 92.34 | 22.47 | 33.03 | 20.42 | 85.54 |

Source: South African Weather Service (2018).
Table 2
Effect of treatment factors on brace root traits.

| Treatments | Tasseling stage | | | | Physiological maturity | | | |
|---|---|---|---|---|---|---|---|---|
| Location | B race angle (°) | Brace number (plants/ha) | Brace Depth (cm) | B race angle (°) | Brace number (plants/ha) | Brace Depth (cm) | | |
| Molelwane | 45.27b | 15.17b | 7.79b | 46.33b | 16.55b | 8.00b | | |
| Taung | 45.67a | 16.35a | 13.92a | 47.83a | 17.41a | 14.67a | | |
| LSD (p ≤ 0.05) | 0.29 | 0.23 | 0.49 | 0.93 | 0.16 | 0.08 | | |
| Plant density (plants/ha) | | | | | | | | |
| 33,333 | 46.16a | 15.94a | 10.19a | 47.36a | 16.43c | 11.33b | | |
| 44,444 | 44.06b | 15.86a | 10.94a | 47.33a | 17.39a | 11.44a | | |
| 55,555 | 46.17a | 8.00b | 10.64a | 46.54a | 17.13b | 11.25b | | |
| LSD (p ≤ 0.05) | 0.23 | 0.29 | 0.76 | 1.13 | 1.55 | 0.09 | | |
| N rates (kg/ha) | | | | | | | | |
| 0 | 43.42e | 15.83b | 10.83a | 46.87b | 16.33c | 11.35b | | |
| 60 | 46.31b | 15.42c | 10.21b | 48.69a | 16.71bc | 11.56a | | |
| 120 | 47.68a | 16.21a | 10.62a | 47.90a | 17.48a | 11.36b | | |
| 180 | 45.21c | 15.52bc | 10.62a | 46.44b | 16.94b | 11.38b | | |
| 240 | 44.71d | 15.81b | 10.73a | 45.48b | 16.94b | 11.04c | | |
| LSD (p ≤ 0.05) | 0.37 | 0.37 | 0.30 | 1.46 | 0.25 | 0.12 | | |

Notes: Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 according to Duncan’s multiple range test.

Table 3
Effect of main treatment factors on crown root traits.

| Treatment | Tasseling stage | | | | Physiological maturity | | | |
|---|---|---|---|---|---|---|---|---|
| Location | Crown angle (°) | Crown number (plants/ha) | Crown Depth (cm) | Crown angle (°) | Crown number (plants/ha) | Crown Depth (cm) | | |
| Molelwane | 61.72a | 20.05b | 12.21a | 63.21a | 20.96 | 12.08a | | |
| Taung | 56.93b | 23.57a | 12.21a | 58.44b | 20.57 | 12.08a | | |
| LSD (p ≤ 0.05) | 1.13 | 0.41 | 0.31 | 1.27 | 2.70 | 0.33 | | |
| Plant density (kg/ha) | | | | | | | | |
| 33,333 | 59.51a | 18.40b | 12.06a | 60.98a | 21.46a | 11.94b | | |
| 44,444 | 59.42a | 17.70c | 12.20a | 60.69a | 20.10b | 11.94b | | |
| 55,555 | 59.02a | 19.11a | 12.38a | 60.81a | 20.74a | 12.38a | | |
| LSD (p ≤ 0.05) | 1.38 | 0.50 | 0.38 | 1.55 | 0.31 | 0.41 | | |
| N rates (kg/ha) | | | | | | | | |
| 0 | 60.02a | 18.52a | 11.77b | 61.60a | 19.98b | 11.25b | | |
| 60 | 59.37a | 18.83a | 12.30a | 61.56a | 22.10a | 12.29a | | |
| 120 | 59.73a | 18.10b | 12.40a | 60.90a | 21.15b | 12.50a | | |
| 180 | 60.06a | 18.42a | 12.30a | 59.33b | 20.02b | 12.40a | | |
| 240 | 57.42b | 18.15b | 12.30a | 60.69a | 20.68b | 11.98ab | | |
| LSD (p ≤ 0.05) | 1.78 | 0.64 | 0.49 | 2.00 | 4.26 | 0.53 | | |

Notes: Notes: Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 to Duncan’s multiple range test.

The interaction effect of location, plant densities and nitrogen fertilizer rates on root system architectural trait is presented in Tables 5 and 6. Table 7 presents relationship between architectural root system traits and grain yield. Fig. 1a–e presents relationship between N rates and root system architectural trait.

2. Experimental design, materials, and methods

2.1. Description of study area

The experiment was carried out at the Molelwane, North-West University (NWU) Research Farm (25° 48¹S, 45° 38¹E.; 1012 m asl) and Taung Experimental Station (27° 30¹S, 24° 30¹E;
1111 m asl) of the Provincial Department of Agriculture Research Station during 2015/2016 and 2016/2017 planting seasons respectively. Both sites are located in the North West Province of South Africa. The experimental soils were Ferric Luvisol and Rhodic Ferralsol. The chemical properties of Ferric Luvisol are pH (4.41) total N (0.13%), available P (43 mg/kg) and K (241 mg/kg). However, the Rhodic Ferralsol had the following chemical properties, pH (5.38), total N (0.10%), available P (27 mg/kg) and K (207.5 mg/kg) across two planting seasons.

There were five N rates (0, 60, 120, 180 and 240 kg N/ha) and three plant densities (33,333, 44,444 and 55,555 plants/ha). The experiment was laid out in split plot and the treatments were arranged in randomized complete block design, replicated four times. The main plot effect was the three plant densities (33,333, 44,444 and 55,555 plants/ha) while the five N fertilizer rates (0.60, 120,180 and 240 kg N/ha) constituted the sub plot effect. Maize (WE 3127) seeds were sown at spacing of 1 m x 0.3 m, 0.75 m x 0.3 m and 0.9 m x 0.2 m to achieve the density of 33,333, 44,444 and 55,555, respectively. The fertilizer application treatment was carried out by applying a third of the each rate as basal treatment at planting using NPK 20:7:3 while two-third and a third of the remaining quantity from each rate was applied as top dressing at 3 and 5 weeks after sowing (WAS) using lime ammonium nitrate (LAN, 28%). Weeding was done manually at 3 and 7 weeks after sowing.

2.2. Assessment of root system architecture

Root system architecture was assessed at the tasseling and physiological maturity stages using two uprooted plants from the based at 30 cm in each plot. A manually designed shovelomics score board was used to score the root architecture as described by Trachsel et al. [2]. Root system architectural traits assessed include brace root, crown root and lateral root with focus on the number, branching angle and depth. Root depths were classified as shallow or deep/steeep. Root with 0–5 cm depth was classified as shallow while that within 5–10 cm depth was classified as deep/steeep as described by Trachsel et al. [2]. Classification of brace and crown angle was 10–50° as shallow and 50–90° as deep and steep while assessment of root number was by counting using the standard procedure described by Trachsel et al. [2]. Grain yield of WEMA maize was obtained as described by Adebayo [1].
Table 5
Interaction effect of treatment factors on brace root traits.

| N rates | Plant density | Tasseling stage | Physiology maturity stage |
|---------|---------------|-----------------|---------------------------|
|         |               | Brace root angle (°) | Brace root number | Brace root branch depth (cm) | Brace root angle (°) | Brace root Number | Brace root branch depth (cm) |
|         |               | Mole | Taun | Mole | Taun | Mole | Taun | Mole | Taun | Mole | Taun | Mole | Taun | Mole | Taun |
|**0**    |               | 46.38 | 43.38 | 14.88 | 16.38 | 10.00 | 10.00 | 43.62 | 48.12 | 17.13 | 16.25 | 11.25 | 10.63 |
|         |               | 40.62 | 46.75 | 14.38 | 15.38 | 10.00 | 11.25 | 46.12 | 48.25 | 15.88 | 18.63 | 11.25 | 11.25 |
|         |               | 38.25 | 45.13 | 16.75 | 17.25 | 10.62 | 11.88 | 43.75 | 51.38 | 15.13 | 18.00 | 11.25 | 11.25 |
|**60**   |               | 42.62 | 46.25 | 13.75 | 16.88 | 9.38 | 9.38 | 46.88 | 48.25 | 16.88 | 18.00 | 10.63 | 11.88 |
|         |               | 52.00 | 49.25 | 13.38 | 15.13 | 10.63 | 10.62 | 50.25 | 49.88 | 16.75 | 16.88 | 11.25 | 11.25 |
|         |               | 41.12 | 46.62 | 15.75 | 15.63 | 10.00 | 10.62 | 50.62 | 46.25 | 16.88 | 14.25 | 11.25 | 10.62 |
|**120**  |               | 50.37 | 41.75 | 15.50 | 16.75 | 8.75 | 11.88 | 47.50 | 46.75 | 16.88 | 19.00 | 11.88 | 10.63 |
|         |               | 47.12 | 47.75 | 15.50 | 15.13 | 10.00 | 11.25 | 44.88 | 50.87 | 17.63 | 17.88 | 11.25 | 11.25 |
|         |               | 45.62 | 41.75 | 15.88 | 18.50 | 10.63 | 11.25 | 46.13 | 51.25 | 16.50 | 17.00 | 12.50 | 10.63 |
|**180**  |               | 46.62 | 46.00 | 16.13 | 15.70 | 11.25 | 10.00 | 46.75 | 44.88 | 18.00 | 15.00 | 11.88 | 11.25 |
|         |               | 42.13 | 40.75 | 14.00 | 15.38 | 10.63 | 10.62 | 45.38 | 46.50 | 16.00 | 19.50 | 11.88 | 11.25 |
|         |               | 48.12 | 47.63 | 14.63 | 17.25 | 10.63 | 10.62 | 42.00 | 53.13 | 14.88 | 17.75 | 11.25 | 11.25 |
|**240**  |               | 45.62 | 45.62 | 15.50 | 16.13 | 10.00 | 10.00 | 49.50 | 43.12 | 16.38 | 17.25 | 11.88 | 10.00 |
|         |               | 49.38 | 46.00 | 17.25 | 17.25 | 11.88 | 10.00 | 46.75 | 44.37 | 15.88 | 16.38 | 11.25 | 10.63 |
|         |               | 43.00 | 43.38 | 14.25 | 14.50 | 11.25 | 11.25 | 44.75 | 44.38 | 17.50 | 16.38 | 11.25 | 11.25 |
|**LSD**(0.05) |       | 3.35 | 0.90 | 1.61 | 3.58 | 1.19 | 1.81 |

*Mole = Molelwane and Taun = Taung.*
Table 6
Treatment interaction effect on crown root traits.

| N rates | Plant density | Tasseling stage | Crown root angle (°) | Crown root Number | Crown root branch depth (cm) | Physiology maturity | Crown root angle (°) | Crown root Number | Crown root branch depth (cm) |
|---------|---------------|-----------------|----------------------|-------------------|----------------------------|---------------------|----------------------|-------------------|----------------------------|
|         |               |                 | Molelwane | Taung | Molelwane | Taung | Molelwane | Taung | Molelwane | Taung | Molelwane | Taung | Molelwane | Taung | Molelwane | Taung | Molelwane | Taung |
| 0       | 33.333        |                 | 64.75     | 55.62 | 19.25     | 19.75 | 12.50     | 12.50 | 64.87     | 58.25 | 20.63     | 19.25 | 11.88     | 12.50 |
| 60      | 33.333        |                 | 64.12     | 59.37 | 22.37     | 16.75 | 11.25     | 11.25 | 66.13     | 60.62 | 19.88     | 21.88 | 10.63     | 11.25 |
|         | 55,555        |                 | 61.25     | 57.12 | 17.25     | 18.50 | 11.88     | 11.88 | 66.87     | 55.25 | 25.25     | 22.13 | 12.50     | 11.88 |
| 120     | 33.333        |                 | 66.38     | 60.38 | 20.50     | 17.87 | 11.88     | 11.88 | 67.00     | 60.62 | 19.50     | 19.12 | 12.50     | 11.88 |
|         | 44,444        |                 | 60.50     | 57.00 | 23.62     | 14.87 | 12.50     | 12.50 | 63.62     | 56.00 | 22.75     | 40.75 | 12.50     | 11.88 |
| 180     | 33.333        |                 | 62.25     | 59.25 | 22.12     | 18.62 | 12.50     | 11.88 | 61.12     | 58.12 | 20.25     | 20.12 | 12.50     | 12.50 |
|         | 44,444        |                 | 62.00     | 57.37 | 20.50     | 15.50 | 12.50     | 12.50 | 60.37     | 63.25 | 14.75     | 26.88 | 12.50     | 12.50 |
| 240     | 33.333        |                 | 65.00     | 57.00 | 18.37     | 15.00 | 12.50     | 12.50 | 62.12     | 60.62 | 22.75     | 21.00 | 12.50     | 12.50 |
|         | 44,444        |                 | 60.50     | 55.00 | 18.25     | 15.25 | 11.88     | 12.50 | 62.87     | 59.12 | 17.63     | 26.88 | 12.50     | 11.88 |
| 240     | 33.333        |                 | 61.88     | 61.88 | 21.37     | 17.25 | 12.50     | 11.88 | 62.25     | 58.88 | 22.50     | 20.12 | 12.50     | 12.50 |
|         | 44,444        |                 | 59.50     | 55.00 | 18.25     | 15.25 | 11.88     | 12.50 | 62.87     | 59.12 | 17.63     | 26.88 | 12.50     | 11.88 |
| 240     | 55,555        |                 | 63.37     | 62.50 | 17.75     | 16.75 | 12.50     | 12.50 | 59.75     | 60.88 | 22.63     | 21.00 | 12.50     | 12.50 |
|         | 44,444        |                 | 63.62     | 55.00 | 20.25     | 16.62 | 12.50     | 12.50 | 64.75     | 56.50 | 23.38     | 22.63 | 11.88     | 11.88 |
| 240     | 55,555        |                 | 58.37     | 56.37 | 19.62     | 17.87 | 11.88     | 12.50 | 65.75     | 54.25 | 19.00     | 19.62 | 12.50     | 11.25 |
| LSD(0.05) | 1.63         |                 | 1.57      | 1.19  | 3.21      | 5.29  | 0.65      |      |            |      |            |      |            |      |
Fig. 1. a. Regression relationship between N fertilizer and brace root traits during tasseling stage. b. Regression relationship between N fertilizer and crown root traits during tasseling stage. c. Regression relationship between N fertilizer and brace root traits during physiological maturity stage. d. Regression relationship between N fertilizer and crown root traits during physiological maturity stage. e. Regression relationship between N fertilizer and numbers of lateral roots during tasseling and physiological maturity stages.

Table 7
Effect of location, plant density and nitrogen fertilizer rates on number of lateral root of WEMA at different growth stages.

| N rates | Plant density | Tasseling stage | Physiological maturity stage |
|---------|---------------|-----------------|------------------------------|
|         |               | Molelwane | Taung | Molelwane | Taung |
| 0       | 33,333        | 4.88     | 4.00  | 4.12      | 3.63  |
|         | 44,444        | 3.25     | 4.88  | 3.75      | 3.13  |
|         | 55,555        | 5.13     | 3.25  | 3.63      | 4.75  |
| 60      | 33,333        | 5.50     | 3.25  | 4.13      | 3.88  |
|         | 44,444        | 4.13     | 3.50  | 4.13      | 4.13  |
|         | 55,555        | 4.75     | 3.75  | 4.00      | 4.00  |
| 120     | 33,333        | 3.75     | 4.63  | 4.00      | 4.75  |
|         | 44,444        | 4.13     | 4.38  | 4.00      | 3.75  |
|         | 55,555        | 6.00     | 4.00  | 5.00      | 4.00  |
| 180     | 33,333        | 4.88     | 4.63  | 3.38      | 3.00  |
|         | 44,444        | 6.25     | 3.50  | 4.25      | 3.13  |
|         | 55,555        | 4.75     | 4.38  | 3.63      | 4.63  |
| 240     | 33,333        | 4.75     | 3.00  | 3.88      | 4.13  |
|         | 44,444        | 4.13     | 4.75  | 4.13      | 3.75  |
|         | 55,555        | 5.00     | 4.13  | 4.00      | 4.50  |
| LSD (0.05) |             | 0.47     |       | 0.43      |       |
Table 8
Relationship between root system architectural traits and grain yield.

| Root architecture parameters | Physiology maturity stage | Equation | R²  |
|------------------------------|--------------------------|----------|-----|
| Brace root angle             |                          | \( y = 0.0017x^2 - 0.0577x + 2.8048 \) | 0.65** |
| Brace root number            |                          | \( y = 0.0287x^2 - 1.0313x + 13.628 \) | 0.007ns |
| Brace root branch depth      |                          | \( y = 0.1003x^2 - 1.6616x + 8.9689 \) | 0.65** |
| Crown root angle             |                          | \( y = 0.0048x^2 - 0.4739x + 13.69 \) | 0.74** |
| Crown root number            |                          | \( y = -0.0018x^2 + 0.36x - 2.0552 \) | 0.62** |
| Crown root branch depth      |                          | \( y = 0.0854x^2 - 1.3006x + 6.9787 \) | 0.71** |
| Number of lateral root       |                          | \( y = -0.0515x^2 + 1.3576x + 0.1385 \) | 0.56* |

2.3. Statistical analysis

All data obtained were subjected to analysis of variance (ANOVA) using the GenStat 11th edition. Differences between the treatment means were separated using Duncan Multiple Range Test (DMRT) test at 5% level of probability. Regression was used to estimate relationship between N rates grain yield and root system architectural trait using Excel program.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi: 10.1016/j.dib.2020.105561.

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