Data in brief on inter-row rainwater harvest and fertilizer application on yield of maize and pigeon-pea cropping systems in sub humid tropics

Paul S. Saidia a, b, *, Folkard Asch c, Anthony A. Kimaro d, Jorn Germer c, Frederick C. Kahimba e, Frieder Graeff f, Johnson M.R. Semoka g, Cornel L. Rweyemamu b

Tanzania Agriculture Research Institute (TARI) Ukiriguru, Mwanza, Tanzania
Sokoine University of Agriculture, Department of Crop Science and Horticulture, Morogoro, Tanzania
University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics, Stuttgart, Germany
World Agroforestry Centre (ICRAF), Country Head Office, Dar Es Salaam, Tanzania
Sokoine University of Agriculture, Department of Engineering Sciences and Technology, Morogoro-Tanzania
ZALF, Institute of Land Use Systems, Müncheberg Germany
Sokoine University of Agriculture, Department of Soil and Geological Sciences, Morogoro, Tanzania

Data Article

Data in brief on inter-row rainwater harvest and fertilizer application on yield of maize and pigeon-pea cropping systems in sub humid tropics

Paul S. Saidia a, b, *, Folkard Asch c, Anthony A. Kimaro d, Jorn Germer c, Frederick C. Kahimba e, Frieder Graeff f, Johnson M.R. Semoka g, Cornel L. Rweyemamu b

Tanzania Agriculture Research Institute (TARI) Ukiriguru, Mwanza, Tanzania
Sokoine University of Agriculture, Department of Crop Science and Horticulture, Morogoro, Tanzania
University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics, Stuttgart, Germany
World Agroforestry Centre (ICRAF), Country Head Office, Dar Es Salaam, Tanzania
Sokoine University of Agriculture, Department of Engineering Sciences and Technology, Morogoro-Tanzania
ZALF, Institute of Land Use Systems, Müncheberg Germany
Sokoine University of Agriculture, Department of Soil and Geological Sciences, Morogoro, Tanzania

A R T I C L E  I N F O

Article history:
Received 25 July 2019
Received in revised form 10 August 2019
Accepted 22 August 2019
Available online 30 August 2019

A B S T R A C T

Soil moisture management and fertilizer micro-dosing on yield and land utilization efficiency of inter-cropping maize-pigeon-pea in sub humid Tanzania [1]. Farmers typically grow pigeon-pea as a mixed cropping system, the advances of these systems have been well studied, for example: increased productivity and rainfall infiltration. Much research has been done on cereal-pigeon pea intercropping on research stations, comparing yields in intercrops with sole maize. However, the role of inorganic fertilizers in sustainably intensifying intercropping systems has not been optimised in all cases. For example in a recent study “Sustainable Intensification with Cereal-Legume Intercropping in Eastern and Southern Africa” published in Sustainability 2019, 11, 2891; https://doi.org/10.3390/su1102891, also the effect of inorganic fertilizers were studied. But usually these studies did not pay attention on the relation with water supply.

DOI of original article: https://doi.org/10.1016/j.agwat.2019.105712.

* Corresponding author. Tanzania Agriculture Research Institute (TARI) Ukiriguru, Mwanza, Tanzania.
E-mail address: paul.saidia@tari.go.tz (P.S. Saidia).

https://doi.org/10.1016/j.dib.2019.104456
2352-3409/© 2019 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Data in this article presents rainfall variability in the season and between seasons, yield of maize (Zea mays cv. TMV1) and pigeon-pea (Cajanus cajan cv. Babati White) under sole crop and intercropping. Yield of maize and pigeon-pea is analyzed under interrow rainwater harvesting practices and fertilizer application in the field. Sole cropping and intercropping biological and/or economic yield are used to determine land use efficiency through land equivalent ratio. Comparisons between sites and seasons are done using a T-test.

© 2019 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Data

1.1. Rainfall data

Daily rainfall data set is provided for 2014/15 and 2015/16 cropping seasons. It shows the variation within and between the cropping seasons at two study sites in terms of rainfall pattern, frequency and distribution (Table 1 and Table 2). Rainfall is bimodal with short rains from November to January and...
long rains from late February or early March to May or June [1]. These variations within and between cropping seasons are influenced by climate changes [2].

Rainfall on set, pattern, frequency, and distribution vary from one cropping season to another. This affects cropping calendar and crop production of smallholder farming systems and are influenced by geographical characteristics [3].

1.2. Maize yield and pigeon-pea yield data

Data set for yields of maize and pigeon-pea indicates total yield and significance of differences among the treatments applied. Inter-row water harvesting practices and fertilizer application significantly affect yields under different cropping systems (Table 3). Ridges with fertilizer application have significant increase in maize yield than flat cultivation due to rainwater harvest, moisture conservation and water retention in soil profiles [1]. Fertilizers used supply nitrogen and phosphorus that promote growth and increase crop yield [3]. However, data for pigeon-pea shows that yield is not increased by fertilizer application especially nitrogen due to ability of fixing nitrogen biologically. Data indicates that inter-cropping maize cv. TMV1 and pigeon-pea cv. Babati white have higher substantial yield than sole cropping due to complementary effects and reduced inter-specific competition [4]. These crop cultivars have different growth habits that include days to maturity, canopy size and root systems which facilitate growth and increase yield under inter-cropping [1].

1.3. T-test comparing cropping seasons and sites on crop performance

Data in Table 4 shows the effect of cropping seasons and sites on yields of maize and pigeon-pea crops. There is significant effect of cropping years on crop yield, but also the site locations and conditions significantly influence crop performance [3].

2. Experimental design, materials and methods

2.1. Material

Maize cv. TMV1, medium maturing (110 days) and open pollinated [5], and pigeon-pea cv. Babati white, a long maturing variety that takes about nine months to mature [6] were used as test crops. Fertilizers used were di-ammonium phosphate DAP ((NH4)2HPO4), a granulated solid fertilizer (18% N and 46% P2O5), and urea (46% N) [3].

2.2. Experimental design and management

The field experiment was laid out in split-split plot design with five replications as described by Montgomery [7] at selected sites in Ilakala and Changarawe, Tanzania. The main plot comprised of three moisture management options: (1) tied ridges, (2) open ridges, and (3) flat cultivation. The sub-plot factor was composed of three cropping options: (1) maize sole crop, (2) pigeon-pea sole crop, and (3) 1:1 additive inter-cropping of maize with pigeon-pea as described by Natarajan [8]. The sub-sub plot factor comprised three crop specific fertilizer application rates: (1) control (0 kg P and 0 kg N/ha), (2) micro-dosing rate (10 kg P and 20 kg N/ha in maize; 10 kg P and 9 kg N/ha in pigeon-pea) and (3) recommended rates of 40 kg P/ha and 80 kg N/ha for maize [9] and 20 kg P/ha [10] and 18 kg N/ha for pigeon-pea.

Ridges were 75 cm apart with 20 cm height; with the distance between ties at 150 cm and 15 cm high. Seeds were sown in holes at a spacing of 75 cm × 30 cm for maize and 75 cm × 50 cm for pigeon-pea in both sole and inter-cropping. Fertilizers DAP and urea were placed in holes 5 cm away from plant hills to avoid direct seed contact.
2.3. Data collection

2.3.1. Rainfall data

Rainfall data was collected on daily basis using the standard rain-gauges installed at Ilakala and Changarawe study sites.

2.3.2. Maize yield data

Four rows in flat cultivation and four rows in open and tied ridges were harvested. About 12 to 13 maize plants were cut 5 cm above the ground from a 3 m² sampling area, cobs were dehusked and shelled. Grains collected were oven dried till 12.5% grain moisture content was achieved using a grain moisture meter [11]. Grain weight was measured by using the Advanced Electronic Balance ENDEL™ K-3000BH and converted into hectare basis (kg or t ha⁻¹) for both maize sole and intercropping plots.

2.3.3. Pigeon-pea yield data

Procedures for harvesting pigeon pea were based on ICRISAT [12], with 8–9 plants harvested from each plot in a 3 m² sampling area. Grains collected from pods were oven dried at 80 °C to 10% grain moisture content. Grain weight was measured by using the Advanced Electronic Balance ENDEL™ K-3000BH and converted into hectare basis (kg or t ha⁻¹) for both maize sole and intercropping plots.

### Table 1

| Days | Nov 14 | Dec 14 | Jan 15 | Feb 15 | Mar 15 | Apr 15 | Nov 15 | Dec 15 | Jan 16 | Feb 16 | Mar 16 | Apr 16 | May 16 | Jun 16 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1    | 0      | 0      | 0      | 0      | 0      | 2.1    | 0      | 1.4    | 1.4    | 0      | 2.8    | 0      | 0      |        |
| 2    | 0      | 0      | 0      | 0      | 0      | 6.5    | 5      | 0      | 11     | 0      | 18     | 2.8    | 0      |        |
| 3    | 0      | 0      | 0      | 0      | 0      | 0.5    | 0      | 2.1    | 0      | 0      | 20     | 2.8    | 0      |        |
| 4    | 3.4    | 0      | 0      | 0      | 0      | 3.2    | 0      | 0      | 0      | 0      | 27     | 0      | 0      |        |
| 5    | 2      | 0      | 0      | 0      | 0      | 3.1    | 0      | 4.8    | 0      | 8.24   | 20     | 2.8    | 0      |        |
| 6    | 6      | 0      | 0      | 0      | 0      | 4.6    | 1.1    | 0      | 0      | 0      | 0      | 33     | 0      |        |
| 7    | 0      | 0.6    | 0      | 0      | 0      | 0      | 0      | 10     | 0      | 0      | 4.2    | 0      | 0      |        |
| 8    | 0      | 0      | 0      | 0      | 0      | 2.2    | 0      | 0      | 10     | 1.4    | 10     | 5.2    | 0      |        |
| 9    | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 6.2    | 10     | 0      | 0      | 0      | 0      |        |
| 10   | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 4.2    | 0      | 2.8    | 6.27   | 0      | 0      |        |
| 11   | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 10     | 1.4    | 0      | 0      | 0      | 0      |        |
| 12   | 0.4    | 0      | 14     | 0      | 0      | 6.2    | 0      | 0      | 50     | 16     | 0      | 0      | 0      |        |
| 13   | 0.6    | 0.8    | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 14.16  | 0      | 0      |        |
| 14   | 0      | 0      | 2.4    | 0      | 0      | 0      | 0      | 10     | 0      | 14.8   | 0      | 4.16   | 0      |        |
| 15   | 0      | 0      | 4.8    | 18.6   | 0      | 0      | 0      | 8.3    | 0      | 0      | 0      | 4.16   | 0      |        |
| 16   | 0      | 0      | 0      | 0      | 1.2    | 0      | 0      | 1.7    | 0      | 0      | 7.3    | 0      | 0      |        |
| 17   | 0      | 0      | 0      | 8.8    | 2.7    | 1.8    | 0      | 1.3    | 14.18  | 0      | 0      | 0      | 0      |        |
| 18   | 0      | 0      | 0      | 6.4    | 6      | 2      | 1.5    | 1.4    | 6.8    | 0      | 0      | 4.2    | 0      |        |
| 19   | 0      | 0      | 3.6    | 7.6    | 6      | 0      | 0      | 0      | 4.2    | 0      | 0      | 0      | 4.2    |        |
| 20   | 0      | 0      | 13     | 1      | 10     | 0      | 0      | 2.8    | 0      | 0      | 17     | 0      | 5.2    |        |
| 21   | 0      | 0      | 48.8   | 0      | 20     | 0      | 0      | 50     | 0      | 0      | 0      | 45     | 0      |        |
| 22   | 0      | 0      | 3.2    | 0      | 40     | 4.7    | 0      | 9.3    | 2.6    | 0      | 0      | 6.24   | 0      |        |
| 23   | 0      | 0      | 0      | 0      | 18     | 3      | 0      | 4.2    | 42     | 0      | 14     | 34     | 0      |        |
| 24   | 0      | 2.2    | 4.8    | 0      | 2.8    | 11     | 0      | 0      | 15.7   | 0      | 0      | 24     | 0      |        |
| 25   | 0      | 0      | 0      | 0      | 2.8    | 2      | 0      | 1.4    | 4.2    | 0      | 18     | 35     | 0      |        |
| 26   | 0      | 0      | 0      | 1.4    | 5      | 2.8    | 0      | 0      | 0      | 0      | 0      | 0      | 0      |        |
| 27   | 0      | 2      | 0      | 0      | 11     | 6      | 5.1    | 0      | 0      | 0      | 0      | 0      | 0      |        |
| 28   | 0      | 0      | 0      | 4.8    | 2      | 0      | 0      | 0      | 13     | 0      | 0      | 2.8    | 0      |        |
| 29   | 10     | 1.3    | 0      | 0      | 24     | 11.8   | 0      | 0      | 0      | 0      | 0      | 0      | 0      |        |
| 30   | 0      | 0      | 0      | 12.2   | 39     | 0      | 16.1   | 0      | 36     | 3.2    | 0      | 0      | 0      |        |
| 31   | 0      | 0      | 0      | 0      | 0      | 4.2    | 0      | 0      |        |        |        |        |        |        |

NB: Months without rainfall are omitted from the Table.
2.4. Data analysis

2.4.1. Analysis of variance

Analysis of variance (ANOVA) for yield data was completed based on the statistical model for the three factors main effects and their interaction effects as follows:

\[ Y_{ijkm} = \mu + \beta_i + A_j + \delta_{ij} + B_k + AB_{jk} + \omega_{ijk} + C_m + AC_{jm} + BC_{km} + ABC_{jkm} + \epsilon_{ijkm} \]  

(1)

Where: \( Y_{ijkm} \) = Response level, \( \mu \) = general mean, \( \beta_i \) = block effect, \( A_j \) = main plot effect, \( \delta_{ij} \) = the main plot random error (Error a), \( B_k \) = sub-plot effect, \( AB_{jk} \) = interaction effect between the main plot and the sub-plot, \( \omega_{ijk} \) = subject error (Error b), \( C_m \) = sub-subplot effect, \( AC_{jm} \) = interaction effect between main plot and sub-subplot, \( BC_{km} \) = interaction effect between sub-plot and sub-subplot, \( ABC_{jkm} \) = the three way (Factors A* B* C), and \( \epsilon_{ijkm} \) = sub-sub-plot random error effect (Error c) was used to test the treatment effects on the indices calculated.

2.4.2. Mean separation test

Comparison of means for yield data was accomplished using Tukey’s test at \( p \leq 0.05 \) as described by Montgomery [7].

2.4.3. T-test

Effects of two study sites and two cropping seasons were compared using T-test [7].
### Table 3
Effect of rainwater harvest and fertilizer use on yield (kg/ha) of maize and pigeon-pea cropping systems.

| S/N | Code | Treatment        | Ilakala 2015 | Ilakala 2016 | Changarawe 2015 | Changarawe 2016 |
|-----|------|------------------|--------------|--------------|-----------------|-----------------|
| 1   | 111  | TR x SM x NF     | 973 cde      | 2577 fg      | 1006 abcd       | 1284 abc        |
| 2   | 112  | TR x SM x MF     | 2420 kl      | 3760 hj      | 2293 ijk        | 2870 fghi       |
| 3   | 113  | TR x SM x RF     | 2620 lm      | 3776 hj      | 3040 mn         | 3078 ghij       |
| 4   | 121  | TR x SP x NF     | 468 a        | 1040 abcd    | 890 ab          | 1012 ab         |
| 5   | 122  | TR x SP x MF     | 766 abcd     | 1518 bcd     | 790 a           | 988 ab          |
| 6   | 123  | TR x SP x RF     | 646 abcd     | 1037 abcd    | 823 a           | 854 a           |
| 7   | 131  | TR x MPI x NF    | 1272 efg     | 2991 gh      | 1853 ghi        | 1824 cde        |
| 8   | 132  | TR x MPI x MF    | 2183 ikj     | 4098 j       | 2711 klm        | 2747 fgh        |
| 9   | 133  | TR x MPI x RF    | 2668 lm      | 3919 ij      | 2708 jklm       | 3501 i          |
| 10  | 211  | OR x SM x NF     | 992 de       | 1888 def     | 1080 abcddef    | 1228 abc        |
| 11  | 212  | OR x SM x MF     | 2178 ikj     | 3457 hij     | 2185 hijk       | 2523 efg        |
| 12  | 213  | OR x SM x RF     | 2613 lm      | 3643 hj      | 2880 lmn        | 2849 fghi       |
| 13  | 221  | OR x SP x NF     | 784 abcd     | 985 abc      | 1017 abcddef    | 776 a           |
| 14  | 222  | OR x SP x MF     | 885 bcd      | 430 a        | 854 a           | 1045 ab         |
| 15  | 223  | OR x SP x RF     | 709 abcd     | 859 ab       | 1521 bcdefg     | 884 a           |
| 16  | 231  | OR x MPI x NF    | 1379 fg      | 2594 fg      | 1537 cdefg      | 1640 bcd        |
| 17  | 232  | OR x MPI x MF    | 2577 lm      | 3700 hj      | 1813 ghij       | 3297 hij        |
| 18  | 233  | OR x MPI x RF    | 2827 m       | 4011 ij      | 3389 n          | 3717 j          |
| 19  | 311  | Fl x SM x NF     | 1020 def     | 1720 cde     | 913 abc         | 1230 abc        |
| 20  | 312  | Fl x SM x MF     | 1841 hi      | 3236 ghi     | 2068 ghij       | 2166 def        |
| 21  | 313  | Fl x SM x RF     | 2313 jkl     | 3539 hj      | 2711 klm        | 2755 fgh        |
| 22  | 321  | Fl x SP x NF     | 828 abcd     | 1196 abcd    | 823 a           | 1290 abc        |
| 23  | 322  | Fl x SP x MF     | 970 ab       | 793 ab       | 1011 abcd       | 1352 abc        |
| 24  | 323  | Fl x SP x RF     | 609 abc      | 1169 abcd    | 1640 dfgf       | 1077 ab         |
| 25  | 331  | Fl x MPI x NF    | 1548 gh      | 2552 efg     | 2277 jkl        | 2276 def        |
| 26  | 332  | Fl x MPI x MF    | 2008 ij      | 3980 ij      | 4649 o          | 3307 hij        |
| 27  | 333  | Fl x MPI x RF    | 2678 lm      | 4117 j       | 4302 o          | 3573 ij         |

CV (%) 8.20 13.60 12.50 13.60
SEM (±) 65.90 150.10 113.10 130.50
P Value (RWH) 0.012 0.005 0.001 0.216
P Value (CS) 0.001 0.001 0.001 0.001
P Value (FU) 0.001 0.001 0.001 0.001
P (RWH x CS) 0.008 0.044 0.001 0.003
P (RWH x FU) 0.001 0.026 0.001 0.042
P (CS x FU) 0.001 0.001 0.001 0.001
P (RWH x CS x FU) 0.031 0.084 0.001 0.088

Key: TR = Tied Ridge, OR = Open Ridge, Fl = Flat cultivation; SM = Sole Maize, SP = Sole Pigeon-pea, MPI = Maize and Pigeon-pea Intercropping system; NF = No Fertilizer, MF = Micro-dose Fertilizer, RF = Recommended Fertilizer application; CV = Coefficient of Variation, SEM = Standard Error of Means, P = Probability Value.

Means followed by same letter(s) are not significantly different according to Tukey's test at p ≤ 0.05.

### Table 4
T-test to compare the effect of sites and seasons on yield of maize and pigeon-pea crops.

| Location/Site | Changarawe 2015 | Changarawe 2016 | Ilakala 2015 | Ilakala 2016 |
|--------------|-----------------|-----------------|--------------|--------------|
| Season/Year  | 2015            | 2016            | 2015         | 2016         |
| Maize yield (t/ha) | 1.81 NS         | 2.03 NS         | 1.80 ***     | 2.74 ***     |
| Pigeon-pea yield (t/ha) | 1.12 NS         | 1.03 NS         | 0.53 ***     | 1.07 ***     |

Key: t = tonnes, ha = hectare, NS = Not Significant, *** Significant at p ≤ 0.001.

### Acknowledgements

Special thanks to the Germany Federal Ministry of Education and Research (BMBF) and the Germany Federal Ministry for Economic Cooperation and Development (BMZ) for sponsoring this...
The support of researchers at the Tanzania Agriculture Research Institute (TARI) is appreciated.

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.

References

[1] P.S. Saidia, F. Asch, A.A. Kimaro, J. Germer, F.C. Kahimba, F. Graef, J.M.R. Semoka, C.L. Rweyemamu, Soil moisture management and fertilizer micro-dosing on yield and land utilization efficiency of inter-cropping maize-pigeon pea in sub humid Tanzania, Agric. Water Manag. 223 (2019) (2019) 105712. https://doi.org/10.1016/j.agwat.2019.105712.

[2] A.L. Kijazi, L.B. Chang'a, E.T. Liwenga, A. Kanemba, S.J. Nindi, The use of indigenous knowledge in weather and climate prediction in Mahenge and Isumani Wards, Tanzania, in: Proceedings of the First Climate Change Impacts, Mitigation and Adaptation Programme Scientific Conference, CCIAM) Programme, 2012, pp. 42–48. Dar es salaam: The Climate Change Impacts, Adaptation and Mitigation.

[3] P.S. Saidia, C.L. Rweyemamu, F. Asch, J.M.R. Semoka, A.A. Kimaro, J. Germer, F. Graef, P. Lagweni, F. Kahimba, E. Chilagane, Effects of nitrogen and phosphorus micro-doses on maize growth and yield in a sub-humid tropical climate, Ann. Biol. Res. 9 (2) (2018) 20–35.

[4] A.A. Kimaro, V.R. Timmer, S.A.O. Chamshama, Y.N. Ngaga, D.A. Kimaro, Competition between maize and pigeon-pea in semi-arid Tanzania: effect on yields and nutrition of crops, Agric. Ecosyst. Environ. 134 (2009) 115–125.

[5] S. Lyimo, Z. Mduruma, H. De Groote, The use of improved maize varieties in Tanzania, Afr. J. Agric. Res. 9 (7) (2014) 643–657.

[6] K.B. Saxena, K. Ravishankar, R. Vijaya Kumar, K.P. Sreejith, R.K. Srivastava, Vegetable Pigeonpea — a High Protein Food for All Ages. Information Bulletin No. 83. Patancheru 502 324, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Andhra Pradesh, India, 2010, p. 124.

[7] D.C. Montgomery, Design and Analysis of Experiments, eighth ed. ed., John Wiley and Sons, Inc., New York, USA, 2013, p. 757.

[8] M. Natarajan, Spatial arrangement of the component crops in developing inter-cropping systems: some concepts and methodologies, in: Research Methods for Cereal/Legume Inter-cropping: Proceedings of a Workshop on Research Methods for Cereal/Legume Inter-cropping in Eastern and Southern Africa. Mexico, D. F.: CIMMYT, 1990, pp. 68–73.

[9] A.E.T. Marandu, J.D.J. Mbongoni, G.J. Ley, Revised Fertilizer Recommendations for Maize and Rice in the Eastern, Southern Highlands and Lake Zones of Tanzania, Department of Research and Development, Dar es salaam, Tanzania, 2014, p. 40. Ministry of Agriculture, Food Security and Cooperatives.

[10] J.V.D.K. Kuma Rao, C. Johansen, M. Usha Kiran, Nitrogen requirements at different growth stages of short-duration pigeonpea (Cajanus cajan L. Millsp.), J. Agron. Crop Sci. 175 (1995) 15–28.

[11] CIMMYT, Yield and Yield Components: A Practical Guide for Comparing Crop Management Practices, International Maize and Wheat Improvement Center, Mexico, 2013, p. 28.

[12] ICRISAT, Pigeonpea Botany and Production Practices: Skill Development Series no.9, Human Resource Development Program of the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, 1992, p. 41, 502 324, India.