*Original Research Article*

# Impact of Potassium Fertilization on the Growth and Yield of Small Millets


## ABSTRACT

**Aims:** To evaluate the effects of varying potassium application levels on small millet growth and yield, assess the impact of potassium management on growth parameters and yield attributes, and analyze the economic viability of potassium application in small millet farming.
**Study design:** Split plot design with three ~~replication~~replications.
**Place and Duration of Study:** Field experiments were conducted during *kharif* 2020 and *kharif* 2021 at the Centre of Excellence in Millets, Athiyandal Thiruvannamalai.
**Methodology:** In the main plot four crops were sown *viz*., $C_1$- Proso millet, $C_2$ - Barnyard millet, $C_3$ - Kodo millet, and $C_4$ -Browntop millet. In ~~sub~~ the plot, four doses of potassium fertilizer were applied ~~like~~ $K_1$ - 0, $K_2$ -10, $K_3$ - 20, and $K_4$ - 30 kgs /ha. From each experimental plot, 5 plants were randomly tagged for recording observations on growth *viz*., plant height (cm), number of tillers/plant; yield attributes *viz*., number of panicles /plant, 1000 grain weight (g), biomass production/ plant (g) and grain yield (kg/ha). Economics was calculated as per the standard methods formulated by CIMMYT (1988). Growth and yield parameters were observed during different stages of the crops. The statistical analysis of the data was done by the analysis of variance (ANOVA) method.
**Results:** The results indicated that~~,~~ Proso millet ($C_1$) showed a plant height increase from 75.85 to 94.37 cm, several~~number of~~ productive tillers (4.73) with high potassium doses, while Barnyard millet ($C_2$) reached a maximum height of 119.13 cm, grain yield significantly increased from 1547 kg/ha without potassium to 2055 kg/ha with the highest potassium dose. Barnyard millet ($C_2$) ~~achieving~~ achieved the highest gross return of Rs 61650/ha and a B: C ratio of 2.20 with the highest potassium dose.
**Conclusion:** ~~Application~~ The application of potassium 20 kg/ha, along with the recommended dose of nitrogen and phosphorus, recorded a 31.8% higher yield, greater tolerance to lodging, reduced pest and disease incidence, and remunerative economics in millet cultivation.



*Keywords: Small millet; Potassium; Economics; Net return; Benefit Cost Ratio*


## 1. INTRODUCTION

Small millets are vital crops in rainfed semi-arid regions, but their cultivation remains limited compared to other millets, largely due to a shift towards cash crops from traditional varieties [1]. Some small millets, especially wild types, are even considered weeds. Nonetheless, these crops are important locally, flourishing on marginal lands and providing consistent yields, which contributes significantly to food security. Despite their benefits, small millets face several challenges that impede their broader cultivation and adoption [2,3].

A major issue is the inadequate management of nutrients, particularly potassium deficiency in dryland conditions [4]. Potassium is a crucial macronutrient involved in essential physiological processes such as photosynthesis, osmoregulation, and enzyme activation [5,6]. Unfortunately, potassium application is often neglected in rainfed areas, leading to soil depletion and decreased crop yields over time. This nutrient's importance has frequently been underestimated in many regions, including India, resulting in soil potassium depletion and declining crop productivity [7].

Although the role of potassium in crop nutrition is well-recognized, there is limited research on its specific impact on small millet cultivation, especially in rainfed semi-arid areas. Addressing this research gap is essential for developing sustainable agronomic practices that improve small millet productivity and resilience to environmental stresses. This study aims to evaluate the effects of varying potassium application levels on small millet growth and yield, assess the impact of potassium management on growth parameters and yield attributes, and analyze the economic viability of potassium application in small millet farming.

## 2. MATERIAL AND METHODS

Field experiments were conducted during *kharif* 2020 and ~~-~~*kharif* 2021 at the Centre of Excellence in Millets, Athiyandal Thiruvannamalai. During the cropping period monthly mean maximum and minimum temperature ranged between 34.4 and 24.9°C, The treatments were laid out in a split plot design with three ~~replication~~replications. In the main plot four crops were sown *viz*., $C_1$- Proso millet, $C_2$ - Barnyard millet, $C_3$ - Kodo millet, and $C_4$ -Browntop millet. In ~~sub~~ the plot four doses of potassium fertilizer were applied ~~like~~ $K_1$ - 0, $K_2$ -10, $K_3$ - 20, and $K_4$ - 30 kgs /ha. After sowing where seeds failed to germinate, gap filling was done 10 days after sowing. When more than one seedling was present in a hill, ~~which it were~~ was thinned out to maintain one seedling for proper spacing at 20 days after sowing. From each experimental plot, 5 plants were randomly tagged for recording observations on growth *viz*., plant height (cm), number of ~~tillers/plant~~tillers/plants; yield attributes *viz*., number of panicles /plant, 1000 grain weight (g), biomass production/ plant (g) and grain yield (kg/ha) Economics was calculated as per the standard methods formulated by [8]. ~~For each~~Each treatment budget was calculated to determine the expenses incurred and net returns based on the present prices of inputs prevailing in the market during the 2020 and 2021 ~~of~~ cropping ~~season~~ seasons to calculate the benefit-cost ratio (BCR). Growth and yield parameters were observed during different stages of the crops. The statistical analysis of the data was done by the analysis of variance (ANOVA) method for ~~split plot~~split-plot design.

## 3. RESULTS AND DISCUSSION

From the pooled data, various potassium management practices had a significant effect on the growth and yield parameters (Table 1 & 2).

### Effect of potassium on the growth of small millets

The impact of different potassium doses on small millets was assessed across various growth and yield parameters. For growth parameters, plant height and the number of productive tillers were measured. The results indicated that increasing potassium doses generally enhanced plant height and tiller numbers across different millet types. Specifically, Proso millet ($C_1$) showed a plant height increase from 75.85 cm to 94.37 cm with potassium doses, while Barnyard millet ($C_2$) reached a maximum height of 119.13 cm. The number of productive tillers also improved with potassium application, with the highest count of 4.73 tillers observed in Proso millet with the highest potassium dose.

**Table 1. Role of potassium in the growth of various small millets**

| Treatments | Plant height (cm) | | | | | No. of productive tillers | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean |
| $K_0$ | 73.0 | 109.7 | 66.6 | 58.9 | 77.1 | 3.2 | 4.2 | 6.1 | 9.4 | 5.7 |
| $K_1$ | 81.9 | 113.4 | 67.3 | 64.4 | 81.8 | 3.6 | 4.9 | 6.1 | 13.8 | 7.1 |
| $K_2$ | 96.6 | 125.7 | 68.9 | 71.5 | 90.7 | 4.7 | 4.4 | 6.3 | 15.6 | 7.7 |

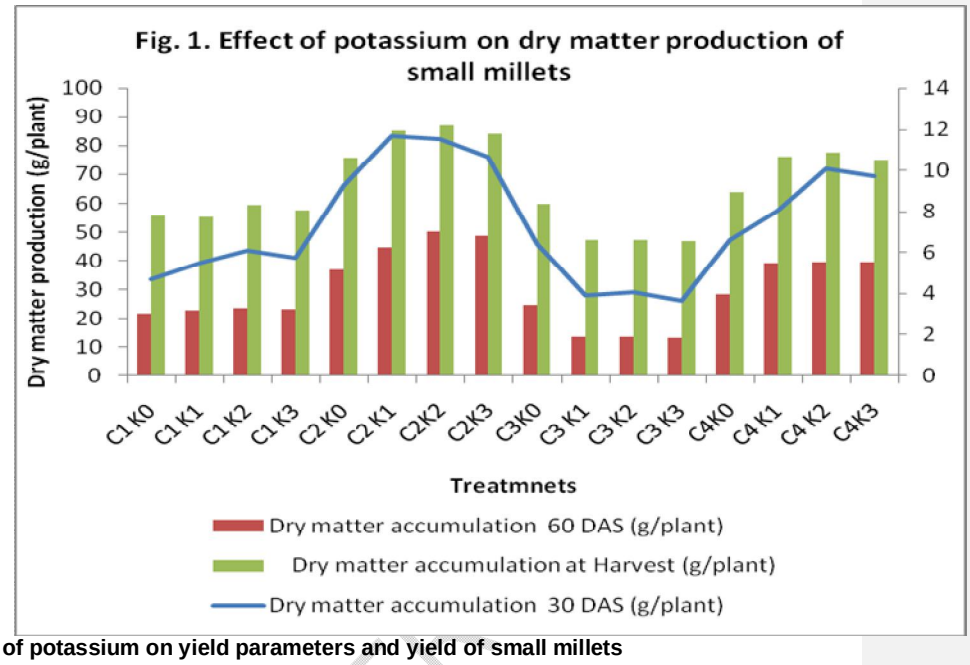
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $K_3$ | 88.0 | 118.3 | 67.2 | 69.1 | 85.6 | 4.0 | 4.0 | 6.5 | 14.1 | 7.2 |
| Mean | 84.9 | 116.8 | 67.5 | 66.0 | | 3.9 | 4.4 | 6.3 | 13.3 | |
| | | C | K | C x K | K x C | | C | K | C x K | K x C |
| S.E.d. | | 1.58 | 1.52 | 3.07 | 3.04 | | 0.28 | 0.35 | 0.66 | 0.69 |
| CD (p=0.05) | | 3.86 | 3.14 | 6.65 | 6.28 | | 0.67 | 0.71 | 1.41 | 1.43 |

**Table 2. Role of potassium in yield parameters and yield of various small millets**

| Treatments | 1000 seed weight (g) | | | | | Grain yield (t/ha) | | | | | Straw yield (kg/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean |
| $K_0$ | 4.42 | 5.36 | 3.21 | 2.98 | 3.99 | 0.99 | 1.63 | 1.83 | 2.27 | 1.68 | 1.39 | 2.50 | 2.74 | 3.42 | 2.51 |
| $K_1$ | 4.64 | 5.38 | 4.09 | 3.57 | 4.42 | 1.06 | 1.80 | 2.06 | 2.54 | 1.87 | 1.54 | 2.74 | 3.07 | 3.76 | 2.78 |
| $K_2$ | 4.72 | 7.27 | 4.56 | 3.67 | 5.05 | 1.41 | 2.11 | 2.26 | 2.81 | 2.15 | 2.09 | 3.18 | 3.44 | 4.21 | 3.23 |
| $K_3$ | 4.80 | 6.47 | 4.33 | 3.51 | 4.78 | 1.19 | 1.92 | 2.16 | 2.65 | 1.98 | 1.81 | 2.95 | 3.31 | 4.03 | 3.03 |
| Mean | 4.64 | 6.12 | 4.05 | 3.43 | | 1.16 | 1.86 | 2.08 | 2.57 | | 1.71 | 2.85 | 3.13 | 3.86 | |
| | | C | K | C x K | K x C | | C | K | C x K | K x C | | C | K | C x K | K x C |
| S.E.d. | | 0.06 | 0.06 | 0.13 | 0.13 | | 0.04 | 0.04 | 0.07 | 0.07 | | 0.05 | 0.05 | 0.09 | 0.09 |
| CD (p=0.05) | | 0.15 | 0.13 | 0.28 | 0.27 | | 0.09 | 0.08 | 0.16 | 0.15 | | 0.11 | 0.09 | 0.19 | 0.19 |

**Role of potassium on dry matter production of small millets**

Regarding dry matter production (Fig.1), potassium application significantly boosted dry matter accumulation at 30 days after sowing (DAS), 60 DAS, and harvest. For instance, Barnyard millet ($C_2$) achieved the highest dry matter accumulation at harvest, increasing from 75.43 g/plant without potassium to 86.87 g/plant with 20 kg/ha of potassium. Similarly, Browntop millet ($C_4$) also showed considerable increases in dry matter across the growth stages with potassium application.




**Effect of potassium on yield parameters and yield of small millets**

In terms of yield parameters, potassium application had a notable effect on seed weight, grain yield, straw yield, and harvest index (Table 3). For example, the grain yield of Barnyard millet ($C_2$) increased significantly from 1547 kg/ha without potassium to 2055 kg/ha with the highest potassium dose. The harvest index also improved with potassium application, reaching a maximum of 43.43% for Proso millet ($C_1$) with 30 kg/ha of potassium. The economic analysis showed a positive impact on gross returns and the benefit-cost ratio, with Barnyard millet ($C_2$) achieving the highest gross return of Rs 61650/ha and a B: C ratio of 2.20 with the highest potassium dose.

Potassium application improved both the growth and yield parameters of small millets, enhancing their productivity and economic viability [9].

**Table 3. Role of potassium in harvest index and B: C ratio of various small millets**

| Treatments | Harvest index | | | | | B: C ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Mean |
| $K_0$ | 41.37 | 39.40 | 40.00 | 39.87 | 40.16 | 1.08 | 1.79 | 2.01 | 2.49 | 1.84 |
| $K_1$ | 40.83 | 39.63 | 40.07 | 40.37 | 40.23 | 1.16 | 1.96 | 2.24 | 2.77 | 2.03 |
| $K_2$ | 40.30 | 39.83 | 39.63 | 40.00 | 39.94 | 1.52 | 2.27 | 2.44 | 3.03 | 2.32 |
| $K_3$ | 39.70 | 39.37 | 39.43 | 39.63 | 39.53 | 1.27 | 2.05 | 2.31 | 2.83 | 2.12 |
| Mean | 40.55 | 39.56 | 39.78 | 39.97 | | 1.26 | 2.02 | 2.25 | 2.78 | |
| | | C | K | C x K | K x C | | | | | |
| S.E.d. | | 0.22 | 0.25 | 0.49 | 0.50 | | | | | |
| CD (p=0.05) | | 0.53 | 0.52 | 1.04 | 1.04 | | | | | |

The candidate manuscript does not have a robust scientific discussion, I suggest the authors incorporate the suggested paragraphs, in this way, it would improve the scientific quality of the manuscript:

This study holds significant scientific and contemporary relevance as it addresses the crucial role of potassium fertilization in enhancing the growth and yield of small millets, a group of cereal crops vital for food security and nutrition in marginal and resource-poor regions [10,11, 12]. By systematically evaluating the effects of varying potassium levels on multiple millet species, the research provides robust data on optimal fertilization practices that can lead to substantial yield improvements [13, 14]. This is particularly important in the context of increasing agricultural productivity sustainably, as small millets are resilient crops that can thrive in diverse and often challenging agro-environmental conditions [15, 16, 17]. The findings, which show a marked increase in yield and economic returns with appropriate potassium management, underscore the potential for improving millet production, which is essential for addressing food security in regions where these crops are a staple [18, 19, 20].

The importance of these findings becomes even more apparent when compared with similar studies in tropical regions of Latin America, where potassium fertilization has been investigated for various crops, including maize, rice, and beans [21,22, 23]. In these studies, potassium has been shown to enhance crop resilience, improve grain quality, and increase yields, particularly in soils that are deficient in this nutrient. [24, 25, 26] However, while much of the research in Latin America has focused on major staple crops, the current study's emphasis on small millets fills a critical gap, given that millets are often overlooked despite their importance in ensuring food security and nutritional diversity in tropical and subtropical regions [27, 28, 29]. The study's methodology, including the use of a split-plot design and comprehensive economic analysis, provides a detailed understanding of how potassium impacts both growth parameters and economic viability, which is crucial for smallholder farmers who rely on these crops for their livelihoods [30, 31].

In comparison to other studies in tropical Latin American regions, the findings of this research are particularly valuable for informing agricultural practices that optimize productivity under varying agro-environmental conditions [32, 33]. The significant yield increase, reduced pest incidence, and improved economic outcomes observed in this study demonstrate the broader applicability of potassium fertilization strategies across different regions where small millets are grown [34]. Furthermore, the study's conclusion that a 20 kg/ha potassium application is optimal aligns with findings from other tropical research, where balanced nutrient management has been shown to enhance crop performance and sustainability. By providing a clear, economically viable strategy for improving millet production, this study contributes to a global effort to enhance food security, particularly in regions vulnerable to climate change and soil degradation [35, 36].

## 4. CONCLUSION

From the above results, it could be concluded that the application of 20 kgs of potassium per hectare, along with the recommended dose of nitrogen and phosphorus, recorded higher yield and remunerative economics in millets. Yield increased by up to 31.8%, showing significant improvement and greater tolerance to lodging. Additionally, this treatment reduced pest and disease incidence compared to the control. The data indicates that higher potassium levels not only enhance potassium uptake but also contribute to overall plant health and productivity, leading to better economic outcomes for millet cultivation.

## REFERENCES


1. Malathi, B, Appaji Chari, Rajender, G, Dattatri, K, and Sudhakar, N. Growth pattern of millets in India. Indian Journal of Agricultural Research. 2016; 50(4):382-386. doi: 10.18805/ijare.v50i4.11257.
2. Malleshi, N, and Dayakarrao, B. Creating demand of millets through value addition. In Tonapi VA, Patil JV (eds) Millets ensuring climate resilience and nutritional security. Daya Publishing House, New Delhi. 2015; 551-574.
3. Kumar, A, Tomer, V, Kaur, A, Kumar, V, and Gupta, K. Millets: A solution to agrarian and nutritional challenges. Agriculture and Food Security. 2018;7(31):13989547. https://doi.org/10.1186/s40066-018-0183-3
4. Jyoti Rawat, Pankaj Sanwal, and Jyoti Saxena. Potassium and Its Role in Sustainable Agriculture. In V.S. Meena et al. (eds.). Potassium Solubilizing Microorganisms for Sustainable Agriculture. Springer, India 2016;231-253. doi:10.1007/978-81-322-2776-2_17.
5. Hawkesford, M, Horst, W, Kichey, T, Lambers, H, Schjoerring, J, Møller, IS and White, P. Functions of Macronutrients. In P. Marschner (Ed.), *Marschner's Mineral Nutrition of Higher Plants* (3rd ed., pp. 135-189). Pergamon. 2012. https://doi.org/10.1016/B978-0-12-384905-2.00006-6
6. Rawat, J, Pandey, N, Saxena, J. Role of Potassium in Plant Photosynthesis, Transport, Growth and Yield. In: Iqbal, N., Umar, S. (eds) Role of Potassium in Abiotic Stress. Springer, Singapore. 2022; https://doi.org/10.1007/978-981-16-4461-0 1.
7. Brar, MS, Bijay-Singh, SK. Bansal and Ch. Srinivasarao. Role of Potassium Nutrition in Nitrogen Use Efficiency in Cereals. 2022; e-ifc No. 29 - Research Findings
8. CIMMYT. An Economic Training Handbook. Economic Programme, CIMMYT, Mexico. 1988
9. Reddy, ES and Shikha Singh. Effect of spacing and potassium levels on growth and yield of finger millet (*Eleusine coracana* L.), Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 2021;23(2):158-162.
10. Bertorelli, M., B.O. Olivares. Population fluctuation of Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) in sorghum cultivation in Southern Anzoategui, Venezuela. Journal of Agriculture University of Puerto Rico., 2020. 104(1):1-16. https://doi.org/10.46429/jaupr.v104i1.18283
11. Olivares, B., Pitti, J., Montenegro, E. Socioeconomic characterization of Bocas del Toro in Panama: an application of multivariate techniques. Revista Brasileira de Gestao e Desenvolvimento Regional, 2020. 16(3):59-71. https://doi.org/10.54399/rbgdr.v16i3.5871
12. Olivares, B., Araya-Alman, M., Acevedo-Opazo, C. et al. Relationship Between Soil Properties and Banana Productivity in the Two Main Cultivation Areas in Venezuela. J Soil Sci Plant Nutr. 2020. 20 (3): 2512-2524. https://doi.org/10.1007/s42729-020-00317-8
13. Olivares, B.; Hernandez, R.; Arias, A; Molina, JC., Pereira, Y. Eco-territorial adaptability of tomato crops for sustainable agricultural production in Carabobo, Venezuela. Idesia, 2020. 38(2):95-102. http://dx.doi.org/10.4067/S0718-34292020000200095
14. Olivares, B., Hernández, R. Ecoterritorial sectorization for the sustainable agricultural production of potato (Solanum tuberosum L.) in Carabobo, Venezuela. Agricultural Science and Technology. 2019. 20(2): 339-354. https://doi.org/10.21930/rcta.vol20_num2_art:1462


**Formatted:** Font: (Default) Arial

**Formatted:** Portuguese (Brazil)

**Formatted:** Portuguese (Brazil)

**Formatted:** Spanish (Spain, International Sort)

15. Rodríguez-Yzquierdo, G.; Olivares, B.O.; González-Ulloa, A.; León-Pacheco, R.; Gómez-Correa, J.C.; Yacomelo-Hernández, M.; Carrascal-Pérez, F.; Florez-Cordero, E.; Soto-Suárez, M.; Dita, M.; et al.. Soil Predisposing Factors to Fusarium oxysporum f.sp Cubense Tropical Race 4 on Banana Crops of La Guajira, Colombia. Agronomy, 2023 13, 2588. https://doi.org/10.3390/agronomy13102588
16. Rodríguez-Yzquierdo, G.; Olivares, B.O.; Silva-Escobar, O.; González-Ulloa, A.; Soto-Suarez, M.; Betancourt-Vásquez, M. Mapping of the Susceptibility of Colombian Musaceae Lands to a Deadly Disease: Fusarium oxysporum f. sp. cubense Tropical Race 4. Horticulturae 2023. 9, 757. https://doi.org/10.3390/horticulturae9070757
17. Montenegro, E., Pitti-Rodríguez, J, Olivares-Campos, B. Identification of the main subsistence crops of Teribe: a case study based on multivariate techniques. Idesia (Arica), 2021. 39(3), 83-94. https://dx.doi.org/10.4067/S0718-34292021000300083
18. Rodríguez, J. E. P., Olivares, B. O., Montenegro, E. J., Miller, L., & Ñango, Y. The role of agriculture in the Changuinola District: A case of applied economics in Panama. Tropical and Subtropical Agroecosystems, 2021. 25(1). http://dx.doi.org/10.56369/tsaes.3815
19. Olivares, B.O.; Rey, J.C.; Perichi, G.; Lobo, D. Relationship of Microbial Activity with Soil Properties in Banana Plantations in Venezuela. Sustainability 2022. 14, 13531. https://doi.org/10.3390/su142013531
20. Olivares B, Rey JC, Lobo D, Navas-Cortés JA, Gómez JA, Landa BB. Machine Learning and the New Sustainable Agriculture: Applications in Banana Production Systems of Venezuela. Agricultural Research Updates. 2022. 42, 133 - 157. Nova Science Publishers, Inc
21. Olivares, B. Description of soil management in agricultural production systems in the Hamaca de Anzoátegui sector, Venezuela. La Granja: Revista de Ciencias de la Vida. 2016. 23(1): 14–24. https://n9.cl/ycp08
22. Hernández, R., Olivares, B., Application of multivariate techniques in the agricultural land's aptitude in Carabobo, Venezuela. Tropical and Subtropical Agroecosystems, 2020. 23(2):1-12. https://n9.cl/zeedh
23. Hernández, R; Olivares, B. Arias, A; Molina, JC., Pereira, Y. Agroclimatic zoning of corn crop for sustainable agricultural production in Carabobo, Venezuela. Revista Universitaria de Geografía. 2018. 27 (2): 139-159. https://n9.cl/l2m83
24. Hernández, R; Olivares, B., Arias, A; Molina, JC., Pereira, Y. Identification of potential agroclimatic zones for the production of onion (Allium cepa L.) in Carabobo, Venezuela. Journal of the Selva Andina Biosphere., 2018. 6 (2): 70-82. http://www.scielo.org.bo/pdf/jsab/v6n2/v6n2_a03.pdf
25. Araya-Alman, M., Olivares, B., Acevedo-Opazo, C. et al. (2020). Relationship Between Soil Properties and Banana Productivity in the Two Main Cultivation Areas in Venezuela. J Soil Sci Plant Nutr.; 20 (3): 2512-2524. https://doi.org/10.1007/s42729-020-00317-8
26. Olivares, B.O., Calero, J., Rey, J.C., Lobo, D., Landa, B.B., Gómez, J. A. (2022a). Correlation of banana productivity levels and soil morphological properties using regularized optimal scaling regression. Catena,; 208: 105718. https://doi.org/10.1016/j.catena.2021.105718
27. Lobo, D; Olivares, B; Rey, J.C; Vega, A; Rueda-Calderón, A. Relationships between the Visual Evaluation of Soil Structure (VESS) and soil properties in agriculture: A meta-analysis. Scientia agropecuaria, 2023; 14 - 1, 67 - 78. https://doi.org/10.17268/sci.agropecu.2023.007
28. Campos, B. O. Banana Production in Venezuela: Novel Solutions to Productivity and Plant Health. 2023. Springer Nature. https://doi.org/10.1007/978-3-031-34475-6
29. Campos, B. O. O., Araya-Alman, M., & Marys, E. E. Sustainable Crop Plants Protection: Implications for Pest and Disease Control (p. 200). MDPI-

**Formatted:** Spanish (Spain, International Sort)

**Formatted:** Spanish (Spain, International Sort)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

Multidisciplinary Digital Publishing Institute. 2023. https://doi.org/10.3390/books978-3-0365-9150-6

30. Olivares, B.O.; Rey, J.C.; Perichi, G.; Lobo, D. Relationship of Microbial Activity with Soil Properties in Banana Plantations in Venezuela. Sustainability 2022. 14, 13531. https://doi.org/10.3390/su142013531
31. Olivares B, Rey JC, Lobo D, Navas-Cortés JA, Gómez JA, Landa BB. Machine Learning and the New Sustainable Agriculture: Applications in Banana Production Systems of Venezuela. Agricultural Research Updates. 2022. 42, 133 - 157. Nova Science Publishers, Inc
32. Olivares, B. Description of soil management in agricultural production systems in the Hamaca de Anzoátegui sector, Venezuela. La Granja: Revista de Ciencias de la Vida. 2016. 23(1): 14–24. https://n9.cl/ycp08
33. Olivares, B., Verbist, K., Lobo, D., Vargas, R. y Silva, O. Evaluation of the USLE model to estimate water erosion in an Alfisol. Journal of Soil Science and Plant Nutrition of Chile. 2011. 11 (2):71-84. http://dx.doi.org/10.4067/S0718-95162011000200007
34. Viloria, J.A.; Olivares, B.O.; García, P.; Paredes-Trejo, F.; Rosales, A. Mapping Projected Variations of Temperature and Precipitation Due to Climate Change in Venezuela. Hydrology 2023, 10, 96. https://doi.org/10.3390/hydrology10040096
35. Olivares, B. y Zingaretti, ML. Analysis of the meteorological drought in four agricultural locations of Venezuela by the combination of multivariate methods. UNED Research Journal. 2018. 10 (1):181-192. http://dx.doi.org/10.22458/urj.v10i1.2026
36. Olivares, B. Tropical conditions of seasonal rain in the dry-land agriculture of Carabobo, Venezuela. La Granja: Journal of Life Sciences. 2018. 27(1):86-102. http://doi.org/10.17163/lgr.n27.2018.07

~~9.~~

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** English (United States)

**Formatted:** Spanish (Spain, International Sort)

**Formatted:** Indent: Left: 0.25", No bullets or numbering