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Fertilizer Reduction Techniques on Growth and Yield of Cabbage (*Brassica oleracea* var *capitata* L.)

Gurumurthy N [a*], Vasant M. Ganiger [a], Yamuna Hanamasagar [b], T. B. Alloli [c], Bhuvaneshwari G [c] and J.B Gopali [c]

[a] Department of Vegetable Science, College of Horticulture, Bagalkot, India.
[b] Department of Plant Pathology, College of Horticulture, Bengaluru, India.
[c] University of Horticultural Sciences, Bagalkot- 587104, Karnataka, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out to find out the effect of reduction in RDF through foliar application of water-soluble fertilizers on the growth and yield of cabbage. The result showed that the growth and yield parameters significantly varied with a reduction in RDF through foliar application of water-soluble fertilizers at different concentrations. The maximum plant height (15.83 cm), number of loose leaves (15.85), leaf length of outer leaf (22.46 cm), leaf breadth of the outer leaf (22.48 cm), leaf area (504.90 cm^2), and weight of loose leaves per plant (549.98 g) and yield parameters like maximum weight of head (0.96 kg), fresh weight of five heads (4.80 kg), head diameter (15.78 cm), yield per plot (33.54 kg), total yield (54.09 tha^{-1}) and highest marketable yield (53.26 tha^{-1}) were recorded superior in the treatment T_9 (66 % RDF + 2.5 % F A) in all growth and yield parameters

**Corresponding author: Email: gurumurthyn1435@gmail.com;*

with foliar sprays of water-soluble formulation NPK 19:19:19 sprayed at 3 times compared to check treatment T_{13} (100 RDF% alone) and all these parameters are minimum in T_1 (33 % RDF + 2.5% FA).

Keywords: Fertilizer reduction; foliar application; growth; yield; techniques.

1. INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the important winter vegetables and the second most widely grown crop among the cruciferous vegetables in India after cauliflower. It belongs to the family Brassicaceae with chromosome number 2n=2X=18. Even though it originated in the Mediterranean region, cabbage is distributed throughout the world and is grown in Europe, India, Indonesia, Malaysia etc. India is the third largest producer of cabbage in the world with an area of 0.406 million hectares and production of 8.97 million tonnes [1]. Major cabbage-producing states are West Bengal, Odissa, Bihar, Uttar Pradesh, Madhya Pradesh, Gujarat and Karnataka. West Bengal stands 1st in both area and production of 79.13 ('000' ha) and 2271.2 ('000' MT) while Madhya Pradesh stands first in productivity and 6th most widely grown vegetable crop in India.

Among the cruciferous vegetables cabbage is an exhaustive feeder concerning nutrients. Farmers use inorganic fertilizers with indiscriminate and non judicious use of costly inorganic fertilizers in cabbage and this routine practice of farmers leads to soil and crop hazards with high incurred costs. There is an urgent need to address the farmers through alternate recommendations that emphasize the required nutrients through appropriate foliar application in split doses at different crop growth stages. Owing to this fertilizer recommendations should be viable more scientific and synchronize with nutrient uptake and crop performance. The judicious use of nutrients can activated by allocating for basal application, besides foliar application during the critical growth stage in this approach the nutrient use efficiency (NUE) can be augmented besides achieving higher profi with quality. Presently recommended nutrient dosages are highly soil application are slowly available, fixation and immobilization, also which causes more loss of fertilizers and polluted environments in one or other ways.

Foliar application has multiple dimensional advantages concerning high penetration rate, efficient utilization, avoids leaching and evaporation. Hence, foliar nutrition is recognized as an important method of fertilization in modern agriculture. This method provides utilization of nutrients more efficiently and corrects deficiencies rapidly, especially for short-duration crops. Recently, new-generation specialty fertilizers have been introduced exclusively for foliar feeding and fertilization. Specialty fertilizers are a better source for foliar application [2]. These fertilizers have different ratios of N, P, and K which are highly water-soluble and so amenable for foliar nutrition [3].

2. MATERIALS AND METHODS

The study was carried out at the Vegetable division in Main Horticultural Research and Extension Centre (MHREC), University of Horticultural Science, Bagalkot (K.A.) during 2017-18 on a well-drained Red loamy soil to find out the effect of reduction in RDF through foliar application of water-soluble fertilizers on the growth and yield of cabbage var 'Saint'. The field experiment was laid out in a Randomized Complete Block Design with three replications consisting of thirteen treatments including check. RDF for cabbage is 150:100:125 kg of N: P_2O_5: K_2O with 25 tonnes of FYM (As per Package of practice – UHS, Bagalkot).

The size of each single plot was 3.1m × 2.0 m. The gap between the plots was 50 cm and between the blocks was 100 cm. 4-5 weeks old seedlings are transplanted into the main field with a spacing of 45cm × 30 cm (As per package of practice - UHS, Bagalkot) basal dose of 50 % N and a full dose of P and K from each treatment was applied at the time of field preparation. The remaining dose of nitrogen (50 %) was applied at 2 split doses *viz.,* after 20 and 40 days of transplanting. During the investigation, three foliar applications (Source of foliar spray - 19:19:19) at different concentrations (2.5, 5.0, and 7.5 %) along with reduction in RDF within different treatments were sprayed at early growth stage (20 DAT), medium growth stage (40 DAT) and grand growth stage (60 DAT) and different growth parameters were recorded at 30 and 60 DAT and yield parameters were also recorded at the time of harvest from the randomly selected and tagged plants. The mean data was subjected to statistical analysis using ANOVA and mean separation (LSD) procedures.

Table 1. Treatment details

Treatments	Reduction in RDF		Foliar spray	Treatments	Reduction in RDF		Foliar spray
T_1	33 % RDF	+	2.5%	T_8	50 % RDF alone	+	--------
T_2	33 % RDF +	+	5 %	T_9	66 % RDF	+	2.5%
T_3	33 % RDF	+	7.5 %	T_{10}	66 % RDF	+	5 %
T_4	33 % RDF alone	+	----	T_{11}	66 % RDF	+	7.5 %
T_5	50 % RDF	+	2.5%	T_{12}	66 % RDF alone	+	-------
T_6	50 % RDF	+	5 %	T_{13}	100 % RDF alone	+	-------
T_7	50 % RDF	+	7.5 %	----------	----------		----------

(Note: 2.5 %, 5.0 % & 7.5% RDF is reduced by dividing 3 and applied through foliar application)

Table 2. Initial status of physical and chemical properties of soil of the experimental site

Sl. No	Parameters	Values
1	**Physical properties**	
a	Sand	34%
b	Silt	52%
c	clay	14%
d	soil type	Red loamy
2	**Chemical properties**	
a	pH	7.98
b	EC (ds/m)	0.42
c	OC (%)	0.76
3	**Macronutrients available in soil**	
d	Available Nitrogen (Kg/ha)	173.46
e	Available Phosphorus (Kg/ha)	53.56
f	Available Potassium (Kg/ha)	386.72
g	Available Calcium (meq/100 g)	22.65
h	Available Magnesium (meq/100 g)	6.57
i	Available Sulphur (ppm)	12.42

3. RESULTS AND DISCUSSION

The data recorded in Table 3 and Table 4 showed the growth and yield parameters significantly varied with a reduction in RDF through foliar application of water-soluble fertilizers at different concentrations. Among the growth parameters, the maximum plant height (15.83 cm), number of loose leaves (15.85), leaf length of outer leaf (22.48 cm), leaf breadth of the outer leaf (22.46 cm), leaf area (504.90 cm^2) and weight of loose leaves per plant (549.98 g) and in yield parameters, a maximum weight of the head (0.96 kg), fresh weight of five heads (4.80 kg), head diameter (15.78 cm), yield per plot (33. 54 kg) and highest marketable yield (53.26 tha^{-1}) were recorded superior in the treatment T_9 (66 % RDF + 2.5 % F A) with foliar sprays of NPK 19:19:19 sprayed at 3 times compared to check treatment T_{13} (100 RDF% alone) in all growth and yield parameters. The increase in plant height, number of loose leaves,

, leaf length, leaf breadth, leaf area and weight of loose leaves per plant might due to the availability and utilization of major essential plant nutrients from split doses of RDF through foliar applied fertilizers at the required quantity at various growth stages and less prone to fixation, immobilization, volatilization and leaching losses thereby readily available for the plant from foliage to hastening the metabolic processes like increased rapid cell division and cell elongation and proper translocation of photosynthates for better growth and development of the plant increased the vegetative growth in this treatment. Similar results were conformity with Koleta and Osinska [4], Naryanamma et al. [5], Naher et al. [6], and Ashruba et al. [7] in cabbage, Chauasia et al. [8] and Afzal et al. [9] in tomato and El-Tohamy et al. [10] in carrot.

Table 3. Effect of reduction in RDF through foliar application of WSF on **growth parameters of cabbage**

Treatments	Plant Height (cm)		No. of loose leaves per plant		Leaf length of outer leaf (cm)		Leaf breadth of outer leaf (cm)		Leaf area (cm^2)		Wt. of loose leaves per plant (g)
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	
T_1 – 33 % RDF + 2.5% F.A	9.32	11.31	9.66	12.62	13.62	17.19	15.81	18.42	215.33	316.64	423.04
T_2 – 33 % RDF + 5 % F.A	9.86	12.12	10.32	13.73	14.59	18.01	16.64	19.8	241.78	356.60	437.56
T_3 - 33 % RDF + 7.5 % F.A	9.71	12.04	10.04	13.16	14.38	17.45	16.23	19.59	233.29	341.60	434.34
T_4 – 33 % RDF alone	9.23	11.17	9.52	11.98	13.30	16.26	15.44	18.37	205.35	298.70	415.80
T_5 – 50 % RDF + 2.5 % F.A	11.72	14.79	11.78	14.72	16.81	20.93	18.85	21.82	316.87	456.69	526.17
T_6 - 50 % RDF + 5% F.A	11.57	14.52	11.62	14.55	16.46	19.59	18.26	21.23	310.27	415.90	515.98
T_7 - 50 % RDF + 7.5 % F.A	10.84	13.78	10.86	14.16	15.84	18.71	17.56	20.67	278.15	386.74	495.10
T_8 - 50 % RDF alone	10.10	13.22	10.40	13.42	15.23	17.33	17.02	20.82	259.21	360.81	499.44
T_9 - 66 % RDF + 2.5 % F.A	12.27	15.83	12.80	15.85	17.32	22.46	19.63	22.48	340.00	504.90	549.98
T_{10} - 66 % RDF + 5 % F.A	12.06	15.11	12.61	15.42	16.95	21.31	19.23	21.96	325.95	467.97	532.34
T_{11} - 66 % RDF + 7.5 % F.A	11.70	14.45	11.45	14.37	16.13	18.13	18.02	21.14	290.66	383.27	509.64
T_{12} - 66 % RDF alone	11.32	14.21	11.31	14.11	15.36	17.31	17.87	19.33	274.48	334.60	489.14
T_{13}- 100 % RDF alone	11.45	14.43	11.52	14.46	16.36	19.22	18.15	21.16	296.93	406.70	510.98
SEm ±	0.51	0.68	0.48	0.65	0.75	0.59	0.75	0.71	26.93	32.36	24.50
CD @ 5%	1.51	2.01	1.41	1.91	2.22	1.72	2.22	2.08	78.63	94.44	71.80

Table 4. Effect of reduction in RDF through foliar application of WSF on **yield parameters of cabbage**

Treatments	Average wt. of head (kg)	Fresh wt. of five heads (kg)	Head diameter (cm)	Yield per plot (kg)	Total yield (t/ ha)	Marketable yield (t/ ha)
T_1 – 33 % RDF + 2.5% F.A	0.68	3.45	11.68	23.08	33.39	31.68
T_2 – 33 % RDF + 5 % F.A	0.70	3.60	11.84	24.18	38.94	37.75
T_3 - 33 % RDF + 7.5 % F.A	0.64	3.20	10.89	22.09	35.63	33.95
T_4 – 33 % RDF alone	0.57	2.85	9.72	19.70	31.77	29.23
T_5 – 50 % RDF + 2.5 % F.A	0.90	4.50	15.21	30.82	49.72	47.57
T_6 - 50 % RDF + 5% F.A	0.86	4.30	14.94	29.66	47.84	44.23
T_7 - 50 % RDF + 7.5 % F.A	0.78	3.90	13.92	27.43	44.25	43.38
T_8 - 50 % RDF alone	0.72	3.60	13.33	24.87	40.11	39.65
T_9 - 66 % RDF + 2.5 % F.A	0.96	4.80	15.78	33.54	54.09	53.26
T_{10} - 66 % RDF + 5 % F.A	0.92	4.60	15.54	32.74	52.81	51.72
T_{11} - 66 % RDF + 7.5 % F.A	0.85	4.25	14.78	30.33	48.92	47.12
T_{12} - 66 % RDF alone	0.79	3.95	14.30	27.41	44.22	42.55
T_{13}- 100 % RDF alone	0.83	4.15	14.83	29.41	47.44	46.18
SEm ±	0.05	0.19	0.58	1.23	3.55	3.22
CD @ 5%	0.14	0.55	1.68	3.72	10.58	10.32

However, the increase in average weight of the head, head diameter yield per plot, and yield per hectare might be due to the quick and greater availability of nutrients, and increased uptake of nutrients and water, resulting in more photosynthesis and enhanced food accumulation in the edible part of the plant which enhanced the average weight of the head, head diameter ultimately increase in total yield per hectare. The present findings conform with the reports of Palaniappan et al. [3] and Churasia et al. [8] on tomato, Kanujia et al. [11], Nandi and Nayak [12], Wang-Xiude et al. [13] and Swaitkiewies and Sandy [14] in cabbage.

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:

The study on the effect of reducing the recommended dose of fertilizer (RDF) through foliar application of water-soluble fertilizers on the growth and yield of cabbage is scientifically relevant for several reasons. The resource Optimization, with concerns about environmental sustainability and resource conservation, optimizing fertilizer usage is crucial. This study explores a potential method to reduce the amount of fertilizer needed for cabbage cultivation while maintaining or even enhancing yield. This is particularly important given the environmental impact of excessive fertilizer use, such as eutrophication of water bodies.

Cabbage is a significant vegetable crop globally, contributing to food security and the agricultural economy. Understanding methods to maintain or increase cabbage yield while reducing input costs (such as fertilizer) is vital for sustainable agriculture and ensuring food availability [15,16]. Foliar application of fertilizers is an efficient method to deliver nutrients directly to the plant, bypassing potential losses in the soil due to leaching or immobilization [17]. Investigating the effectiveness of this technique specifically for cabbage cultivation adds to the body of knowledge regarding best practices for nutrient management in different crops [18,19].

The findings of this study have practical implications for farmers, providing them with evidence-based recommendations on optimizing fertilizer application for cabbage cultivation [20,21]. By reducing the reliance on conventional soil-applied fertilizers, farmers may achieve cost savings while potentially improving environmental sustainability [22,23].

Precipitation [24,25,26], temperature [27], and soil quality [28,29,30] are fundamental environmental factors influencing crop growth and productivity. Variations in these factors can significantly impact cabbage yield through effects on water availability, nutrient availability, and plant metabolism. Understanding how these factors interact with fertilizer application methods, as explored in the study, helps in developing holistic strategies for sustainable agriculture [31].

Apart from fertilizer application, agronomic practices such as irrigation, crop rotation, pest management, and tillage practices also influence cabbage growth and yield. Integrating knowledge from various agronomic aspects allows for comprehensive management strategies tailored to specific agroecological conditions [32,33,34].

Machine learning techniques offer opportunities to analyze vast amounts of agricultural data, including environmental variables, crop genetics, and management practices, to optimize productivity [35,36]. By utilizing machine learning algorithms, researchers can identify complex relationships between environmental factors, agronomic practices, and crop yield, leading to more precise recommendations for farmers [37,38,39,40].

4. CONCLUSION

From the foregoing results and discussion, it has been observed that the application of 66 percent recommended dose of fertilizers with 2.5 percent foliar application (T_9) was found significantly superior over the rest of the treatments concerning growth and yield parameters followed by T_{10}, T_5, and T_6 in cabbage cultivation. Hence foliar fertilization in cabbage is an important farm practice for management for sustainable and successful crop production. This is a novel measure due to its effect on the entire crop production. It will not only increase the efficacy of cabbage plant nutrient uptake and also reduce soil pollution but also maximize crop yield at the same time reduce the total cost of cultivation. Foliar fertilization is a simple nutrient corrective technique used in vegetable crops during the growth cycle when soil application is ineffective and leads to hazards as expensive. Hence further one or more trails with different locations are conducted if it shows the same beneficial

effect, it can be directly recommended for the farmers' field.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous; 2017. www.Indiaagristat.com, page no., 10.
2. Vibhute CP, A process for manufacturing complex solid and liquid completely water soluble fertilizers. Fert. News. 1988; 43(8):63.
3. Palanippan SP, Jeybal A, Chelliah S, Response of tomato and chilli to foliar application of specialty fertilizers. Veg. Sci.. 1999;26(2):198-200.
4. Kolota E, Osinska M, Efficiency of foliar nutrition of field vegetables grown at different nitrogen rates. Acta Hort. 2001;563:87-91.
5. Narayanamma M, Chiranjeevi C, Ahemed SR, Effect of foliar application of micronutrients on growth, yield and nutrient content of cabbage. Indian J. Hort. 2007; 34(2):213-221.
6. Naher MNA, Alam MN, Jahan N, Effect of nutrient management on the growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.) in calcareous soil. A Scientific J. Krishi Found. 2014;12(2):24-33.
7. Ashruba, Effect of foliar application of micronutrients on growth, yield, and quality of cabbage (*Brassica oleracea* var. *capitata* L.). M. Sc. Thesis, JRVNMKV, Parbhani-431402 (MS), India; 2017.
8. Chaurasia SNS, Singh KP, Rai M, Effect of foliar application of water soluble fertilizers on growth, yield and quality of tomato (*Lycopersicon esculentum* L.). Sri Lankan J. Agric. Sci. 2005;42:66–70.
9. Afzal I, Hussain1 B, Maqsood S, Basral A, Ullah SH, Shakeel Q, Kamran M, Foliar application of potassium improves fruit quality and yield of tomato plants. Acta Sci. Pol. Hortorum Cultus. 2015;14 (1):3-13.
10. El-Tohamy WA, El-Abagy HM, Badra MA, Hussein ESD, Helmy YI, The influence of foliar application of potassium on yield and quality of carrot (*Daucus carota* L.) plants grown under sandy soil conditions. Australian J. Basic App. Sci. 2011;5(3):171-174.
11. Kanuja SP, Ahmed N, Chato MA, Jabeen N, Narayan S, Effec tof micronutrients on growth and yield of cabbage. Indian J. Hort. 2006;8(1):15-18.
12. Nandi, Nayak SC, Performance of hybrid cabbage as influenced by foliar micronutrients sprays. J. Micro. Food Tech. 2008;35(1):45-48.
13. Wang- Xiude D, Wang FT, Liao ZX, Yung J, Mao P, Study on formula selection and rational application amount of organic, inorganic granular fertilizer for some vegetable species. Acta Agri. Shanghai. 1996;12(1):61-65.
14. Swiatkiewies, Sandy W, Effect of nitrogen fertilizer on Cu, Mn, Fe, Zn B and Mo availability in commercially grown white head cabbage. J. Elemntology. 2015;15 (3):455-465.
15. Araya-Alman M, Olivares B, 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. Available:https://doi.org/10.1007/s42729-020-00317-8
16. Campos BO. Banana production in venezuela: Novel solutions to productivity and plant health. Springer Nature; 2023. Available:https://doi.org/10.1007/978-3-031-34475-6
17. 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. Nova Science Publishers, Inc. 2022a;42:133 - 157.
18. Hernandez R, Olivares B, 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. Available:http://dx.doi.org/10.4067/S0718342920200002000095
19. Olivares BO, Rey JC, Perichi G, Lobo D. Relationship of microbial activity with soil properties in banana plantations in Venezuela. Sustainability. 2022b ;14:13531. Available:https://doi.org/10.3390/su142013531

20. 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. Available:https://n9.cl/l2m83
21. 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. Available:https://n9.cl/zeedh
22. 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. Available:http://www.scielo.org.bo/pdf/jsab/v6n2/v6n2_a03.pdf
23. Hernández R Olivares, B. Ecoterritorial sectorization for the sustainable agricultural production of potato (*Solanum tuberosum* L.) in Carabobo, Venezuela. Agricultural Science and Technology. 2019;20(2):339-354. Available:https://doi.org/10.21930/rcta.vol20_num2_art:1462
24. Olivares B, Parra R, Cortez A. y Rodríguez MF. Patterns of rainfall homogeneity in climatic stations of the Anzoátegui state, Venezuela. Revista Multiciencias. 2012;12(Extraordinario):11-17. Available:https://n9.cl/xbslq
25. Rodríguez MF, Cortez A, Olivares B, Rey JC, Parra R, Lobo D. Spatio-temporal analysis of precipitation in the state of Anzoátegui and its surroundings. Agronomía Tropical. 2013;63(1-2): 57-65. Available:https://n9.cl/14iow
26. Olivares B, Hernández R, Coelho R, Molina JC, Pereira Y. Spatial analysis of the water index: Advances in sustainable decision-making in Carabobo agricultural territories, Venezuela Revista Geográfica de América Central. 2018;60(1): 277-299. Available:https://doi.org/10.15359/rgac.60-1.10
27. Viloria J, Olivares B. et al. Mapping projected variations of temperature and precipitation due to climate change in Venezuela. Hydrology. 2023;10:96. Available:https://doi.org/10.3390/hydrology10040096
28. 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. Available:https://n9.cl/ycp08
29. Calero J, Olivares BO, Rey JC, Lobo D, Landa BB, Gómez JA. Correlation of banana productivity levels and soil morphological properties using regularized optimal scaling regression. Catena. 2022a;208:105718. Available:https://doi.org/10.1016/j.catena.2021.105718
30. Lobo D, Olivares B, Rey JC, 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. Available:https://doi.org/10.17268/sci.agropecu.2023.007
31. Olivares B, Torrealba J. y Caraballo L. Variability of the precipitation regime in the period 1990-2009 in the location of El Tigre, Anzoátegui state, Venezuela. Rev. Fac. Agron. (LUZ). 2013;30 (1):19-32. Available:https://n9.cl/mic0l
32. Orlando 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. Available:https://doi.org/10.54399/rbgdr.v16i3.5871
33. Montenegro E, Pitti J, Olivares B. Identification of the main subsistence crops of Teribe: A case study based on multivariate techniques. Idesia. 2021;39(3):83-94. Available:http://dx.doi.org/10.4067/S0718-34292021000300083
34. Pitti J, Olivares B, Montenegro E.The role of agriculture in the Changuinola District: A case of applied economics in Panama. Tropical and Subtropical Agroecosystems. 2021;25 – 1:1 - 11. Available:http://dx.doi.org/10.56369/tsaes.3815
35. Olivares BO, Vega A, Calderón MAR, Rey JC, Lobo D, Gómez JA, Landa BB. Identification of soil properties associated with the incidence of banana wilt using supervised methods. Plants. 2022c;11: 2070.

Available:https://doi.org/10.3390/plants11152070

36. Rodríguez-Yzquierdo G, Olivares BO, 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. 2023a ;9:757.
Available:https://doi.org/10.3390/horticulturae9070757

37. Olivares B, Rey JC, Lobo D, Navas-Cortés JA, Gómez JA, Landa BB. Fusarium wilt of bananas: A review of agro-environmental factors in the venezuelan production system affecting its development. Agronomy. 2021a;11(5):986.
Available:https://doi.org/10.3390/agronomy11050986

38. Olivares, B., Paredes F, Rey J, Lobo D, Galvis-Causil S. The relationship between the normalized difference vegetation index, rainfall, and potential evapotranspiration in a banana plantation of Venezuela. SAINS TANAH - Journal of Soil Science and Agroclimatology. 2021b ;18(1):58-64.
Available:http://dx.doi.org/10.20961/stjssa.v18i1.50379

39. Rodríguez-Yzquierdo G, Olivares BO, González-Ulloa A, León-Pacheco R, Gómez-Correa JC, 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. 2023b ;13:2588.
Available:https://doi.org/10.3390/agronomy13102588

40. Jeybal A, Murlidhar Rao M, Palanippam SP, Chelliah S, Technical bulletin on specialty fertilizers. Nagarjuna Agri. Res. and Develop. Institute, Secunderabad; 1998.

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