Effect of nitrogen and boron on Growth Parameters, Yield Attributes and Yield of MustardCrop in Chitrakoot Area

Abstract

A field experiment was conducted during the *Rabi*seasonof 2022at the Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.). The present experiment having 13 treatmentcombinations replicated thrice in a randomized block design.Mustard variety Pusa Mahakwas grown with recommended agronomic practices. ~~On the basis of~~Based on the results emanated from present investigation, it could be concluded that application of T_{12}[½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] significantly recorded maximum growth parameters such as plant height (198.8 cm), number of branches plant^{-1}(8.7) and maximum yield attributing characters such as number of siliqua plant^{-1} (166.8), number of seed siliqua^{-1}(13.4) and 1000 seed weight (5.1 g).The result showed the highest grain yield (1523.81 kg ha^{-1}) andstraw yield (4761.90 kg ha^{-1}),with treatment T_{12}[½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)]in comparison to all the treatments. While the minimum value of growth parameters viz. plant height (171.2 cm), number of branches plant^{-1} (6.3), and yield attributes such as number of siliqua plant^{-1} (117.5), number of seed siliqua^{-1} (11.7) and 1000 seed weight (3.8 g) recorded under the treatment T_1 [100 % NPK as per RDF]

Keywords:Nano-urea, Mustard, Yield and Boron.

1.Introduction

Indian mustard is one of the most important edible oilseed *rabi* ~~crop~~ cropsof North India commonly known as *Sarson*, *Rai*,or *Laha*. It belongs to the family Brassicaceae and the genus *Brassica*. It comprises various traditionally grown indigenous species, namely, Toria (*Brassica campestris* L. var. toria), Brown sarson (*Brassica campestris* L. var. brown sarson), Yellow sarson (*Brassica campestris* L. var. yellow sarson), Black mustard (*Brassica nigra*) and Taramira (*Eruca sativa/vesicaria* Mill.) which are grown over different parts of the country **(Radhamani*et al.*, 2013).**

Rapeseed mustard is the second most consumed edible oilseed crop in India, after soybean. India has 6.23 million hectares area under rapeseed mustard and 9.34 million tonnes production with average productivity of 1499 kg ha^{-1}, which is about ~~three-fourth~~three-fourths of the world's average productivity (1960 kg ha^{-1}) **(DAC & FW, 2020).** Rajasthan ranks first both in terms of area and production of Indian mustard, which accounts for 45% of mustard ~~of~~ inthe country. It is the most important *rabi* season oilseed crop of Rajasthan which is grown on 2.18 million hectares with annual production of 3.40 million tonnes at an average productivity of 1558 kg ha^{-1}**(Anonymous, 2019-20).** In the Madhya Pradesh, it is grown on an area 1038.15 thousand hectares with a production of 1.69 million tonnes **(Anonymous 2021-22).**

Urea is a rich source of nitrogen, an essential nutrient for plant growth. Nitrogen is a crucial component of chlorophyll, the green pigment in plants responsible for photosynthesis. Adequate nitrogen supply helps mustard plants produce more chlorophyll, leading to improved photosynthesis and overall plant growth. Mustard plants respond well to nitrogen fertilizers like urea during their vegetative stage **(Shorna *et al.*, 2020).** Urea provides the necessary nitrogen for the formation of leaves, stems, and branches, resulting in increased plant height and canopy development. This can lead to better light interception and more efficient utilization of sunlight. The application of urea at the right time and in the right amount can significantly increase mustard crop yield. One of the most common symptoms of nitrogen deficiency is the yellowing of older leaves, starting from the tips and progressing ~~towards~~ towardthe base of the plant. Urea deficiency can lead to reduced plant height, fewer branches, and a generally stunted appearance. Mustard plants may fail to reach their full growth potential **(Iqbal *et al.*, 2015).**

Nano fertilizers possess unique ~~feature~~ features~~which~~ thatenhance plant performance in terms ofultrahigh absorption, increase in production, and rise in the ~~leaves~~ leaf'ssurface area. ~~Beside~~ Besidesthe controlled~~released~~ releaseof nutrients contributes ~~in~~ topreventing eutrophication and pollution in water resources.Replacementof traditionalfertilizers bynanofertilizer isbeneficialasuponapplication,itreleases nutrients into the soil steadily and in a controlled way, thus,preventing ~~the~~ waterpollution**(Naderi and Danesh Shahraki2013, Moaveni and Kheiri,2011).**

Among most recent technical ~~improvement~~ improvementsin the field of agriculture nanotechnologyholds an eminent position in remodeling agriculture and food production to fulfil the demands ~~inan efficient and cost-effective way~~efficiently and cost-effectively.

Nanotechnology is a promising tool and has the potential tofoster a new era of precise farming techniques and therefore, may emerge as a possible solutionfor their problems. Nanotechnology has the potential to improve global food production and foodquality **(Sugunan and Dutta, 2008).** Nano ~~fertilizer~~ fertilizersare nutrient carriers of nano dimensionsrangingfrom30-40nmandcapableofholdingbountifulofnutrientionsduetotheirhighsurfaceareaandreleaseditslowlyandsteadilythatcommensuratewithcropdemand**(Subramanian *et al.* 2015)** and have a profound influence on crop production **(Panwar *et al.*2012).**

Boron is essential for the formation and stability of plant cell walls. It is involved in the cross-linking of pectin molecules, which helps maintain the structural integrity of plant cells. In mustard plants, this is especially important for maintaining stem and seed pod strength. Adequate boron levels promote efficient pollination and higher seed set, ultimately contributing to increased yield. Boron aids in the uptake and translocation of other essential nutrients within the plant. It helps in the movement of calcium, which is important for cell division and overall plant growth **(Sharma *et al.*, 2020).** Boron deficiency in mustard often leads to the development of distorted, misshapen, and brittle young leaves and stems. This is known as "dieback" or "little leaf" syndrome. Boron deficiency can result in reduced flower formation and poor fruit or seed development. Flowers may drop prematurely, leading to decreased yield. In severe cases of boron deficiency, mustard stems can become hollow or brittle. This can make the plant more susceptible to lodging (falling over) and disease **(Masum *et al.*, 2019).**

Keeping in view the significance of potassic fertilizers in combination with organic manures on growth ~~parameter~~parameters, yield components and yield of pigeon pea present investigation was undertaken at Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.)

2. Materials and Methods

2.1 Experimental Site

The experiment was carried out at Rajaula Agriculture farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) which lies in the semi- arid and sub-tropical region of Madhya Pradesh between 25.148° North latitude and 80.855°East longitude. The altitude of town is about 190-210 meter above mean sea level.

2.2 Edaphic Condition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.4 (1:2.5 soil: water suspension method given by **Jackson, 1973**), low in organic carbon percentage in soil is 0.31 per cent (Walkley and Black's rapid titration method given by **Walkley and Black, 1934**), low in available nitrogen 97.68 kg ha^{-1} (Alkaline permanganate method given by **Subbiah and Asija, 1956**), medium in available phosphorus as sodium bicarbonate-extractable P was 16.25 kg ha^{-1} (Olsen's calorimetrically method**, Olsen *et al.*, 1954**), high in available potassium was 292.90 kg ha^{-1} (Flame photometer method given by **Hanwey and Heidel, 1952**), low in available boron 0.38 mg kg^{-1} (Azomethine-H methodgiven by **Berger and Troug, 1939)**

2.4 Experimental Details

The experiment was laid out in randomized block design and replicated thrice comprising with 12 treatment combinations.

Table no.-1: Treatment details

Symbol	**Treatment Combinations**	**Details of Treatment**
T_0		100 % NPK as per RDF
T_1	N_0B_0	½ of RDN + (2 water spray + 0.0 kg B)
T_2	N_1B_0	½ of RDN + (I^{st} nano-urea spray + 2^{nd} water spray + 0.0 kg B)
T_3	N_2B_0	½ of RDN + (I^{st} nano-urea spray + 2^{nd} nano-urea spray + 0.0 kg B)
T_4	N_0B_1	½ of RDN + (2 water spray + 0.5 kg B)
T_5	N_1B_1	½ of RDN + (I^{st} nano-urea spray + 2^{nd} water spray + 0.5 kg B)
T_6	N_2B_1	½ of RDN + (I^{st} nano-urea spray + 2^{nd} nano-urea spray + 0.5 kg B)
T_7	N_0B_2	½ of RDN + (2 water spray + 1.0 kg B)
T_8	N_1B_2	½ of RDN + (I^{st} nano-urea spray + 2^{nd} water spray + 1.0 kg B)
T_9	N_2B_2	½ of RDN + (I^{st} nano-urea spray + 2^{nd} nano-urea spray + 1.0 kg B)
T_{10}	N_0B_3	½ of RDN + (2 water spray + 1.25 kg B)
T_{11}	N_1B_3	½ of RDN + (I^{st} nano-urea spray + 2^{nd} water spray + 1.25 kg B)
T_{12}	N_2B_3	½ of RDN + (I^{st} nano-urea spray + 2^{nd} nano-urea spray + 1.25 kg B)

Note: Recommended dose of fertilizer (60:40:40 kg ha^{-1}) was applied.

2.5Fertilizer application

FYM was applied @ 10 q ha^{-1} as basal dose. After the layout of experimental plot, the fertilizers were weighed and applied in the plots and thoroughly mixed with soil. As per the experimental recommended doses of Nitrogen, Phosphorus, Potassium ~~were~~was applied to assigned plots. Recommended dose of Nitrogen, Phosphorus and Potassium were applied through Urea, DAP and MOP (60:40:40 kg ha^{-1}) whereas boron was applied through borax (0, 0.5, 1.0, 1.25 kg B ha^{-1}).

2.5.3 Seed and sowing:The seed sowing was done on 19th Nov. 2022. The seed was sown in line after making a narrow furrow with the help of pointed wooden stick at different row spacing. The seeds were dropped in the furrow after mixture with fine dust of soil and then after seeds were covered with thin soil layer. The total quantity of seed was required @ 6 kg/ha. The Mustard variety was "**Pusa Mahak**".

2.5.6 Harvesting: The crop was harvested on 14th Feb., 2023 when it reached to its physiological maturity i.e. when the leaves were turned yellow and more than 70 % capsules were full matured to avoid shattering of the crop.

2.6 Observations recorded

2.6.2 Grain yield (q ha^{-1}): The total weight of clean and dried grains from each plot was weighed with the help of electronic balance in kg/ha.

2.6.3 Straw yield (q ha^{-1}): Straw yield of each plot can be obtained by deducting the grain yield from the respective biological yield and expressed in kg/ha.

2.7 Statistical Analysis: The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were analyzed statistically using the methods advocated by **Gomez and Gomez (1984).**

3. Result and Discussion

3.1. Growth Parameters

Data pertaining to growth parameters mainly plant height (cm), and number of branches plant^{-1} are presented in table no. 2 clearly revealed that application of nano urea and boron increased these attributes significantly over control. The results revealed that the plant height varied in between 171.2 to 198.8 cm and all the treatments were significantly superior to treatment T_1 [100 % NPK as per RDF]. The treatment combination T_{12}[½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] gave the maximum plant height (198.8). Number of branches plant^{-1}of mustard varied in between 6.3 to 8.7 and all the treatments were significantly superior to T_1 [100 % NPK as per RDF]. The treatment combination T_{12} [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] gave the maximum no. of branches plant^{-1} (8.7). Minimum plant height (171.2 cm) and number of branches plant^{-1} (6.3) were associated with the treatment T_0 [100 % NPK as per RDF]. These findings are further supported by **Khan *et al.* (2010), Shagata *et al.* (2020) and Satyanarayana *et al.* (2021)**

Table no.-2: Effect of different treatment combinations on growth parameters of mustard

Treatment	Plant height (cm)	No. of branches plant^{-1}
T_0	171.2	6.3
T_1	174.8	6.5
T_2	177.3	6.7
T_3	183.4	7.0
T_4	180.5	6.8
T_5	185.7	7.1
T_6	188.3	7.5
T_7	186.1	7.3
T_8	193.2	8.0
T_9	196.8	8.4
T_{10}	191.5	7.7

T_{11}	194.6	8.2
T_{12}	198.8	8.7
S.E.m±	**1.31**	**0.25**
C.D. (P= 0.05)	**3.94**	**0.76**

3.2. Yield Components

Data pertaining to yield attributing parameters mainly no. of siliqua plant^{-1},no. of seed siliqua^{-1}and 1000 seed weight (g) are presented in tableno. 3 clearly revealed that application of nano urea in combination with boron increased yield attributes significantly over control except 1000 seed weight (g). Maximum no. of siliqua plant^{-1}(166.8), no. of seed siliqua^{-1} (13.4) and 1000 seed weight (5.1 g) were recorded under the treatment T_{12} [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] followed by treatment T_9 [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.0 kg B)] with the value 164.7, 13.2 and 5.0 g respectively and the minimum no. of siliqua plant^{-1} (117.5) no. of seed siliqua^{-1} (11.7) and 1000 seed weight (3.8 g) was recorded under the treatment T_0[100 % NPK as per RDF]. These findings are further supported by **Khatkar *et al.* (2009), Kumar *et al.* (2020) and Choudhary *et al.* (2023)**

Table no.-3: Effect of different treatment combinations on yield attributes of mustard

Treatment	**No. of siliqua plant^{-1}**	**No. of Seed siliqua^{-1}**	**1000 seed weight (g)**
T_0	117.5	11.7	3.8
T_1	126.4	11.9	3.8
T_2	132.2	12.1	3.9
T_3	140.9	12.4	4.1
T_4	136.7	12.2	4.0
T_5	144.4	12.5	4.2

T_6	152.3	12.8	4.5
T_7	149.5	12.6	4.3
T_8	159.7	13.0	4.7
T_9	164.7	13.2	5.0
T_{10}	156.4	12.9	4.6
T_{11}	161.2	13.1	4.9
T_{12}	166.8	13.4	5.1
S.E.m±	**6.19**	**0.16**	**0.08**
C.D. (P= 0.05)	**18.58**	**0.49**	**NS**

3.3Productivity Parameters

It was observed that application of nano urea and boronboth enhanced the grain yield and straw yield of mustardsignificantly and present in table no. 4. Maximum grain yield (1523.81 kg ha^{-1}) was recorded under the treatment T_{12} [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] followed by treatment T_9 [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.0 kg B)] with the value 1485.71 kg ha^{-1} and the minimum grain yield (958.73 kg ha^{-1}) was recorded under the treatment T_0[100 % NPK as per RDF]. Maximum stover yield (4761.90 kg ha^{-1}) was recorded under the treatment T_{12} [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] followed by treatment T_9 [½ of RDN + (Ist nano-urea spray + 2nd nano-urea spray + 1.0 kg B)] with the value 4685.71 kg ha^{-1} and the minimum stover yield (3498.41 kg ha^{-1}) was recorded under the treatment T_0[100 % NPK as per RDF]. These findings are further supported by the findings of **Rashid *et al.* (2012), Sharma *et al.* (2020), Kumar *et al.* (2022) and Dhaliwal *et al.*, (2022)**

Table no.-4: Effect of different treatment combinations on yields of mustard

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_0	958.73	3498.41

T_1	1009.52	3631.74
T_2	1066.67	3771.42
T_3	1155.55	4012.69
T_4	1117.46	3879.36
T_5	1212.70	4133.33
T_6	1346.03	4374.60
T_7	1295.24	4279.36
T_8	1422.22	4539.68
T_9	1485.71	4685.71
T_{10}	1384.13	4457.14
T_{11}	1453.97	4628.57
T_{12}	1523.81	4761.90
S.E.m±	**3.64**	**7.84**
C.D. (P= 0.05)	**10.75**	**23.14**

It is necessary to discuss these results, with emphasis on the causes of the matter. Therefore I recommend citing the scientific manuscripts.

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Understanding the impact of nitrogen and boron on mustard crop growth and yield is pivotal for enhancing agricultural productivity, especially in regions like Chitrakoot, which may face specific soil (Lobo et al. 2023) and climate challenges (Viloria et al. 2023). This research can provide valuable insights into optimizing nutrient management practices to achieve higher yields while conserving resources (Araya-Alman et al. 2020). Furthermore, comparing the findings with existing studies on soil quality and productivity in tropical territories broadens the scope of this research, facilitating a more comprehensive understanding of how specific nutrient amendments can contribute to sustainable agricultural practices in tropical regions worldwide (Olivares et al. 2022). Such comparative analysis not only aids local farmers but also contributes to the global pursuit of sustainable agriculture amidst changing environmental conditions (Zingaretti et al. 2016; Hernandez et al. 2020).

The scientific significance of this study extends beyond its immediate agricultural implications. It addresses broader ecological concerns by delving into the relationships between nutrient supplementation, crop growth, and environmental sustainability (Hernandez et al. 2018; Hernandez and Olivares, 2020). The knowledge gained from this research can inform strategies for mitigating the environmental impacts of agricultural practices, such as reducing excess nutrient runoff that can harm aquatic ecosystems (Parra et al. 2012; Hernandez and Olivares, 2019; Olivares, 2022). Additionally, by comparing the results with studies in tropical territories, this research has the potential to identify patterns and generalizable insights that can be applied to other regions facing similar climatic and soil challenges (Rey et al. 2022; Campos, 2023; Olivares, 2023). Overall, the study's scientific relevance lies in its potential to enhance agricultural productivity, reduce environmental impacts, and contribute to the global effort to address food security and sustainability challenges in tropical regions.

5.Conclusion

The experimental results indicated that superiority in regard to growth parameters, yield components and productivity parameters *viz*, grain yield (kg ha^{-1}), stover yield (kg ha^{-1}), with the use of treatment combination T_{12} [½ of RDN + (I^{st} nano-urea spray + 2^{nd} nano-urea spray + 1.25 kg B)] gave in soil ensure highest growth parameters, yield components and productivity,of mustard crop as comparison to all the treatments.

6. References

Anonymous, (2019-20). Rajasthan agricultural statistics at a glance, Commissionerate of Agriculture, Jaipur, Rajasthan, 88.

Anonymous, (2020-21). Rajasthan agricultural statistics at a glance, Commissionerate of Agriculture, Jaipur, Rajasthan, 72.

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

Berger, K. C., & Truog, E. (1939). Boron determination in soils and plants. *Industrial & Engineering Chemistry Analytical Edition*, *11*(10), 540-545.

Campos, B.O.(2023). Fusarium Wilt of Bananas: A Threat to the Banana Production Systems in Venezuela. In: Banana Production in Venezuela. The Latin American Studies Book Series. Springer, Cham. 2023, https://doi.org/10.1007/978-3-031-34475-6_3

Choudhary, R. S., Mondal, A. K., Sharma, V., Puniya, R., Bhanwaria, R., Yadav, N. K., & Jhajhra, S. (2023). Effect of Organic Manures and Boron Application on Yield Attributes and Yield of Mustard (*Brassica junciea* L.) under Jammu Region. *Communications in Soil Science and Plant Analysis*, *54*(8), 1024-1041.

Dhaliwal, S. S., Sharma, V., Shukla, A. K., Kaur, M., Verma, V., Sandhu, P. S., & Hossain, A. (2022). Biofortification of oil quality, yield, and nutrient uptake in Indian mustard (*Brassica juncea* L.) by foliar application of boron and nitrogen. *Frontiers in Plant Science*, *13*, 976391.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John wiley & sons.

Hanway, J.J; and Heidel, H. (1952). Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. *Iowa Agriculture* **54**: 1-31.

Hernandez, R.; Olivares, B.; Arias, A; Molina, JC., Pereira, Y. (2020). Eco-territorial adaptability of tomato crops for sustainable agricultural production in Carabobo, Venezuela. Idesia, 38(2):95-102. http://dx.doi.org/10.4067/S0718-34292020000200095

Hernández R, Olivares BO, Arias A, Molina JC, Pereira Y. (2018). Agroclimatic zoning of corn cultivation for the sustainability of agricultural production in Carabobo, Venezuela. Revista Universitaria de Geografía.;27(2):135-56. https://n9.cl/l2m83

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Hernández, R.&Olivares, B., (2020). Application of multivariate techniques in the agricultural land's aptitude in Carabobo, Venezuela. Tropical and Subtropical Agroecosystems, 23(2):1-12. https://n9.cl/zeedh

Hernández R., &Olivares B.(2019). Ecoterritorial sectorization for the sustainable agricultural production of potato (*Solanum tuberosum* L.) in Carabobo, Venezuela. Agricultural Science and Technology.; 20(2): 339-354. https://doi.org/10.21930/rcta.vol20_num2_art:1462

Iqbal, N., Umar, S., & Khan, N. A. (2015). Nitrogen availability regulates proline and ethylene production and alleviates salinity stress in mustard (Brassica juncea). *Journal of Plant Physiology*, *178*, 84-91.

Jackson, M.L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd, New Delhi.

Khan, A. M., Rajamaniand. A. K. and Reddy, P.K. (2010). Effect of integrated nutrient management on yield, quality, nutrient content and uptake of sweet sorghum in pongamia based Agri silviculture system. *Ind. J. Dryland Agril. Res. and Dev.* 25(2): 95-99.

Khatkar, Y., Dawson, J., Zade, K.K., Dixitand, P.M. and Khatkar, R. (2009). Effect of nitrogen, phosphorus and sulphur fertilization on growth and yield of mustard (*Brassica juncea* L.). *Int. J. Agric. Sci*. 5 (2): 396-398.

Kumar, A., Singh, K., Verma, P., Singh, O., Panwar, A., Singh, T., Kumar, Y. and Raliya, R. (2022). Effect of nitrogen and zinc nano fertilizer with the organic farming practices oncerealand oil seedcrops.*Scientificreports*. Apr28;12(1):1-7.

Kumar, Y., Tiwari, K.N., Nayak, R.K., Abhimanyu, R.A., Singh. S.P., Singh, A.N., Toma, H.,Singhand, T. and Raliya, R. (2020). Nano fertilizers for increasing nutrient use efficiency,yield and economic returns in important winter season crops of Uttar Pradesh. *IndianJournalof Fertilisers* 16 (8): 772-786.

Lobo, D; Olivares, B; Rey, J.C; Vega, A; Rueda-Calderón, A. (2023). Relationships between the Visual Evaluation of Soil Structure (VESS) and soil properties in agriculture: A metaanalysis. *Scientia agropecuaria*, 14 - 1, 67 - 78. https://doi.org/10.17268/sci.agropecu.2023.007

Masum, M. A., Miah, M. N. H., Islam, M. N., Hossain, M. S., Mandal, P. and Chowdhury, A. P. (2019). Effect of boron fertilization on yield and yield attributes of mustard (var. BARI Sarisha-14). *Journal of Bioscience and Agriculture Research*, 20(02), 1717-1723.

Moaveni, P. and Kheiri, T. (2011). In 2nd International Conference on Agricultural and AnimalScience;November25–27,2011 inMaldives.Singapore:IACSITPress22:160–163.

Naderi, M.R. and Danesh-Shahraki, A. (2013). Nano fertilizers and their roles in sustainableagriculture.InternationalJournal ofAgricultureandCrop Sciences5,2229–2232.

Olsen, S.R, Cole, C.V., Watanable, F. S. and Dean, L. A. (1954). Estimation of available phosphorous in soil by extraction with sodium bicarbonate. *USDA, Cric*. **930**:19- 23

Olivares, B.O., Calero, J., Rey, J.C., Lobo, D., Landa, B.B., Gómez, J. A. (2022). 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

Olivares, B.O. (2023). Evaluation of the Incidence of Banana Wilt and its Relationship with Soil Properties. In: Banana Production in Venezuela. The Latin American Studies Book Series. Springer, Cham. 2023, https://doi.org/10.1007/978-3-031-34475-6_4

Olivares B. (2022). Machine Learning and the New Sustainable Agriculture: Applications in Banana Production Systems of Venezuela. Agricultural Research Updates. 42, 133 - 157.

Panwar, J. J., Bhargav, N. A., Akhtar, M.S. and Yun, Y.S. (2012). Positive effect of zinc oxidenanoparticlesontomatoplants:asteptowardsdeveloping“Nanofertilizers”.In:Proceedings of 3rd international conference on environmental research and technology(ICERT),Penang, Malaysia. 348-352.

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Parra, R., Olivares, B., Cortez, A. y Rodríguez, M.F.(2012). Patterns of Pluviometric Homogeneity at Weather Stations in the State of Anzoategui, Venezuela. Revista Multiciencias., 12 (Extraordinario): 11-17. https://n9.cl/xbslq

Radhamani, J., Singh, R., Srinivasan, K., & Tyagi, R. K. (2013). Conservation of trait-specific germplasm of brassicas in National Genebank. *National Bureau of Plant Genetic Resources, New Delhi*, *114*.

Rashid, M. H., Hasan, M. M., Ahmed, M., Rahman, M. T., & Rahman, K. A. M. M. (2012). Response of mustard to boron fertilization. *Bangladesh Journal of Agricultural Research*, *37*(4), 677-682.

Rey, J.C.; Olivares, B.O.; Perichi, G.; Lobo, D. (2022). Relationship of Microbial Activity with Soil Properties in Banana Plantations in Venezuela. Sustainability 14, 13531. https://doi.org/10.3390/su142013531

Satyanarayana, U., Singh, R., Chhetri, P. and Singh, E. (2021). Effect of Nutrient Combinations on Growth, Yield and Quality of Mustard (*Brassica juncea* L.). *Int. J. Curr. Microbiol. App. Sci*. 10(02): 411-417.

Shagata, I.S., Mohammed, A.S. P., Mohammed, A.S., Moshtari, A.M., Mohammed, A.H., Biswas, A. and Mohammed, A. H. (2020). Effects of nitrogenous fertilizer on growth and yield of Mustard Green. *Tropical Plant Research* 7(1): 30–36.

Sharma, S., Chaudhray, S., & Singh, R. (2020). Effect of boron and sulphur on growth, yield and nutrient uptake of mustard (*Brassica juncea* L.). *International Journal of Chemical Studies*, *8*(4), 1998-2001.

Shorna, S. I., Polash, M. A. S., Sakil, M. A., Mou, M. A., Hakim, M. A., Biswas, A., & Hossain, M. A. (2020). Effects of nitrogenous fertilizer on growth and yield of Mustard Green. *Tropical Plant Research*, *7*(1), 30-36.

Subbiah, B.V. and Asija, C.L. (1956). A rapid procedure for the estimation of available N in Soil. *Curr. Sci.* **25**:259-260.

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Subramanian, K. S., Manikandan, A., Thirunavukkarasu, M. and Rahale, C. S. (2015). Nanofertilizers for balanced crop nutrition. In: Rai, M, Ribeiro, C., Mattaso, L. and Duran, N.(eds)Nanotechnologies in foodand agriculture. Springer,Switzerland, 69-80.

Sugunan, A. and Duttu, J. (2008). IEEE international conference on semiconductor electronics A6-A11.

Viloria, J.A.; Olivares, B.O.; García, P.; Paredes-Trejo, F.; Rosales, A.(2023). Mapping Projected Variations of Temperature and Precipitation Due to Climate Change in Venezuela. Hydrology, 10, 96. https://doi.org/10.3390/hydrology10040096

Walkley, A. and Black, C. S.A. (1934). Old piper, S.S. soil and plant analysis. Soil Sci. 37:29-38.

Zingaretti, M.L., Olivares, B., Demey Zambrano, J.A. y Demey, J.R. (2016). Typification of agricultural production systems and the perception of climate variability in Anzoátegui, Venezuela. Revista FAVE - Ciencias Agrarias, 15 (2): 39-50. https://doi.org/10.14409/fa.v15i2.6587

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