



The Influence of Integrated Nutrient Management on Major Nutrient Status and Physico-chemical Properties of Soil in Quinoa (*Chenopodium quinoa* Willd.)

D. Bindu ^{a*}, B. Mamatha ^a, B. Gayathri ^a, S. R. Anand ^b,
C. T. Subbarayappa ^a and D. S. Rohitha ^a

^a Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, Bangalore, Karnataka–560065, India.

^b Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Bangalore, Karnataka–560065, India.

Authors' contributions

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

Article Information

DOI: <https://doi.org/10.9734/ajsspn/2024/v10i3358>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/122224>

Original Research Article

Received: 15/06/2024

Accepted: 17/08/2024

Published: 21/08/2024

ABSTRACT

A field experiment was conducted during *rabi* 2022-23 to study the effect of Integrated Nutrient Management on physical and chemical properties of soil such as soil bulk density, maximum water holding capacity, pH, electrical conductivity, organic carbon, available major nutrients. The following

*Corresponding author: Email: bindudpal35@gmail.com;

Cite as: Bindu, D., B. Mamatha, B. Gayathri, S. R. Anand, C. T. Subbarayappa, and D. S. Rohitha. 2024. "The Influence of Integrated Nutrient Management on Major Nutrient Status and Physico-Chemical Properties of Soil in Quinoa (*Chenopodium Quinoa* Willd.)". *Asian Journal of Soil Science and Plant Nutrition* 10 (3):467-74. <https://doi.org/10.9734/ajsspn/2024/v10i3358>.

parameters were investigated in an experiment comprising eleven treatments replicated thrice in randomized complete block design with quinoa. The results of the experiment suggested that soil physico-chemical properties like maximum water holding capacity, organic carbon had significantly influenced with the application of 50% nitrogen dose (ND) + 50% N through FYM + seed treatment (Azotobacter + PSB). Soil major nutrients like nitrogen, phosphorus and potassium had a higher significant effect with the application of 50% nitrogen dose (ND) + 50% N through vermicompost (VC) + seed treatment (Azotobacter + PSB) in comparison to application of 100% fertilizer dose. In the other hand, soil properties like bulk density, pH, electrical conductivity did not have a significant influence with the practice of Integrated Nutrient Management in quinoa.

Keywords: *Integrated nutrient management; quinoa; soil physical; chemical properties.*

1. INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.), a nutritious pseudo-cereal, is an annual herbaceous plant from the Amaranthaceae family, originating in South America and used by the Inca civilization since 5,000 B.C. It is gluten-free, suitable for diabetic patients and high in protein. Discovered by North Americans and Europeans in the 1970s, quinoa has gained popularity due to its high protein content and amino acid content. It contains Ca, Fe, Zn, Cu, and Mn, and has an oil content of 1.8 to 9.5%. Quinoa is also high in linoleate and linolenate, two essential fatty acids. The FAO designated 2013 as the International Year of Quinoa [1], highlighting its nutritional value. Quinoa can tolerate various environmental conditions, including pH ranging from 6 to 8.5, varying temperatures ranging from subtropical to tropical and humid regions, and altitudes above 3,900 meters above sea level. It is hardy and can grow well under moisture stress, but sandy loam is the most suitable soil. Quinoa grows rapidly, reaching heights of 2 meters, with alternating, coarsely serrated, triangular to ovate leaves.

Soil quality improvement and maintenance are crucial for enhancing agricultural production and India's food and nutritional security. To meet future demands, better planning and resource management are needed. Chemical or inorganic fertilizers are increasing in use, but they can lead to long-term effects like soil structure deterioration, soil health issues, and environmental pollution. The cost of chemical fertilizers is also increasing. Using organic manures alone as a replacement for inorganic fertilizers is not practical or economical, as it may not sustain current crop production levels and meet growing food demand. Combining organic manures with inorganic fertilizers can increase agricultural production and maintain soil health for longer periods [2]. This approach

offers farmers significant potential for increasing crop yield, maintaining soil fertility, and health.

Integrated Nutrient Management (INM) is a crucial approach to maintaining and improving soil properties [3]. It ensures a balanced supply of essential nutrients like nitrogen, phosphorus, and potassium, preventing imbalances that can harm soil health and plant growth. INM incorporates organic materials like compost and manure, enhancing soil fertility and building organic matter. It also addresses soil pH issues, ensuring nutrient availability and microbial activity. INM practices reduce soil degradation, erosion, and nutrient depletion, contributing to long-term soil property preservation. It minimizes nutrient losses, reducing water pollution and environmental damage. INM promotes soil resilience to climate change and supports sustainable agriculture.

In recent years, some farmers showing interest to grow this crop because of its nutrient content and climate resilience. Since, very limited research has been done on this crop in our country, the study has been conducted to standardize the nutrient management practices in quinoa. At the same time due to more dependent on chemical fertilizers causing harmful effect on soil health. So, for sustainable agriculture practice of INM is important and this crop respond well to use of organic and biofertilizers from previous studies. In this context, an experiment was designed to evaluate the influence of Integrated Nutrient Management on major nutrient status and physico-chemical properties of soil in Quinoa (*Chenopodium quinoa* Willd.).

2. MATERIALS AND METHODS

A Field experiment was conducted in M-block, GKV, Bengaluru. It is located at an

altitude of 924 m above MSL at 13° 09' North latitude and 77° 57' East longitudes situated in the Eastern Dry Zone of Karnataka. During *rabi* 2022-23 with a test crop quinoa. The recommended dose of fertilizer (60:40:40, N, P₂O₅ and K₂O for *Alfisol*) applied as basal dose with recommended spacing of 45x15 cm. Randomized complete block design was used with 11 treatment and 3 replications. The initial physical

and chemical properties of the soil from the experimental area are depicted in Table 1. There are different types of organic manures like Farm Yard Manure (FYM), Vermicompost (VC) and Neem Cake (NC), biofertilizers like Azotobacter, Phosphorus Solubilizing Bacteria (PSB) for seed treatment and inorganic fertilizers like Urea, DAP, MOP has been used in the present investigation and the following are the treatment combinations.

List 1. Treatment details of the experiment

T ₁	100% Fertilizer dose
T ₂	75% ND + 25% N through Farm yard manure (FYM)
T ₃	75% ND + 25% N through Vermicompost (VC)
T ₄	75% ND + 25% N through Neem cake (NC)
T ₅	50% ND + 50% N through Farm yard manure (FYM)
T ₆	50% ND + 50% N through Vermicompost (VC)
T ₇	50% ND + 50% N through Neem cake (NC)
T ₈	50% ND + 50% N through FYM + Seed treatment (Azotobacter + PSB)
T ₉	50% ND + 50% N through VC + Seed treatment (Azotobacter + PSB)
T ₁₀	50% ND + 50% N through NC + Seed treatment (Azotobacter + PSB)
T ₁₁	Absolute control

Note:

ND=Nitrogen Dose

100% Fertilizer dose = 60:40:40 (N:P₂O₅:K₂O kg ha⁻¹), 7.5 tons FYM ha⁻¹
100% P₂O₅, K₂O and FYM common for all the treatments except for absolute control

Table 1. Initial physico-chemical properties of the soil from the experimental site

Particular	Value	Method followed
A. Mechanical properties		
1. Sand %	53.08	International Pipette method [4]
2. Silt %	23.27	
3. Clay %	23.65	
4. Textural classes	Sandy Clay Loam	
5. Taxonomical class	Typic haplustepts	
5. Bulk density (Mg m ⁻³)	1.41	Keen's cup method [4]
6. Maximum water holding capacity (%)	30.44	
B. Chemical properties		
1. Soil pH (1:2.5)	6.33	pH Meter [5]
2. Electrical Conductivity (d Sm ⁻¹) at 25°C (1:2.5)	0.24	EC meter [5]
3. Organic Carbon (per cent)	0.46	Walkley and Black's method [6]
4. Available N (kg ha ⁻¹)	294.52	Alkaline KMnO ₄ method [7]
5. Available P ₂ O ₅ (kg ha ⁻¹)	26.86	Bray's method [8]
6. Available K ₂ O (kg ha ⁻¹)	151.62	Neutral normal NH ₄ OAC method [9]
7. Exchangeable Ca [c mol (p ⁺) kg ⁻¹]	2.38	Versenate titration method [5]
8. Exchangeable Mg c mol (p ⁺) kg ⁻¹	1.46	Versenate titration method [5]
9. Available S (mg kg ⁻¹)	13.72	Turbidometry extraction method [10]
14. Available B (mg kg ⁻¹)	0.32	Hot water-soluble extraction method [11]
10. DTPA extractable Fe (mg kg ⁻¹)	5.62	Atomic Absorption spectrophotometry
11. DTPA extractable Mn (mg kg ⁻¹)	3.00	[12]
12. DTPA extractable Zn (mg kg ⁻¹)	0.56	
13. DTPA extractable Cu (mg kg ⁻¹)	0.66	

2.1 Collection of Soil Samples and Methodology for Soil Analysis

Soil samples at a plough layer depth (0-15 cm depth) were obtained from each of the experimental site's thirty-three plots after the crop's harvest. The samples obtained were dried in shade, rendered with a pestle and motor to ground, passed through 2 mm sieve, and placed in polythene bags. The soil samples that were initially obtained are examined for different physical and chemical characteristics using standard techniques after quinoa harvest.

2.2 Statistical Analysis of Data

The comparative study of experimentally collected results was carried out by implementing Fisher's system of measurement of variance as described by Panse and Sukhatme [13]. The significance level ($p < 0.05$) used in the 'F' evaluation was offered at 5%. Critical difference (CD) values are presented at a significance level of 5%, wherever the 'F' measure was found to be relevant at 5%.

3. RESULTS AND DISCUSSION

3.1 Bulk Density (Mg m^{-3}) and Maximum Water Holding Capacity (MWHC) (%) Status of Soil After the Harvest of Quinoa

The data presented in Table 2. pertains to the post-harvest maximum water holding capacity and bulk density of soil in relation to different integrated nutrient management practices applied during quinoa cultivation.

The recorded MWHC percentage of the soil after harvest ranged from 31.40% to 40.01%. The findings underscore the substantial influence of integrated nutrient management practices on the soil's MWHC. Notably, the MWHC varied among treatments employing diverse nutrient management strategies. In particular, treatment T₈ (50% ND + 50% N through FYM + seed treatment (Azotobacter + PSB)) exhibited the highest MWHC percentage at 40.01% in compare with treatment T₁ receiving 100% fertilizer dose, showed the less MWHC *i.e.*, 32.30%.

On the other hand, bulk density of soil after harvest of quinoa crop were not significantly

altered, though not significantly but bulk density of soil decreased positively with the increasing rate of use of organic manures over 100% inorganic fertilizer dose, while maximum water holding capacity had increased significantly in all the combinations of organic and inorganic treatments over 100% fertilizer dose.

Integrated Nutrient Management practices has had a significant ($p < 0.05$) influence on the physical properties of soil *viz.*, maximum water holding capacity and recorded higher maximum water holding capacity values over the rest of treatments. This may be attributed to the organic matter provides more surface for absorption and adsorption of water molecules in micro and macro pores, respectively accordance with Kleber et al. [14].

3.2 pH and Electrical Conductivity (dS m^{-1}) of Soil after the Harvest of Quinoa

The results regarding soil pH following the harvest of quinoa crops under the influence of integrated nutrient management techniques is presented in Table 3. The dataset illustrates that the pH of the soil after harvest ranged from 6.09 to 6.43. The findings suggest that the integrated nutrient management practices did not exert a significant impact on soil pH. Nonetheless, the treatment T₈ (50% ND + 50% N through FYM + seed treatment (Azotobacter + PSB)) exhibited a numerically higher soil pH of 6.43 compared to treatment T₁, which received the full 100% fertilizer dose and recorded the lowest soil pH of 6.09.

The experimental results information regarding soil electrical conductivity (dSm^{-1}) subsequent to the quinoa crop harvest, influenced by integrated nutrient management practices, is outlined in Table 3. The data within Table 3. unambiguously demonstrate that the integrated nutrient management practices did not exert a significant impact on the electrical conductivity of the soil after harvest. Nevertheless, the treatment T₁₁, representing the absolute control, displayed the lowest numerical value for electrical conductivity (0.23 dSm^{-1}). This was in contrast to treatment T₁ (100% Fertilizer dose), which exhibited the highest electrical conductivity value (0.28 dSm^{-1}).

The data presented in Table 3. indicates that pH and EC in soil, after the harvest of quinoa crop

were not significantly altered by integrated nutrient management practices. pH and EC of surface soil at harvest did not differ significantly over initial values as the duration of the crop is less, the basic soil properties like pH and EC will

not change significantly by application of low quantities of manures and fertilizers. These results are in line with the findings of Arbad et al. (2008) in sweet sorghum and Divya et al. [15] in pearl millet.

Table 2. Effect of integrated nutrient management on bulk density and maximum water holding capacity status of soil after the harvest of quinoa

Treatments	Bulk Density	Maximum Water Holding Capacity
	Mg m ⁻³	%
Initial	1.41	30.44
T ₁ 100 % Fertilizer dose	1.40	32.30
T ₂ 75 % ND + 25 % N through Farm yard manure (FYM)	1.38	37.94
T ₃ 75 % ND + 25 % N through Vermicompost (VC)	1.38	34.50
T ₄ 75 % ND + 25 % N through Neem cake (NC)	1.39	33.20
T ₅ 50 % ND + 50 % N through Farm yard manure (FYM)	1.36	39.48
T ₆ 50 % ND + 50 % N through Vermicompost (VC)	1.37	35.97
T ₇ 50 % ND + 50% N through Neem cake (NC)	1.37	34.90
T ₈ 50 % ND + 50 % N through FYM + Seed treatment (Azotobacter + PSB)	1.34	40.01
T ₉ 50 % ND+ 50 % N through VC + Seed treatment (Azotobacter + PSB)	1.35	36.91
T ₁₀ 50% ND + 50 % N through NC + Seed treatment (Azotobacter + PSB)	1.36	35.82
T ₁₁ Absolute control	1.41	31.40
SEm ±	0.05	1.22
CD (P=0.05)	NS	3.61

Table 3. Effect of integrated nutrient management on pH, electrical conductivity and organic carbon status of soil after the harvest of quinoa

Treatments	pH	EC	Organic Carbon
		dSm ⁻¹	%
Initial	6.33	0.24	0.46
T ₁ 100 % Fertilizer dose	6.09	0.28	0.48
T ₂ 75 % ND + 25 % N through Farm yard manure (FYM)	6.23	0.27	0.50
T ₃ 75 % ND + 25 % N through Vermicompost (VC)	6.22	0.27	0.52
T ₄ 75 % ND + 25 % N through Neem cake (NC)	6.22	0.26	0.49
T ₅ 50 % ND + 50 % N through Farm yard manure (FYM)	6.39	0.26	0.52
T ₆ 50 % ND + 50 % N through Vermicompost (VC)	6.39	0.25	0.57
T ₇ 50 % ND + 50% N through Neem cake (NC)	6.37	0.25	0.50
T ₈ 50 % ND + 50 % N through FYM + Seed treatment (Azotobacter + PSB)	6.43	0.26	0.55
T ₉ 50 % ND+ 50 % N through VC + Seed treatment (Azotobacter + PSB)	6.42	0.26	0.59
T ₁₀ 50% ND + 50 % N through NC + Seed treatment (Azotobacter + PSB)	6.41	0.25	0.54
T ₁₁ Absolute control	6.30	0.23	0.45
SEm ±	0.22	0.19	0.02
CD (P=0.05)	NS	NS	0.05

3.3 Soil Organic Carbon (%) of Soil after the Harvest of Quinoa

Organic carbon levels (%) in the soil subjected to the integrated nutrient management practices after the quinoa harvest as detailed in Table 3. The dataset indicates a range of 0.45% to 0.59% for organic carbon content in the post-harvest soil. The findings highlight a significant impact of integrated nutrient management practices on the percentage of soil organic carbon across various treatments following the quinoa harvest. Remarkably, the treatment labelled as T₉ (50% ND + 50% N through vermicompost + Seed treatment (Azotobacter + PSB)) recorded the highest organic carbon content at 0.59% in compare to the organic carbon content in treatment T₁ (100% fertilizer dose) which recorded value of 0.48%.

With the application of treatment T₉ *i.e.*, 50% ND + 50% N through vermicompost + seed treatment (Azotobacter + PSB) organic carbon content has significantly increased among the treatments. Because vermicompost being a completely decomposed it contributes more amount of carbon to soil and enhances the microbial activity which increases the decomposition rate of plant residue and improves the organic carbon content of the soil. These results were in accordance with Sahoo [16].

3.4 Available Major Nutrients (kg ha⁻¹) Status of Soil after the Harvest of Quinoa

Integrated nutrient management practices influence on available nitrogen, phosphorus and potassium (kg ha⁻¹) in soil after harvest of quinoa crop presented in Table 4. Among the treatments, significantly highest available nitrogen, phosphorus and potassium 361.79, 39.45 and 173.86 (kg ha⁻¹) noticed in treatment T₉ (50% ND + 50% N through vermicompost + Seed treatment (Azotobacter + PSB)), when compare to treatment T₁ (100% Fertilizer dose) was recorded significantly less available nitrogen (305.03, 30.53 and 145.66 kg ha⁻¹).

Data showing available N, P₂O₅ and K₂O of soil after the harvest of quinoa was presented in Table 4. It revealed that, available major nutrients were significantly influenced by different treatments. The greater accessibility of nitrogen might be attributed to the combination of added mineral fertilizer N and organic sources along with biofertilizers. This combination likely played a role in reducing the carbon-to-nitrogen (C:N) ratio, increasing microbial population thereby expediting the decomposition rate. As a result, nutrients from the manures became available more rapidly. This pattern of outcomes aligns with findings from studies conducted by Desai et al. [17] and Negi [18].

Table 4. Effect of integrated nutrient management on available major nutrients (nitrogen, phosphorus and potassium) status of soil after the harvest of quinoa

Treatments	Available Nitrogen	Available Phosphorus	Available Potassium
	kg ha ⁻¹		
Initial	294.52	26.86	151.62
T ₁ 100 % Fertilizer dose	305.03	30.53	145.66
T ₂ 75 % ND + 25 % N through Farm yard manure (FYM)	311.26	31.23	148.41
T ₃ 75 % ND + 25 % N through Vermicompost (VC)	320.34	32.07	154.89
T ₄ 75 % ND + 25 % N through Neem cake (NC)	315.51	31.86	152.04
T ₅ 50 % ND + 50 % N through Farm yard manure (FYM)	327.62	33.41	157.45
T ₆ 50 % ND + 50 % N through Vermicompost (VC)	340.44	35.15	162.86
T ₇ 50 % ND + 50% N through Neem cake (NC)	333.92	34.94	160.76
T ₈ 50 % ND + 50 % N through FYM + Seed treatment (Azotobacter + PSB)	348.53	35.89	166.72
T ₉ 50 % ND+ 50 % N through VC + Seed treatment (Azotobacter + PSB)	361.79	39.45	173.86
T ₁₀ 50% ND + 50 % N through NC + Seed treatment (Azotobacter + PSB)	354.86	37.67	170.45
T ₁₁ Absolute control	282.87	23.76	140.79
SEm ±	11.49	1.19	5.52
CD (P=0.05)	33.84	3.50	16.27

The increased availability of phosphorus could be attributed to the liberation of organic acids during the microbial breakdown of organic substances [19]. These acids likely aided in making native phosphates more soluble, consequently boosting the accessibility of phosphorus. The introduction of organic matter might have facilitated the creation of a layer on the sesquioxide clay minerals, this coating could be the reason behind the diminished capacity of the soil to bind phosphates in plots treated with manure. Comparable outcomes were documented in studies conducted by Sahoo (2020) and Varalakshmi (2005).

The distribution of potassium between non-exchangeable and exchangeable forms is configured in a way that sustains potassium availability throughout the growth period. The positive impact of organic materials and higher microbial population on accessible potassium levels can be attributed to the reduction in potassium fixation and the subsequent release of potassium due to the interaction between organic matter and clay minerals. This interaction goes beyond direct potassium supplementation to the soil's potassium reservoir [17].

4. CONCLUSION

From the present study, it has been observed that integrated use of biofertilizers, organic manures and chemical fertilizers in appropriate combination resulted in the best nutrient management practice. Application of inorganic, bio and organic source of nutrients in right proportions had increased the soil major nutrient availability and also improved the physico-chemical properties of post-harvest soil. Among the different organic treatments in combination with inorganic, vermicompost with seed treatment had a greater effect on soil properties. From the study it is concluded that quinoa is responsive to vermicompost as organic fertilizer that was most effective when applied on sandy clay loam, In addition to its remarkable impact in improving soil properties, soil fertility and soil health management.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input

prompts provided to the generative AI technology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bhargava A, Sudhir S, Deepak O. Quinoa (*Chenopodium quinoa* Willd.). An Indian perspective. Ind. Crops Prod. 2006;23(1s): 73-87.
2. Bhatt MK, Labanya R, Joshi HC. Influence of long-term chemical fertilizers and organic manures on soil fertility-A review. Universal Journal of Agricultural Research. 2019;7(5):177-188.
3. Paramesh V, Mohan Kumar R, Rajanna GA, Gowda S, Nath AJ, Madival Y, Toraskar S. Integrated nutrient management for improving crop yields, soil properties, and reducing greenhouse gas emissions. Frontiers in Sustainable Food Systems. 2023;7:1173258.
4. Piper CS. Soil and plant analysis, Hans Pub: Bombay. 1966;7:368-369.
5. Jackson ML. Soil chemical analysis. Prentice Hall of India, New Delhi. 1973;1: 485-486.
6. Walkley AJ, Black IA. An examination of wet acid method for determining soil organic matter and proposed modification of chromic acid titration method. J. Soil Sci. 1934;37:29-38.
7. Subbaiah AY, Asija GK. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956;25:270-280.
8. Bray RH, Kurtz LT. Determination of total, organic, and available forms of phosphorus in soils. Soil Sci. 1945;59(1):39-46.
9. Page AL, Miller RH, Kenay DR. Methods of Soil Analysis, part – 2, Soil Science Society of America, Inc, Publishers, Madison, Wisconsin, USA; 1982.
10. Black CA. Methods of soil analysis part-1 physical and mineralogical properties. Agronomy Monograph No. 9. American Soc. Agron. Madison, Wisconsin, USA. 1965;7:18–25.
11. John H, Lindsay BU, Sawada Y. Assessment of plant-available boron in some New Zealand soils. J. Agricul. Res. 1975;26(2):191-195.
12. Lindsay WL, Norwell WA. Development of DTPA soil test for zinc, iron, manganese

- and copper. Soil Sci. Soc. Amer. J. 1978; 42:421-428.
13. Panse VC, Sukhatme PV. Statistical methods for agricultural workers. III Rev. New Delhi: ICAR; 1978.
 14. Kleber M, Bourg IC, Coward EK, Hansel CM, Myneni SC, Nunan N. Dynamic interactions at the mineral–organic matter interface. Nature Reviews Earth & Environment. 2021;2(6):402-421.
 15. Divya G, Vani KP, Babu PS, Devi KS. Yield attributes and yield of summer pearl millet as influenced by cultivars and integrated nutrient management. Int. j. curr. microbiol. appl. Sci. 2017;6(10): 491-1495.
 16. Ipsita Sahoo. Response of foxtail millet (*Setaria italica*) varieties to integrated nutrient management. M. Sc. (Agri.) Thesis, Professor Jayashankar Agricultural University, Hyderabad, Telangana; 2020.
 17. Desai LJ, Patel MM, Patel BM. Soil health management through integrated nitrogen management in Grain Amaranth (*Amaranthus hypochondriacus* L.). J. Agron. 2013;24(112):39-41.
 18. Negi MS. Integrated Nutrient Management (INM) in rainfed finger millet (*Eleusine coracana* L.) under tarai condition of Uttarakhand. Doctoral dissertation, GB Pant University of Agriculture and Technology, Pantnagar, 263145; 2017.
 19. Pallavi C, Joseph B, Khan MA, Hemalatha S. Effect of integrated nutrient management on nutrient uptake, soil available nutrients and productivity of rainfed finger millet. Int. J. of Sci., Env. and Tech. 2016;5(5):2798-2813.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/122224>