Nutrient Uptake and Quality of Finger Millet as Influenced by Organic Nutrient Management

K. Ravi Kumar[1*]; B. Rajendra Kumar[2]; D. Shekhar[3]; S. Govinda Rao[4]

[*1]P.G Student, Department of Agronomy, Agricultural College, Naira, ANGRAU
[2]Associate Professor, Department of Agronomy, Agricultural College, Naira, ANGRAU
[3]Professor, Department of Agronomy, Agricultural College, Rajamahendravaram, ANGRAU
[4]Assistant Professor, Department of Statistics and Computer Applications, Agricultural College, Naira, ANGRAU
*Corresponding Author

Received:- 09 September 2025/ Revised:- 15 September 2025/ Accepted:- 22 September 2025/ Published: 30-09-2025

Abstract— *A field experiment was conducted during rabi2023-24 at Agricultural College Farm, Naira, Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The experiment was laid out in a split-plot design and replicated thrice. The finger millet variety Indravathi (CFMV 1) was tested in the present experiment. Application of 100% RDF (60:30:30 NPK kg ha^{-1}) recorded significantly higher nutrient uptake by plant, straw and grain over the rest of the nutrient treatments. Among the organic nutrient foliar sprays, foliar application of Panchagavya spraying twice @ 3% at tillering and flowering stages was found to be the best over other three organic foliar sprays tried under organic finger millet cultivation. Application of 100% RDN through Poultry manure (M_3) recorded significantly higher soil microbial population i.e., total count of bacteria, fungi and actinomycetes, which was however comparable with application of 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure (M_2). Among the foliar sprays, application of Liquid Azospirillum+ PSB+ KRB+ ZnSB@1.25L ha^{-1}biofertilizer consortium by root dipping at transplanting (S_1) recorded. Significantly the highest protein content in grain was recorded with the application of 100% RDF (60:30:30 NPK kg ha^{-1})(M_1), which was superior over the rest of treatments applied and the lowest protein content was recorded with application of 100% RDN through Poultry manure (M_3).*

***Keywords*— Recommended dose of nitrogen, Poultry manure, Finger millet, Vermiwash and Panchagavya, Dry matter production.**

I. INTRODUCTION

Millet crops are indigenous to India and are often referred to as "Nutri-Cereals" because they provide essential nutrients vital for proper bodily function. India, particularly the semi-arid regions including Andhra Pradesh, has long been a hub for millet production. Finger millet, also known as ragi, holds particular importance as a staple food and a dryland crop. It has been part of the diet in India for thousands of years, and its cultivation continues to support agricultural systems, especially in areas where other crops may struggle due to water scarcity and poor soil conditions (Tripathi *et al.,* 2023).

Finger millet is a key small millet crop, predominantly cultivated in regions with erratic rainfall and marginal soils. In India, Finger milletis the third most important millet, next to sorghum and pearl millet, grown over an area of 10.37 lakh hectares with an annual production of 13.86 lakh tonnes and productivity of 1336 kg ha^{-1}. Karnataka is the leading Finger millet producer in India followed by Tamilnadu and Maharashtra states. In Andhra Pradesh, it is cultivated in an area of 27,000 hectares with a production of 33,000 tonnes having productivity of 1222 kg ha^{-1} (Directorate of Agriculture and Farmers' Welfare, 2023-24).

Organic farming, which prohibits the use of synthetic fertilizers and chemicals, offers an alternative approach. In organic systems, crop nutrient requirements are met through organic inputs and biological processes. This method prioritizes the restoration and maintenance of soil fertility and health, promoting sustainability over the long term. Farmers are increasingly recognizing the benefits of organic farming in terms of improved soil quality, enhanced sustainability and long-term productivity. By diversifying and making better use of these resources, farmers can improve soil fertility, reduce dependence on external inputs and move towards more sustainable farming systems.

To address the slow release of nutrients from bulky organic manures, foliar nutrition offers an effective solution by providing nutrients directly to the site of metabolism. This allows for the translocation of nutrients during peak periods of crop growth, promoting more efficient absorption through the leaves, where plants are often able to absorb nutrients more effectively than through their roots. As a result, organic foliar supplementation is considered safe for crops (Sujatha*et al.*, 2016). Various types of foliar sprays, such as vermiwash, panchagavya and jeevamrutham have proven to be excellent means of addressing micronutrient deficiencies in organic farming. Additionally, they contain a diverse range of micro-organisms that not only support plant growth but also help restore soil fertility by activating biological reactions. This microbial diversity in the foliar sprays acts as a plant growth stimulant, enhancing crop productivity and resilience (Swaminathan, 2005 & Sreenivasa *et al.*, 2011).

II. MATERIALS AND METHODS

A field experiment was conducted during *rabi*2023-24 at Agricultural College Farm, Naira, Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The soils of the experimental site were sandy clay loam in texture, neutral in reaction, low in organic carbon (0.49%) and available nitrogen (221 kg ha^{-1}), medium in phosphorus (22.7 kg ha^{-1}) and potassium (245 kg ha^{-1}) having 7.2soil pH with EC 0.25 dSm^{-1}.

The experiment was laid out in a split-plot design and replicated thrice. The treatments consisted of three (inorganic and organic) nutrient sources *viz*M_1: 100% RDF (60:30:30 NPK $kgha^{-1}$), M_2: 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure and M_3: 100% RDN through Poultry manure assigned to main plots, four foliar sprays *viz.*, S_1: Liquid *Azospirillum*+PSB+KRB+ZnSB@1.25 L ha^{-1}biofertilizer consortium by root dipping at transplanting, S_2: Vermiwash spraying twice @ 5% at tillering and flowering stages, S_3: Panchagavya spraying twice @ 3% at tillering and flowering stages andS_4: Jeevamrutham spraying twice @ 10% at tillering and PI stages were allotted to sub plots. The finger millet variety Indravathi (CFMV 1) was tested in the present experiment. The total cost of cultivation of finger millet ($Rsha^{-1}$) was calculated for treatment on the basis of inputs used. Gross returns ($Rsha^{-1}$) were computed by considering the prevailing market price of the output. Net returns ($Rsha^{-1}$) were arrived at by deducting the cost of cultivation of respective treatments from gross returns for the corresponding treatments.

The data recorded on various parameters of finger millet was analyzed statistically by following the analysis of variance for split-plot design as suggested by Panse and Sukhatme (1985). Statistical significance was tested with 'F' test at 5 per cent level of probability and whenever the 'F' value was found significant, critical difference (CD) was worked out at 5 per cent level of probability the treatment means were compared with critical difference.

III. RESULTS AND DISCUSSION

Nutrient uptake of finger millet recorded at 60 DAT and at harvest was significantly influenced by various organic, inorganic sources and foliar sprays. Nutrient uptake of finger millet inclined to increase steadily with advance in the age of the crop up to harvest. The trend of nutrient uptake in response to organic nutrient management practices was similar at all the stages of observations. During the study, among the organic and inorganic sources, significantly the highest nutrient (nitrogen, phosphorus and potassium) uptake by plant was observed with application of 100% RDF (60:30:30 NPK kg ha^{-1}) (M_1). Application of 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure (M_2) is the next best nutrient uptake treatment and was comparable with each other. The lowest nutrient uptake was recorded with application of100% RDN- Poultry manure (M_3). The higher nutrient uptake in inorganic treated plots is due to the higher availability when compared to the organic plot. The uptake of nitrogen and zinc were found significantly high in conventional plot when compared to organic plot. This could be primarily due to increased availability of the nutrients in the crop root zone resulted in increased absorption of the elements by the plants as well as higher dry matter production.

Among the foliar sprays, significantly the highest nutrient uptake was observed with Panchagavya spraying twice @ 3% at tillering and flowering stages (S_3) followed by Vermiwash spraying twice @ 5% at tillering and flowering stages(S_2), which was however comparable with Jeevamrutham spraying twice @ 10% at tillering and PI stages (S_4). Significantly the lowest nutrient uptake was noticed with Liquid *Azospirillum*+PSB+KRB+ZnSB@1.25 L ha^{-1}biofertilizer consortium by root dipping at transplanting (S_1). The increase in uptake of nutrients with inorganic fertilizers might be due to better availability of nutrient which leads to increase nutrient uptake. This could be ascribed primarily due to increased availability of the nutrients in the crop root zone that resulted in increased absorption of the elements by the plants as well as higher dry matter production. These results are in line with the Singh *et al. (*2009) and Vajantha *et al*. (2017).

The N uptake by grain was significantly higher with inorganic treated plot than organic plot. The P, K and Zn uptake by grain and protein content were significantly affected by organic and inorganic treatments. The higher nutrient uptake with inorganic fertilizers may be due to high nutrient in grain coupled with higher grain yield (Somasundarm *et al*. 2020 and Vajantha *et al*. 2017). The elevated uptake of N, P and K may be due to enhanced biological efficiency in crop plants with foliar spray of panchagavya, and jeevamrut creating a more significant source and sink in the plant system, that leads to better nutrient uptake. Above findings are in conformity with Sonawane *et al*. (2024).

Significantly the higher Zn uptake was observed with 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure and is at par with the application of 100% RDF (60:30:30 NPK kg ha^{-1}). The lowest Zn uptake was noticed with 100% RDN through Poultry manure at 60 DAT and harvest. Among foliar sprays highest Zn uptake was recorded with the application of Panchagavya spraying twice @ 3% at tillering and flowering stages and it was on par with Vermi wash spraying twice @ 5% at tillering and flowering stages and Jeevamrutham spraying twice @ 10% at tillering and PI stages at both 60 DAT and harvest.

The highest nutrient (nitrogen, phosphorus, potassium and Zn) uptake by grain and straw was significantly observed with application of 100% RDF (60:30:30 NPK kg ha^{-1}) (M_1). Application of 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure (M_2) is the next best nutrient uptake treatment and was comparable with each other. Among the foliar sprays, significantly the highest nutrient uptake (NPK and Zn) was observed with Panchagavya spraying twice @ 3% at tillering and flowering stages (S_3) followed by Vermiwash spraying twice @ 5% at tillering and flowering stages(S_2), which was however comparable with Jeevamrutham spraying twice @ 10% at tillering and PI stages(S4). Significantly the lowest nutrient uptake was noticed with Liquid *Azospirillum*+PSB+KRB+ZnSB@1.2 L ha^{-1}biofertilizer consortium by root dipping at transplanting (S_1). The yield obtained could be attributed to the combined impact of growth attributes and favorable yield characteristics when provided with sufficient nutrients by organic and inorganic nutrient sources. This encourages the photosynthesis and eventually better partitioning to the sink. These findings are in accordance with Sonewane *et al*. (2024). The possible reasons for increase in nutrient content and uptake by finger millet may be due to ready assimilation of plant nutrients by crop, these plant liquid organics also contain different plant growth promoting substances which results in good crop growth. These findings are in close agreement with those reported by Dholariya *et al.* (2022).

TABLE 1
N PK Zn uptake (Kg ha^{-1}) by plant at maturity and N P K Zn uptake (Kg ha^{-1}) by grain and straw by finger millet as influenced by different organic, inorganic sources and foliar sprays

Treatments	Uptake by plant at maturity				Uptake by grain and straw							
	N	P	K	Zn	N		P		K		Zn	
Fertilizer levels (RDF:60:30:30 kg ha^{-1})					**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
M_1: 100% RDF (60:30:30 NPK kg ha^{-1})	105.5	32.9	109.6	156.6	52.1	48.2	14.3	11.4	40.7	65.6	67.2	94.3
M_2: 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure	104.4	30	106.6	178.1	49.7	45.5	13.7	10.2	38.4	60.8	62.2	93.1
M_3: 100% RDN through Poultry manure	76	28.9	95.8	148.9	37.6	37.5	11.4	9.1	36.6	50.7	61.2	84.9
SEm (±)	2.4	0.79	2.65	4.71	1.1	1.18	0.33	0.2	0.7	1.1	1.1	1.7
CD *(p=0.05)*	9.5	3.1	10.4	18.4	4.5	4.6	1.2	1.1	2.7	4.5	4.4	6.7
CV (%)	8.8	8.9	8.8	10.1	8.6	9.3	8.6	9.5	6.3	6.8	6.2	6.5
Four liquid organic manures												
S_1:Liquid*Azospirillum*+PSB+KRB+ZnSB@1.25 L ha^{-1} biofertilizer consortium by root dipping at transplanting	88.2	28.5	101	143.3	43.2	40.2	12.2	9.3	37.2	56.1	59.4	87
S_2: Vermiwash spraying twice @ 5% at tillering and flowering stages	97.6	31.2	100.5	173.4	48	44.78	13.67	10.29	38.44	60.78	64.67	92
S_3: Panchagavyaspraying twice @ 3% at tillering and flowering stages	101.5	32.7	111.6	169	49.89	47.78	14.44	11.57	41.11	62.33	68.56	95.89
S_4: Jeevamruthamspraying twice @ 10% at tillering and PI stages	93.8	30.1	102.7	159.2	45	42.22	12.33	9.89	37.67	57.11	61.67	88.33
SEm (±)	2.42	0.87	2.91	5.01	0.98	0.96	0.59	0.39	0.94	1.54	2.12	2.08
CD *(p=0.05)*	7.19	2.55	8.64	14.88	2.9	2.86	1.75	1.17	2.78	4.57	6.29	6.18
CV (%)	7.62	8.54	8.39	9.31	6.3	6.61	13.44	11.51	7.27	7.81	9.98	6.87
Interaction												
S at M												
SEm (±)	4.19	1.51	5.04	8.67	1.69	1.67	1.02	0.68	1.62	2.66	3.66	3.6
CD *(p=0.05)*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at S												
SEm (±)	4.37	1.53	5.11	8.86	1.87	1.86	1.33	0.65	0.57	2.58	3.37	3.56
CD *(p=0.05)*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

TABLE 2
Microbial population and protein content (%) as influenced by different doses of RDF and liquid organic manures

Treatments	Soil microbial counts			Protein content (%)
	Bacteria (No. x 10^6 CFU g^{-1})	Fungi (No. x 10^4 CFU g^{-1})	Actinomycetes (No. x 10^3 CFU g^{-1})	
Fertilizer levels (RDF:60:30:30 kg ha^{-1})				
M_1: 100% RDF (60:30:30 NPK kg ha^{-1})	28.42	14.56	13.47	11.13
M_2: 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure	29.74	15.43	15.19	11.49
M_3: 100% RDN through Poultry manure	32.7	17.08	15.72	10.71
SEm (±)	0.66	0.37	0.26	0.36
CD *(p=0.05)*	2.6	1.46	1.03	1.43
CV (%)	7.58	8.23	6.15	11.34
Four liquid organic manures				
S_1: Liquid *Azospirillum*+PSB+KRB+ZnSB@1.25 L ha^{-1}biofertilizer consortium by root dipping at transplanting	32.09	16.67	15.54	10.04
S_2: Vermiwash spraying twice @ 5% at tillering and flowering stages	29.35	15.35	14.49	11.33
S_3: Panchagavyaspraying twice @ 3% at tillering and flowering stages	30.68	15.72	15.16	12.49
S_4: Jeevamruthamspraying twice @ 10% at tillering and PI stages	29.04	15.02	13.98	10.59
SEm (±)	0.71	0.37	0.37	0.31
CD *(p=0.05)*	2.12	1.11	1.09	0.91
CV (%)	7.05	7.13	7.42	8.26
Interaction				
S at M				
SEm (±)	1.23	0.65	0.63	0.53
CD *(p=0.05)*	NS	NS	NS	NS
M at S				
SEm (±)	1.26	0.67	0.61	0.59
CD *(p=0.05)*	NS	NS	NS	NS

Application of 100% RDN through Poultry manure (M_3) recorded significantly higher soil microbial population *i.e.*, total count of bacteria, fungi and actinomycetes, which was however comparable with application of 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure (M_2). Among the foliar sprays, application of Liquid *Azospirillum*+PSB+ KRB+ ZnSB@1.25L ha^{-1}biofertilizer consortium by root dipping at transplanting(S_1) recorded significantly higher soil microbial count followed by Panchagavya spraying twice @ 3% at tillering and flowering stages (S_3) and vermiwash spraying twice @ 5%at tillering and flowering stages(S_2). The lowest soil microbial count was noticed under Jeevamrutham spraying twice @ 10% at tillering and PI stages (S_4). Organic manures not only help to supply the nutrients but also act as a food for microorganisms and encourage the multiplication of their population which in turn improve the mineralization of nutrients in soil and thus fertility and productivity of soil will be improved. Also Basavarajappa *et.al*. (2002) reported similar observations, indicating the use of organics in increasing the yield and soil health as well. In general, organic manures, beside causing overall improvement in the soil health, increased activity and number of soil microorganism by feeding them.

Increase in protein content may be due to increase in carbohydrate production during photosynthesis. In the present investigation significantly the highest protein content in grain was recorded with the application of 100% RDF (60:30:30 NPK kg ha^{-1})(M_1), which was superior over the rest of treatments applied and the lowest protein content was recorded with application of 100% RDN through Poultry manure(M_3). The higher protein content in finger millet grain was mainly due to increased concentration of nutrient in the soil solution thereby uptake of nitrogen and phosphorus with application of 100% RDF compared to other sources. The protein content in grain is in fact a manifestation of nitrogen concentration in grain. Since phosphorus improves quality parameter by regulating the photosynthesis, respiration, root enlargement and carbohydrate metabolism, thus increased the protein content.

Among various foliar sprays studied, Panchagavya spraying twice @ 3% at tillering and flowering stages(S_3) recorded significantly the highest protein content (10.04 %) followed by Vermiwash spraying twice @ 5% at tillering and flowering stages (S_2). This might be because of well- known fact that nitrogen is the precursor of protein. Higher protein content under mixed application of liquid manures might be due to greater availability and uptake of nitrogen and translocation in finger millet seeds. The results are in accordance with Biswas and Das (2024).

IV. CONCLUSIONS

Application of 100% RDF (60:30:30 NPK kg ha^{-1}) recorded significantly higher nutrient uptake by plant, straw and grain over the rest of the nutrient treatments. Among the organic nutrient foliar sprays, foliar application of Panchagavya spraying twice @ 3% at tillering and flowering stages was found to be the best over other three organic foliar sprays tried under organic finger millet cultivation.

Application of 100% RDN through Poultry manure (M_3) recorded significantly higher soil microbial population *i.e.*, total count of bacteria, fungi and actinomycetes, which was however comparable with application of 50% RDF (NPK kg ha^{-1}) + 50% RDN through Poultry manure (M_2). Among the foliar sprays, application of Liquid *Azospirillum*+PSB+ KRB+ ZnSB@1.25L ha^{-1}biofertilizer consortium by root dipping at transplanting(S_1) recorded.

Significantly highest protein content in grain was recorded with the application of 100% RDF (60:30:30 NPK kg ha^{-1}) (M_1) and the lowest protein content was recorded with application of 100% RDN through Poultry manure (M_3).

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