Nutrient uptake and quality parameters of finger millet as influenced by crop residue composting

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Abstract
A field experiment was conducted during \textit{rabi}, 2018-19 at Students Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The experimental soil was sandy clay loam texture with pH 7.46, EC 0.36 dS m\textsuperscript{-1} and OC (0.67\%). The soil was low in available nitrogen (260.0 kg ha\textsuperscript{-1}), medium in available phosphorus (45.1 kg ha\textsuperscript{-1}) and high in available potassium (521.0 kg ha\textsuperscript{-1}). The experiment was laid out in a randomized block design with eight treatments and replicated thrice. The results revealed that, conjunctive use of inorganics and organics through crop residue composting significantly influenced the nutrient uptake and quality parameters of finger millet. Application of 75\% RDN + 25\% N through cotton stubbles vermicompost + 2\% rockphosphate recorded significantly higher grain (3540 kg ha\textsuperscript{-1}) and straw yield (5899 kg ha\textsuperscript{-1}). The lowest grain (1453 kg ha\textsuperscript{-1}) and straw yield (3737 kg ha\textsuperscript{-1}) were recorded with control plot that consisted of no nitrogen application. Similarly, significantly higher NPK uptake (51.0, 5.5 and 21.9 kg ha\textsuperscript{-1}) by grain and straw (56.0, 25.1 and 102.6 kg ha\textsuperscript{-1}) was recorded with application of 75\% RDN+ 25\% N through cotton stubbles vermicompost + 2\% rockphosphate followed by T\textsubscript{5} treatment - 75\% RDN + 25\% N through cotton stubbles vermicompost. Quality parameters viz., calcium (0.44\%), iron (85.2 ppm), zinc (32.0 ppm) and crude protein content (9.0\%) in grain were also higher with the application of 75\% RDN + 25\% N through cotton stubbles vermicompost + 2\% rockphosphate over rest of the treatments and the treatment was comparable with 75\% RDN +25\% N through cotton stubbles vermicompost.

Keywords: Finger millet, integrated nutrient management, crop residue composting, redgram and cotton stubbles vermicompost, FYM and vermicompost. Nutrient uptake and quality parameters of finger millet.

Introduction
Finger millet (\textit{Eleusine coracana} L. Gaertn) commonly known as “nutritious millet” is the fourth important small millet crop grown globally after sorghum, pearl millet and foxtail millet. Finger millet was domesticated in western Uganda and the Ethiopian highlands atleast 5000 years ago before introduction to India approximately 3000 years ago. It is called finger millet, because the inflorescence resembles the fingers of a human hand.

Finger millet, \textit{E. coracana} L. is also known as ragi and mandua (India); kaddo (Nepal); fingerhirse (Germany); petit mil, eleusine cultivee, coracan, koracan (France); bulo (Uganda); kambale, lupoko, mawele, amale, bule (Zambia); poho, rapoko, zviyo, njera, mazhovole (Zimbabwe); finger millet, African millet, koracan (England); dagussa, tokuso, barankiya (Ethiopia); wimbi, mugimbi (Kenya). It is an important staple food in parts of eastern and central Africa and India. The word ragi originated from a Sanskrit word “raga” meaning red. In Telangana, it is cultivated in an area of 1000 hectares, with a production of 1000 tonnes and productivity of 1000 kg ha\textsuperscript{-1} respectively. (Indiastat.com, 2016). Among different states of India, Karnataka ranked first both in area and production, while, Tamilnadu recorded highest productivity followed by Karnataka during 2016-17 (Sakamma et al., 2018) \cite{9}. In Telangana state, cotton, redgram and castor are the major \textit{kharif} crops cultivated under rainfed situations. The stubbles of these crops are generally very strong and pose serious problem for removal and hence, burnt for ease and to facilitate towards timely land preparation for the \textit{rabi} crops. Burning of crop residues/stubbles leads to loss of nutrients and organic matter apart from damaging microflora present in the topsoil. Crop residues form the alternate potent organic source for nutrient substitution through composting and it reduces the pollution generated through burning them.
Keeping, the above points in view the present experiment was initiated to evaluate the effect of compost prepared from cotton and redgram stubbles in combination with inorganic fertilizers on nutrient uptake and quality parameters of finger millet.

Material and Methods
A field experiment was conducted during rabi, 2018-19 at Student Farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad under irrigated conditions. The soil of the experimental site was sandy clay loam with soil pH (7.46), EC (0.36dS m⁻¹) and OC (0.67%). The soil was low in available nitrogen (260.0 kg ha⁻¹), medium in available phosphorus (45.1 kg ha⁻¹) and high in available potassium (521.0 kg ha⁻¹). This experiment was laid out in a Randomized block design with three replications and eight treatments. The size of gross and net plots were 4.5 m x 4.0 m and 3.3 m x 3.6 m respectively. There were eight treatments that comprised of comprised of T₁- 100% RDF (60:30:30 - N: P₂O₅: K₂O kg ha⁻¹), T₂- control without nitrogen T₃- 75% RDN + 25% N through FYM, T₄-75% RDN + 25% N through farmers practice vermicompost. The variety GUP-28 was used in the present experiment. GPU-28 variety seeds were directly sown on 29th September 2018 during adopting a spacing 30 cm x 10 cm. The RDF for finger millet was 60:30:30 NP and K kg ha⁻¹. Entire P (SSP) and K (MOP) fertilizer were applied as basal and N (Urea) was applied in two equal splits, 50% as basal and remaining 50% at 30 DAS. In integrated nutrient management treatments (T₃, T₄, T₅, T₆, T₇ & T₈), 25 per cent nitrogen was applied through organic manures as basal and remaining as that of recommended dose of fertilizers (100% RDF). The organics were applied as per the treatments (Table 1) and incorporated before sowing of the crop. Sowing was done adopting spacing of 30 x 10 cm. A total rainfall of 96.8 mm was received in 7 rainy days during rabi, 2018-19. The crop was harvested at physiological maturity when all the ear heads turned to brown and seeds were easily detachable.

Results and Discussion
Yield and yield components
The yield attributes viz., of number of panicles hill⁻¹, number of fingers ear head⁻¹, 1000- seed weight, grain yield, straw yield and harvest index differed significantly due to nutrient management practices through crop residue composting. Higher number of panicles m⁻² (158), fingers ear head⁻¹ (8.5), and test weight (3.29 g) compared to all other treatment combinations and control. In the treatments consisting of 25% N substitute through organics might be due to prolonged and adequate supply of nutrients coinciding with the critical crop growth stages reflecting in improved growth and yield attributes. These findings are in line with those of Basavaraj Naik et al. (2017) [1] and Ananda et al. (2017) [1], (Table 2).

Significantly higher grain (3540 kg ha⁻¹), straw yield (5899 kg ha⁻¹) and harvest index (37.5%) were registered with T₇- 75% RDN +25% N through cotton stubbles vermicompost + 2% rockphosphate and it was on par with T₈- 75% RDN +25% N through redgram stubbles vermicompost + 2% rockphosphate and T₇- 75% RDN +25% N through redgram stubbles vermicompost. Improved yield in the present study with treatments consisting of conjunctive application of inorganics + 25% N through organics was probably due to higher uptake of nutrients that led to better translocation of photosynthates from source to sink. These results are in line with those of Narayan Hebbal et al. (2018) [6] and Prakash et al. (2018) [8] (Table 2).

Table 1: Details of the nutrient content and amount of material added in nutrient management treatments.

| S. N | Organic source | Nutrient content (%) | Quantity of organics added (t ha⁻¹) |
|------|----------------|----------------------|-----------------------------------|
| 1.   | Vermicompost prepared from redgram stubbles | 2.20 | 2.15 | 0.98 | 0.68 |
| 2.   | Vermicompost prepared from redgram stubbles+2% rockphosphate | 2.35 | 2.60 | 1.08 | 0.63 |
| 3.   | Vermicompost prepared from cotton stubbles | 2.0 | 1.08 | 0.99 | 0.75 |
| 4.   | Vermicompost prepared from cotton stubbles+2% rockphosphate | 2.10 | 1.32 | 0.98 | 0.71 |
| 5.   | Farmers practice of vermicompost | 1.68 | 0.44 | 0.40 | 0.88 |
| 6.   | FYM | 0.50 | 0.22 | 0.41 | 3.0 |

Table 2: Yield attributes of finger millet as influenced by crop residue composting.

| Treatments | Panicles m⁻² | No. of fingers ear head⁻¹ | Test weight (g) | Grain yield (kg ha⁻¹) | Straw yield (kg ha⁻¹) | Harvest index (%) |
|------------|-------------|--------------------------|----------------|-----------------------|----------------------|-------------------|
| T₁- 100% RDF | 138 | 7.3 | 2.90 | 2551 | 4868 | 34.5 |
| T₂- control without nitrogen | 103 | 6.2 | 2.45 | 1453 | 3737 | 27.9 |
| T₃- 75% RDN + 25% N through FYM | 140 | 7.8 | 3.13 | 2895 | 5254 | 35.5 |
| T₄- 75% RDN + 25% N through redgram stubbles vermicompost | 149 | 8.1 | 3.15 | 3114 | 5542 | 36.1 |
| T₅- 75% RDN + 25% N through cotton stubbles vermicompost | 154 | 8.4 | 3.22 | 3402 | 5753 | 37.2 |
| T₆-75% RDN + 25% N through redgram stubbles vermicompost + 2% rockphosphate | 151 | 8.2 | 3.16 | 3231 | 5595 | 36.6 |
| T₇- 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate | 158 | 8.5 | 3.29 | 3540 | 5899 | 37.5 |
| T₈- 75% RDN + 25% N through farmers practice vermicompost | 144 | 7.8 | 3.04 | 2917 | 5252 | 35.6 |
| S. Em ± | 3.6 | 0.2 | 0.1 | 201 | 312 | 1.2 |
| CD (P=0.05) | 9.2 | 0.5 | 0.3 | 522 | 811 | 3.1 |
Nitrogen uptake
The data pertaining to the uptake of nitrogen (kg ha⁻¹) at harvest of finger millet was presented in the Table 3. The crop residue composting had significantly influenced the nitrogen uptake at all stages of crop growth. At harvest, T₇ - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate maintained its superiority by rendering highest N uptake (107.0 kg ha⁻¹) of which 51.0 kg ha⁻¹ was accumulated in grain and remaining 56.0 kg ha⁻¹ was stored in straw and it was significantly superior to the remaining nutrient management treatments. It was followed by T₅ - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (100.8 kg ha⁻¹) and T₆ - 75% RDN + 25% nitrogen through redgram stubbles vermicompost + 2% rockphosphate. (94.7 kg ha⁻¹) and T₄ with (89.9 kg ha⁻¹) and T₈ with application of 75% RDN + 25% nitrogen through farmers practice vermicompost (82.7 kg ha⁻¹) and T₃ - 75% RDN + 25% nitrogen through FYM (78.5 kg ha⁻¹). The 100% RDF recorded total uptake of nitrogen (64.6 kg ha⁻¹). The control recorded least uptake of nitrogen at harvest (30.8 kg ha⁻¹). (Table 3)

Nutrient uptake is the resultant of nutrient content and dry matter accumulation. Significantly higher dry matter accumulation at different crop growth stages coupled with the higher seed yield under treatments T₇ and T₃ resulted in significantly higher nitrogen uptake by crop. Further, increased nitrogen uptake of nitrogen might be attributed to greater availability of nutrients to plant in presence of organic manures due to their solubilizing effect on different forms of nutrients present in the soil and their contribution to growth coupled with improved cell permeability and better absorption. These findings are in agreement with Aariff Khan and Krishna (2016) [2] and Pallavi et al. (2014) [3].

Table 3: Nitrogen, Phosphorus, Potassium uptake (kg ha⁻¹) at harvest by finger millet as influenced by crop residue composting.

| Treatments | Nitrogen uptake | Phosphorus uptake | Potassium uptake |
|------------|-----------------|-------------------|-----------------|
|            | Grain straw Total | Grain straw Total | Grain straw Total |
| T1- 100% RDF | 31.2 33.4 64.6 | 3.20 10.40 13.60 | 11.98 77.88 89.86 |
| T2- control without nitrogen | 13.7 17.1 30.8 | 1.35 6.46 7.81 | 6.30 53.81 60.11 |
| T3- 75% RDN + 25% N through FYM | 37.9 40.6 78.5 | 3.97 18.38 22.35 | 14.40 85.64 100.04 |
| T4- 75% RDN + 25% N through redgram stubbles vermicompost | 42.6 47.3 89.9 | 4.56 20.50 25.06 | 16.81 91.44 108.25 |
| T5- 75% RDN + 25% N through cotton stubbles vermicompost | 48.4 52.4 100.8 | 5.26 23.99 28.50 | 20.75 98.37 119.12 |
| T6-75% RDN + 25% N through redgram stubbles vermicompost + 2% rockphosphate | 44.9 49.8 94.7 | 4.87 22.65 27.21 | 18.73 95.11 113.84 |
| T7- 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate | 51.0 56.0 107.0 | 5.57 25.18 30.75 | 21.94 102.64 124.58 |
| T8- 75% RDN + 25% N through farmer’s practice vermicompost | 39.4 43.3 82.7 | 3.99 18.48 22.47 | 15.75 86.13 101.88 |
| CD (P=0.05) | 4.11 4.7 5.75 | 0.3 1.05 1.13 | 1.38 3.48 0.05 |

* RDF: 60:30:30 - N: P₂O₅: K₂O kg ha

Phosphorus uptake
Results from the experiment reveal that at harvest T₇ maintained its superiority in terms of P uptake over other treatments. Treatment T₇ - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate (30.75 kg ha⁻¹) of which 5.57 kg ha⁻¹ was accumulated in grain and remaining 25.18 kg ha⁻¹ was stored in straw. It was followed by T₅ - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (28.50 kg ha⁻¹), T₆ - 75% RDN + 25% nitrogen through redgram stubbles vermicompost + 2% rockphosphate. (27.21 kg ha⁻¹) and T₄ (25.06 kg ha⁻¹), T₈ - 75% RDN + 25% nitrogen through farmers practice vermicompost (22.47 kg ha⁻¹) and T₃ with application of 75% RDN + 25% nitrogen through FYM (22.35 kg ha⁻¹). The 100% RDF recorded total uptake of nitrogen (13.60 kg ha⁻¹). The control recorded least uptake of phosphorus at harvest (7.81 kg ha⁻¹). (Table 3)

Improved P uptake under combined application of inorganic fertilizer and crop stubble vermicompost at all the growth stages may be ascribed to greater availability of nutrients from added fertilizer and due to the solubility of organic acids produced during degradation of organics resulting in release of both native and applied P. Further, products of organic decay such as organic acids and humus are thought to be effective in forming complexes. Similar results were earlier reported by Varalakshmi et al. (2005) [13] and Shankar et al. (2015) [10].

Potassium uptake
At harvest T₇ - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate (recorded highest K uptake (124.58 kg ha⁻¹) of which 21.94 kg ha⁻¹ was accumulated in grain and remaining 102.64 kg ha⁻¹. It was followed by T₅ - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (119.12 kg ha⁻¹) and T₆ - 75% RDN + 25% nitrogen through redgram stubbles vermicompost + 2% rockphosphate. (113.84 kg ha⁻¹) and T₄ - 75% RDN + 25% nitrogen through redgram stubbles vermicompost (108.25 kg ha⁻¹) and T₈ - 75% RDN + 25% nitrogen through farmers practice vermicompost (101.88 kg ha⁻¹) and T₃ - 75% RDN + 25% nitrogen through FYM (100.04 kg ha⁻¹) followed by 100% RDF recorded total uptake of nitrogen (89.86 kg ha⁻¹). While, the control plot recorded least uptake of phosphorus at harvest (60.11 kg ha⁻¹). (Table 3)

Improved K uptake at all the crop growth stages under treatments T₇ and T₆ could be attributed to the improved dry matter accumulation and K content as evident from the respective data. Further, conjugative use of organics and inorganics through crop residue vermicomposting in the present study helped towards more solubilization of K bearing minerals and from insoluble forms, thus reducing K fixation and facilitating higher availability of K in soils and for crop uptake. Similar results were reported by Varalakshmi et al. (2005) [10] and Shankar et al. (2015) [11].

Quality parameters
Crude protein content (%)
The data on crude protein content (%), calcium content (%), iron content (ppm), zinc content (ppm) in grain of finger millet was significantly influenced by nutrient management through crop residue composting was presented in Table 3.
It is clearly evident from the data that different treatments exerted significant effect on protein content. Among the treatments T1 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate recorded significantly higher protein content (9.0%). However, treatment T2 was on par with and T3 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (8.9%). While, significantly lowest protein content (28.0%) was registered with control with no nitrogen application.

Improved crude protein content in treatments with 25% N substitution through crop residues composting improved N content in grain (Appendix III). Similar results pertaining to higher crude protein content in finger millet was reported by Pallavi et al. (2014) [7] (Table 4).

Table 4: Quality parameters in grain of finger millet as influenced by crop residue composting

| Treatments                                                        | Protein (%) | Calcium (%) | Iron (ppm) | Zinc (ppm) |
|-------------------------------------------------------------------|-------------|-------------|------------|------------|
| T1- 100% RDF                                                     | 7.6         | 0.35        | 72.5       | 23.7       |
| T2- control without nitrogen                                      | 5.9         | 0.31        | 52.7       | 19.3       |
| T3- 75% RDN + 25% N through FYM                                   | 8.2         | 0.42        | 73.6       | 24.5       |
| T4- 75% RDN + 25% N through cotton stubbles vermicompost          | 8.5         | 0.39        | 77.2       | 28.9       |
| T5- 75% RDN + 25% N through cotton stubbles vermicompost          | 8.9         | 0.40        | 83.1       | 31.5       |
| T6-75% RDN + 25% N through redgram stubbles vermicompost + 2% rockphosphate | 8.7         | 0.42        | 82.1       | 31.4       |
| T7- 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate | 9.0         | 0.44        | 85.2       | 32.0       |
| T8- 75% RDN + 25% N through farmers practice vermicompost        | 8.4         | 0.37        | 76.3       | 25.8       |

*RDF: 60:30:30 - N: P2O5: K2O kg ha⁻¹

4.3.2 Calcium content (%)  
It is clearly evident from the data that different treatments exerted significant effect on calcium content. Among the treatments T1 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate recorded significantly higher calcium content (0.44%). However, treatment T2 was on par with and T3 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (0.40%). While, significantly lowest calcium content (0.31%) was registered with control with no nitrogen application. (Table 4) Conjunctive use of organics and inorganics might have improved calcium content in treatments with 25% N substitution through crop residues composting. These results are in line with those of Ananda et al. (2017) [1].

4.3.4 Iron content (ppm)  
The data on iron content (%) in grain of finger millet was significantly influenced by nutrient management through crop residue composting was presented in Table 3. It is clearly evident from the data that different treatments exerted significant effect on calcium content. Among the treatments T1 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate recorded significantly higher calcium content (85.2 ppm). However, treatment T2 was on par with and T3 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (83.1 ppm). (Table 4) Integrated use of organics and inorganics might have improved iron content in treatments with 25% N substitution through crop residues composting. These results are in line with those of Pallavi et al. (2014) [7].

4.3.5 Zinc content (ppm)  
It is clearly evident from the data that different treatments exerted significant effect on calcium content. Among the treatments T1 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost + 2% rockphosphate recorded significantly higher calcium content (32.0 ppm). However, treatment T2 was on par with and T3 - 75% RDN + 25% nitrogen through cotton stubbles vermicompost (31.5 ppm). While, significantly lowest zinc content (19.3 ppm) was registered with control plot with no nitrogen application. Application of organics to Finger millet crop improved the crop uptake, that reflected in quality parameters like zinc content. These results are in line with those of Pallavi et al. (2014) [7].

Table 5: Post- harvest soil available N, P2O5 and K2O (kg ha⁻¹) as influenced by crop residue composting

| Treatments                                                        | Nitrogen (kg ha⁻¹) | P2O5 (kg ha⁻¹) | K2O (kg ha⁻¹) |
|-------------------------------------------------------------------|--------------------|----------------|---------------|
| T1- 100% RDF                                                     | 163.3              | 33.9           | 450.2         |
| T2- control without nitrogen                                      | 139.9              | 28.2           | 391.5         |
| T3- 75% RDN + 25% N through FYM                                   | 173.9              | 35.9           | 509.8         |
| T4- 75% RDN + 25% N through redgram stubbles vermicompost        | 200.2              | 37.6           | 523.2         |
| T5- 75% RDN + 25% N through cotton stubbles vermicompost          | 267.5              | 40.2           | 545.6         |
| T6-75% RDN + 25% N through redgram stubbles vermicompost + 2% rockphosphate | 221.6              | 38.4           | 532.2         |
| T7- 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate | 271.7              | 43.4           | 563.1         |
| T8- 75% RDN + 25% N through farmers practice vermicompost        | 182.9              | 36.8           | 512.3         |

*S.E.m ±

CD (P=0.05)  
40.6 3.94 40.6

Initial available nutrients (kg ha⁻¹)  
260 45.17 521

*RDF: 60:30:30 - N: P2O5: K2O kg ha⁻¹

Conclusions  
From the above results it could be concluded that on red soils of Southern Telanagana regions application of 75% RDN +25% N through cotton stubbles vermicompost + 2% rockphosphate to finger millet results in higher nutrient uptake leading to higher yield, quality parameters and economics of finger millet.
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