Yield and nutrient uptake as influenced by the integrated nutrient management in foxtail millet

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Abstract
A field experiment was conducted at Main Agricultural Research Station, Raichur, during kharif 2018-19 to study the integrated nutrient management on Foxtail millet (Setaria italic L) in black soil. The experiment was laid out with eleven treatments replicated three times in randomized block design. Among all the treatments, application of RDF +2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 at 15, 30 and 45 DAS significantly recorded grain yield and straw yield were significantly recorded (2414 kg ha⁻¹ and 6034 kg ha⁻¹) as compared to absolute control and RDF. The treatment also recorded higher nitrogen, phosphorus and potassium uptake (36.9, 9.7 and 18.1 kg ha⁻¹ in grain, 56.7, 18.1 and 79.1 kg ha⁻¹ in straw, respectively). It is concluded that the application of RDF + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar Spray of 19:19:19 at 15, 30 and 45 DAS is the best treatment in rainfed condition to achieve higher yield, nutrient content and nutrient uptake as compared to RDF and absolute control.

Keywords: Nutrient uptake, foxtail millet

Introduction
Foxtail millet grown since time immemorial is predominantly self-pollinated crop belonging to family graminae. Under condition of low input management, it grows well and produces more than pearl millet. Foxtail millet is one of the world’s oldest cultivated crops. It is also called as famine reserve and it is extensively grown under low rainfall area. Foxtail millet is the second most widely grown species of millet and the most important food crop in East Asia. In India, foxtail millet is important crop in arid and semi-arid regions. In South India, it has been a staple diet among people for a long time and it is a warm season crop, typically grown in late spring season and harvested for grain in 75-90 days (800-900 kg ha⁻¹). Foxtail millet is commonly known as Navane in Karnataka (Vinall, 1924) [21].

Metals such as Zinc, iron and manganese have vital roles in plant’s life cycle and very important for normal growth plants. Zinc is considered as the most limiting factor in producing crops in different parts of the world. Zn is an essential catalytic component of over 300 enzymes, including alkaline phosphatase, alcohol dehydrogenase, Cu-Zn superoxide dismutase, and carbonic anhydrase. Zinc plays an important role in synthesizing proteins, RNA, DNA and precursor of auxin which is essential for cell elongation. Iron plays an important role in nitrogen fixation and photosynthesis. Synthesis of chlorophyll, thylakoid, and many ferrous proteins is dependent on this element. Iron deficiency in plants is caused by factors that either inhibit its absorption and translocation or impair its utilization in metabolic processes.

In this context, it is worth to mention that nutrient management through organics plays a major role in maintaining soil health due to buildup of soil organic matter, beneficial microbes and enzymes besides improving soil physical and chemical properties. In a farming system approach, the nutrient needs are met out through recycling process to achieve sustained soil fertility and crop productivity. The options available on the farm include use of various organic manures viz., FYM, compost, vermicompost, green manures, bio-fertilizers etc. Nutrient management aims at efficient and judicious use of all the major sources of plant nutrients in an integrated manner to get maximum economic yield without any deleterious effects on physico-chemical and biological properties of the soil.
Materials and Methods
The experiment was conducted at MARS, Raichur, Karnataka. A composite surface (0-15 cm) soil sample was drawn from the experimental site before initiation of experiment. The soil was air-dried, powdered and passed through 2 mm sieve and was analyzed for physico-chemical properties. The results and analytical techniques employed for their estimation were given in Table 1. The experiment was conducted with eleven treatments having different sources of organics and recommended dose of fertilizer treatments which were randomly allocated in Randomized Complete Block Design (RCBD) with three replications. The treatment details area T1: Absolute control, T2: RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹), T₃: FYM @ 6 t ha⁻¹, T₄: Vermicompost @ 2.5 t ha⁻¹, T₅: RDF+FYM @ 6 t ha⁻¹ + Bio-fertilizer, T₆: RDF+ Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS, T₇: RDF+ Vermicompost @ 2.5 t ha⁻¹ + Bio-fertilizer, T₈: RDF+ Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS, T₉: FYM @ 6 t ha⁻¹+ Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS, T₁₀: Vermicompost @ 2.5 t ha⁻¹+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS T₁₀: RDF+ FYM @ 6 t ha⁻¹ + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at15, 30 and 45 DAS, T₁₁: RDF+ Vermicompost @ 2.5 t ha⁻¹ + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS.

Note: Recommended Package Of Practices: RDF (30:15:15 kg N, P₂O₅ and K₂O ha⁻¹), FYM @ 6.0 t ha⁻¹, Biofertilizer (Azospirillum @ 200 g ha⁻¹) soil application. The good quality seeds of foxtail millet variety (HN-46) were sown with spacing of 30 x 10 cm. Five plants from the net plot area were randomly selected and they were tagged to record the periodical observations at 30, 60 days after sowing and also at the time of harvest.

Plant sample was collected at harvest stage from each plot and uptake of micro-nutrients was estimated. Nitrogen was determined by Kjeldahl’s digestion distillation method. Plant samples (0.5 g) were digested in digestion flasks using sulphuric acid and the digestion mixture (K₂SO₄ + CuSO₄ + Se in the ratio of 100:20:1). After complete digestion, the digested materials were distilled in alkaline medium and the liberated ammonia was trapped in four per cent boric acid solution containing mixed indicator. The trapped ammonia was titrated against standard sulphuric acid (Piper, 1966). Phosphorus in the plant sample digest was estimated by vanadomolybdophosphoric yellow colour method in nitric acid medium and the colour intensity was measured at 430 nm wave length as outlined by Piper (1966). Potassium in the plant sample digest was estimated by atomizing the diluted acid extract to a flame photometer as described by Piper (1966). The content of Zn, Fe were estimated by using Atomic Absorption Spectrophotometer (AAS) as explained by Jackson (1973). The digested material was directly fed to Atomic Absorption Spectrophotometer (AAS) with suitable dilutions wherever necessary and concentration of these elements was recorded in mg kg⁻¹. Uptake (Kg ha⁻¹) was calculated by multiplying its per cent concentration with seed, Stover yield respectively.

Results and Discussion
Grain yield
There was a significant difference in the grain yield, stover yield and Harvest index of foxtail millet due to different treatment combination and the results are shown in the Table 2 and Fig. 1.

Application of RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T₁) recorded significantly higher grain yield (2414 kg ha⁻¹) and it was on par with treatments T₁₀ where RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (2252 kg ha⁻¹). However, lower grain yield (853 kg ha⁻¹) was obtained in (T₁) absolute control treatment.

Higher grain yield was noticed with application of RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (2414 kg ha⁻¹). It might be due to the adequate amount of nutrients availability both macro and micro nutrient results from treatment effect which enhanced the crop growth. The increased availability of N, P, K, Zn, Cu, Mn and Fe as well as the synergistic effect between organic and inorganic forms of nutrients and formation of stable complexes with humic substances supplied through poultry manure in rice crop (Dosani et al., 1999) [8] in groundnut crop and Balaji and Yakadri 2004 [3]. The combined application of organic and inorganic sources provided greater availability of nutrients for the development of vegetative structures and increased the number of grain, grain weight and resulted in higher grain yield (Uddin et al., 2008) [22].

Stover yield
Significantly higher Stover yield was recorded in the treatment which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (6034 kg ha⁻¹). However, it was on par with treatment which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at15, 30 and 45 DAS (T₁₀) recorded significantly lower straw yield (2230 kg ha⁻¹) was obtained in absolute control (T₁).

Higher the Stover yield was recorded with application of RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (6034 kg ha⁻¹). This was mainly because of increasing in the levels and source of nutrients with organic manures significantly increased the straw yield of hybrid rice which might due to the integrated effect of N, P and K levels and different sources of organic manures on N, P and K availability and their uptake as well as grain and straw yield of hybrid rice. The supply of inorganic and organic manures increased the grain and straw yield of hybrid rice. The addition of organic manure might influence N, P and K availability by maintaining good physical condition of soil for plant growth and yield. The increase in straw yield of hybrid rice with combined application of fertilizer and manure was reported by Rahman et al. (2005), Gupta et al. (2006) [9] and Bajpai et al. (2006) [4].

Nitrogen content in grain and stover
The data on nitrogen content in the grain of foxtail millet at harvest was significantly influenced due to different treatment combination the results were shown in the Table 3 and Fig. 2. Significantly higher nitrogen concentration in the grain (1.53%) was the recorded in treatment T₁ with RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with treatment T₁₀ which received of RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS.
The data pertaining to the application of different organic manures. This might be due to increased N content in grain and stover of foxtail millet at harvest. Similar findings were reported by Singh et al. (2015) and Walia et al. (2010) in rice crop. Higher availability of nutrients and their supply to the roots might have helped in nutrient absorption and mobilisation.

**Phosphorus content in grain and stover**

The data pertaining to the application of different organic manures in combination with inorganic fertilizers influenced the phosphorus concentration in grain and stover at harvest of foxtail millet presented in Table 3 and Fig. 2. Significantly higher phosphorus concentration in grain (0.40%) was recorded in treatment T1 with RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 6 t ha\(^{-1}\) FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 6 t ha\(^{-1}\) FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (0.38%), T6 (0.37%), T9 (0.37%), T8 (0.35%), and T3 (0.32%). However, lower phosphorus concentration in grain (0.27%) was recorded in T1 treatment (control).

Significantly higher phosphorus concentration in stover (0.30%) was recorded in treatment T1 with RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 6 t ha\(^{-1}\) FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (0.30%), T6 (0.29%), T9 (0.29%), T8 (0.26%), and T3 (0.26%). However, lower phosphorus concentration in stover (0.23%) was recorded in T1 treatment (control).

### Table 1: Concentration of N, P and K by grain and stover of foxtail millet in different nutrient management practices at harvest stages.

| Treatment                                      | Nutrient concentration (%) |
|------------------------------------------------|----------------------------|
|                                               | N  | P  | K  |
|                                               | Grain | Stover | Grain | Stover | Grain | Stover |
| T<sub>0</sub>: Absolute control                | 1.18 | 0.43 | 0.27 | 0.23 | 0.55 | 1.19 |
| T<sub>1</sub>: RDF (30:15:15 kg ha<sup>-1</sup>) | 1.25 | 0.54 | 0.30 | 0.25 | 0.64 | 1.33 |
| T<sub>2</sub>: FYM 6 t ha<sup>-1</sup>         | 1.20 | 0.50 | 0.26 | 0.24 | 0.67 | 1.28 |
| T<sub>3</sub>: Vermicompost 2.5 t ha<sup>-1</sup> | 1.22 | 0.52 | 0.27 | 0.24 | 0.62 | 1.3 |
| T<sub>4</sub>: RPP (RDF+ 6 t ha<sup>-1</sup> FYM + Bio-fertilizer) | 1.38 | 0.66 | 0.32 | 0.26 | 0.70 | 1.41 |
| T<sub>5</sub>: RPP (RDF + 2.5 t ha<sup>-1</sup> Vermicompost + Bio-fertilizer) | 1.46 | 0.89 | 0.37 | 0.29 | 0.73 | 1.45 |
| T<sub>6</sub>: RDF+Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 1.33 | 0.62 | 0.29 | 0.25 | 0.67 | 1.38 |
| T<sub>7</sub>: FYM 6 t ha<sup>-1</sup>+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 1.36 | 0.64 | 0.35 | 0.26 | 0.69 | 1.4 |
| T<sub>8</sub>: Vermicompost 2.5 t ha<sup>-1</sup>+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 1.44 | 0.75 | 0.37 | 0.29 | 0.72 | 1.46 |
| T<sub>9</sub>: RPP (RDF+Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 1.49 | 0.91 | 0.38 | 0.30 | 0.74 | 1.43 |
| T<sub>10</sub>: RPP (RDF+ 2.5 t ha<sup>-1</sup> Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 1.53 | 0.94 | 0.40 | 0.30 | 0.75 | 1.48 |
| T<sub>11</sub>: RPP (RDF+ 2.5 t ha<sup>-1</sup> Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 1.53 | 0.94 | 0.40 | 0.30 | 0.75 | 1.48 |
| S.Em ± | 0.05 | 0.06 | 0.12 | 0.01 | 0.03 | 0.02 |
| CD at 5% | 0.15 | 0.18 | 0.34 | 0.04 | 0.08 | 0.05 |
Potassium content in grain and stover

The application of different organic manures in combination with inorganic fertilizers influenced the potassium concentration in grain and stover at harvest of foxtail millet and the results are presented in Table 1 and Fig. 2. Significantly higher potassium concentration in grain (0.75%) was the recorded in treatment T1 receiving RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with treatment T10 which received of RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (0.74%), T6 (0.73%), T5 (0.72%), T3 (0.69%), and T5 (0.62%). However, lower potassium concentration in grain (0.55%) was recorded in T1 control treatment.

Significantly higher potassium concentration in stover (1.48%) was the recorded in treatment T11 receiving RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with treatment T10 which received of RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (1.41%), T6 (1.40%), T5 (1.46%), T4 (1.41%), and T1 (1.40%). However, lower potassium concentration in stover (0.55%) was recorded in T1 control treatment. The increase the K concentration in grain and straw might be due to application of nutrients through organic and inorganic fertilizers which increased the availability of K in soil, hence increasing the K content. The application of RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS produced the maximum K concentration in grain and straw of foxtail millet. This might be due to increased availability of K in soil as a result of mineralization of vermicompost which resulted in higher K concentration as compared to FYM. These findings were supported by Shriram Patil (2014)[17] and Soni and Sikarawar (1989) [19] in rice crop.

Micronutrients content in grain and stover

The data pertaining to concentration of iron, manganese, zinc, and copper in the grain and stover of foxtail millet differed significantly due to application of different

| Treatment | Nutrient concentration (mg kg⁻¹) |
|-----------|---------------------------------|
| Iron      | Zinc                            |
| Grain     | Stover                          |
| Grain     | Stover                          |
| T1: Absolute control | 78.20 | 91.70 | 21.70 | 16.50 |
| T2: RDF(30:15:15 kg ha⁻¹) | 90.00 | 102.20 | 24.80 | 21.50 |
| T3: FYM 6 t ha⁻¹ | 82.20 | 95.10 | 21.50 | 87.00 |
| T4: Vermicompost 2.5 t ha⁻¹ | 84.90 | 98.87 | 23.00 | 20.00 |
| T5: RDF+ 6 t ha⁻¹ FYM + Bio-fertilizer | 99.20 | 111.30 | 27.80 | 22.40 |
| T6: RDF+ 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer | 104.20 | 115.10 | 30.60 | 24.60 |
| T7: RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 94.50 | 106.89 | 27.10 | 21.10 |
| T8: FYM 6 t ha⁻¹+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 97.70 | 109.03 | 27.60 | 21.90 |
| T9: Vermicompost 2.5 t ha⁻¹+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 103.10 | 113.06 | 28.40 | 22.90 |
| T10: RDF+ 6 t ha⁻¹ FYM+ Bio-fertilizer+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 108.20 | 112.80 | 30.30 | 24.10 |
| T11: RDF+ 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 112.69 | 117.25 | 31.10 | 25.40 |
| S.Em ± | 2.08 | 2.26 | 0.42 | 0.39 |
| CD at 5% | 6.24 | 6.78 | 1.26 | 1.16 |
organic manures in combination with inorganic fertilizers. The results are presented in Table 2 and 3. Significantly higher concentration of iron in grain and stover of foxtail millet was recorded in T1, with RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (112.69 and 117.25 mg kg⁻¹ respectively). But it was on par with the treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS in grain (108.2 mg kg⁻¹). But on par with stover in Tc, RPP (RDF + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) (115.1 mg kg⁻¹). However, lower iron concentration in grain and stover (78.2, and 91.7 mg kg⁻¹ respectively) was recorded in (Tg) as absolute control. Significantly higher concentration of zinc in grain and stover of foxtail millet was recorded in T1; RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (31.1 and 24.6 mg kg⁻¹ respectively). It was on par with the treatment Tc; RPP (RDF + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) (30.6 and 24.6 mg kg⁻¹). However, lower zinc concentration in grain and stover (21.7 and 16.5 mg kg⁻¹ respectively) was recorded in (Tg) as absolute control. Significantly higher concentration of manganese in grain and stover of foxtail millet was recorded in T10 which received RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (22.4 and 17.8 mg kg⁻¹). It was on par with the treatment T1; RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (21.9 and 17.2 mg kg⁻¹) as compared to absolute control (Tg). Significantly higher concentration of copper in grain and stover of foxtail millet was recorded in T11; RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (7.4 and 11.0 mg kg⁻¹) as compared to absolute control (Tg) (3.16 and 4.6 mg kg⁻¹). The micronutrient concentration was higher in treatment RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS which may be attributed to more favourable conditions developed either through an increase in solubility of nutrients with in soil solution through added organic manure or possible stimulation of root for absorption (Auntit et al., 1989) [2] in paddy crop. The increase in concentration might be due to effect of natural chelating agents released from the organic manure that helped in keeping micronutrient in soluble state to be more available for plants. The results are in accordance with the findings of Ramsakal (2001) [16].

**Table 3: Uptake of Copper and Manganese by grain and stover of foxtail millet in different nutrient management practices**

| Treatment | Nutrient concentration (mg kg⁻¹) |
|-----------|---------------------------------|
|           | Copper Grain | Copper Stover | Manganese Grain | Manganese Stover |
| T1: Absolute control | 3.16 | 4.6 | 12.6 | 11.8 |
| T2: RDF(30:15:15 kg ha⁻¹) | 5.5 | 4.8 | 14.8 | 16.4 |
| T3: FYM 6 t ha⁻¹ | 4.7 | 7.7 | 14.4 | 15.3 |
| Tc: Vermicompost 2.5 t ha⁻¹ | 5.6 | 8.6 | 13.2 | 17.1 |
| Tg: RPP (RDF+ 6 t ha⁻¹ FYM + Bio-fertilizer) | 5.3 | 6.7 | 15.4 | 14.6 |
| T1: RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 6.1 | 9.2 | 17.5 | 15.9 |
| Tc: FYM 6 t ha⁻¹ + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 5.5 | 9.8 | 18.0 | 16.12 |
| Tg: Vermicompost 2.5 t ha⁻¹ + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 7.5 | 9.9 | 18.4 | 16.35 |
| T10: RPP (RDF+ 6 t ha⁻¹ FYM + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 5.9 | 10.3 | 22.4 | 17.2 |
| T11: RPP (RDF+ 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 6.2 | 11.0 | 21.9 | 17.8 |
| S.Em ± | 0.14 | 0.28 | 0.26 | 0.23 |
| CD at 5% | 0.43 | 0.83 | 0.78 | 0.68 |

**Nutrient uptake of foxtail millet**

**Nitrogen uptake by grain, stover and total nitrogen uptake**

The data on nitrogen uptake by grain, stover, and total nitrogen uptake by foxtail millet at harvest as influenced by nutrient management practices are presented in Table 4. Significantly higher nitrogen uptake by grain was recorded with T1 which received RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (36.90 kg ha⁻¹) as compared to all other treatments. However, significantly lower uptake of nitrogen was obtained with (10.10 kg ha⁻¹) in the treatment T1 absolute control.

Application of RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T11) was recorded significantly higher nitrogen uptake by stover (56.70 kg ha⁻¹). It was on par with the treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (52.60 kg ha⁻¹). However, significantly lower nitrogen uptake by stover was noticed in the treatment T1 as absolute control (9.60 kg ha⁻¹).

Significantly higher total uptake of nitrogen with (93.7 kg ha⁻¹) was recorded due to RPP (RDF + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T11). It was on par with the treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (86.10 kg ha⁻¹). However, significantly lower nitrogen uptake by foxtail millet was recorded in the treatment T1 as absolute control (19.7 kg ha⁻¹).

The uptake of nitrogen by foxtail millet was significantly higher with RDF (30:15:15 kg N:P2O5:K2O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS which might be due to supply of adequate quantity of N through inorganics and mineralization of the nitrogen added through organic manure by soil organisms which facilitated nitrogen transformation and increased release of nitrogen throughout the crop growth and thus contributed to higher concentration and uptake of nitrogen in foxtail millet. Similar results were findings are reported by Laxminarayana (2006) [12] in rice, Singh et al.
Phosphorus uptake by grain, stover and total phosphorus uptake

The data on phosphorus uptake by grain, stover, and total phosphorus uptake by foxtail millet at harvest as influenced by nutrient management practices are presented in Table 4. Significantly higher phosphorus uptake by grain was recorded in the treatment T9 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (9.7 kg ha⁻¹). It was on par with T10 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (8.60 kg ha⁻¹). However, significantly lower uptake by grain was noticed in treatment T1 as absolute control (2.30 kg ha⁻¹). Significantly higher phosphorus uptake by stover was recorded in the treatment (18.1 kg ha⁻¹) T11 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with the treatment T10 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (17.30 kg ha⁻¹), T8 which received RPP (RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹

| Treatment | Nutrient uptake (kg ha⁻¹) | Phosphorus | Potassium |
|-----------|---------------------------|------------|-----------|
|           | Grain | Stover | Total | Grain | Stover | Total | Grain | Stover | Total |
| T1        | 10.1  | 9.6    | 19.7  | 2.3   | 5.1    | 7.4    | 4.7   | 27.5   | 31.2  |
| T2        | 18.1  | 19.1   | 37.2  | 4.3   | 8.8    | 13.2   | 9.3   | 43.2   | 56.3  |
| T3        | 15.4  | 13.0   | 28.4  | 3.3   | 6.2    | 9.6    | 7.7   | 38.1   | 40.9  |
| T4        | 16.4  | 18.0   | 34.5  | 3.6   | 8.3    | 12.0   | 8.4   | 40.1   | 53.5  |
| T5        | 25.6  | 29.9   | 55.5  | 5.9   | 11.8   | 17.7   | 13.0  | 60.1   | 76.8  |
| T6        | 29.6  | 48.6   | 78.1  | 7.5   | 15.8   | 23.3   | 14.8  | 66.9   | 93.9  |
| T7        | 21.2  | 22.7   | 44.0  | 4.6   | 9.2    | 13.8   | 10.7  | 47.9   | 61.3  |
| T8        | 22.8  | 27.3   | 50.1  | 5.9   | 11.1   | 16.3   | 11.6  | 52.2   | 71.2  |
| T9        | 26.5  | 35.2   | 61.6  | 6.6   | 13.6   | 18.6   | 13.2  | 68.5   | 82.1  |
| T10       | 33.6  | 52.6   | 86.1  | 8.6   | 17.3   | 25.9   | 16.7  | 73.7   | 98.8  |
| T11       | 36.9  | 56.7   | 93.7  | 9.7   | 18.1   | 27.8   | 18.1  | 79.1   | 107.4 |
| S.Em ± CD at 5% | 1.17 | 1.65 | 2.94 | 0.53 | 0.43 | 1.86 | 0.66 | 2.12 | 3.63 |

Vermicompost + Bio-fertilizer) (4.83kg ha⁻¹). However, significantly lower uptake of phosphorus by stover (5.10 kg ha⁻¹) was observed in absolute control (T1). Significantly higher total uptake of phosphorus (27.8 kg ha⁻¹) was recorded with treatment T1 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It was on par with the treatment T10 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS T10: RPP (RDF+ 6 t ha-1 Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS. It was on par with the treatment T10 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (18.1 kg ha⁻¹). It was on par at the treatment T10 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (17.30 kg ha⁻¹), T8 which received RPP (RDF+ 2.5 t ha-1 Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 45 DAS T8: RPP (RDF+ 2.5 t ha-1 Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS T10: RPP (RDF+ 6 t ha-1 Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS T10: RPP (RDF+ 6 t ha-1 Vermicompost + Bio-fertilizer) + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS

Potassium uptake by grain, stover and total potassium uptake

The data on uptake of potassium by foxtail millet grain, straw and total uptake as influenced by the application of organic manures in combination with and inorganic fertilizers are presented in Table 4.

Significantly higher potassium uptake by grain was recorded in the treatment T11 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS (18.1 kg ha⁻¹) compared to all other treatments. However, significantly lower uptake of (4.70 kg ha⁻¹) was recorded in the treatment T3 as absolute control. Application of RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 2.5 t ha⁻¹ Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS (T11) was recorded significantly higher potassium uptake by stover (79.1 kg ha⁻¹). It was on par with the treatment T10 which received RDF (30:15:15 kg N:P₂O₅:K₂O ha⁻¹) + 6 t ha⁻¹ FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30, 45 DAS (79.1 kg ha⁻¹).
potassium uptake by foxtail millet was recorded in the treatment with Vermicompost + Bio fertilizer and Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T3). It was on par with the treatment T10 which received RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 6 t ha\(^{-1}\) FYM + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (98.80 kg ha\(^{-1}\)). However, significantly lower potassium uptake by foxtail millet was recorded in the treatment T1 as absolute control (31.20 kg ha\(^{-1}\)).

Significantly higher potassium uptake by foxtail millet in grain, straw and total uptake was recorded in treatment which received RDF (30:15:15 kg N:P2O5:K2O ha\(^{-1}\)) + 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS. It might be attributed to the treatment that sufficiently supplied the nutrient requirement of the crop and increased the efficiency of applied NPK fertilizers thereby, increased the concentration of potassium in foxtail millet grain and straw. Higher uptake of potassium by foxtail millet grain and straw might be due to higher biomass production as influenced by addition of organic manures. The present results are in agreement with the findings by who reported higher N, P and K uptake by foxtail millet with organic manure application over no fertilizer and inorganic fertilizers application (Ashwini et al., 2015 and Hossain et al., 2010)\(^{[3, 10]}\).

### Uptake of Iron, Manganese, Zinc and copper in grain and stover

The data pertaining to the uptake of iron, manganese, zinc and copper by foxtail millet grain, stover and total uptake differed significantly due to application different nutrient management practices are presented in the Table 5, 6 and Fig. 2.

Significantly higher uptake of iron in grain, stover and total uptake (272.0, 707.5 and 979.5 g ha\(^{-1}\), respectively) was recorded in the treatment where RDF (30:15:15 kg

| Treatment | Nutrient Uptake (g ha\(^{-1}\)) | Nutrient Uptake (g kg\(^{-1}\)) |
|-----------|-------------------------------|-------------------------------|
| Iron      |                                |                               |
| Grain     | Stover                        | Total                         |
| T1:       | Absolute control              | 67.6                          | 204.5  |
| T2:       | RDF (30:15:15 kg ha\(^{-1}\)) | 130.3                         | 361.2  |
| T3:       | Vermicompost 2.5 t ha\(^{-1}\) | 114.4                         | 343.0  |
| T4:       | RPP (RDF+ 6 t ha\(^{-1}\) FYM + Bio-fertilizer) | 183.8                         | 504.2  |
| T5:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 150.7                         | 392.1  |
| T6:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 164.0                         | 464.6  |
| T7:       | RPP (RDF+ 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 243.7                         | 651.4  |
| T8:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 272.0                         | 707.5  |
| T9:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 59.27                         | 72.54  |

| Zinc      |                                |                               |
| Grain     | Stover                        | Total                         |
| T1:       | Absolute control              | 6.7                           | 20.0   |
| T2:       | RDF (30:15:15 kg ha\(^{-1}\)) | 8.0                           | 24.0   |
| T3:       | Vermicompost 2.5 t ha\(^{-1}\) | 7.5                           | 29.9   |
| T4:       | RPP (RDF+ 6 t ha\(^{-1}\) FYM + Bio-fertilizer) | 9.8                           | 30.4   |
| T5:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.0                          | 46.9   |
| T6:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.7                          | 47.3   |
| T7:       | RPP (RDF+ 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.3                          | 59.5   |
| T8:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 15.0                          | 65.5   |
| T9:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 16.4                          | 72.8   |

### Table 6: Concentration Copper and manganese by grain and stover of foxtail millet nutrient management practices at harvest stage.

| Treatment | Nutrient uptake (g kg\(^{-1}\)) | Nutrient uptake (g kg\(^{-1}\)) |
|-----------|-------------------------------|-------------------------------|
| Copper    |                               |                               |
| Grain     | Stover                        | Total                         |
| T1:       | Absolute control              | 2.7                           | 10.2   |
| T2:       | RDF (30:15:15 kg ha\(^{-1}\)) | 8.0                           | 17.0   |
| T3:       | Vermicompost 2.5 t ha\(^{-1}\) | 6.0                           | 20.0   |
| T4:       | RPP (RDF+ 6 t ha\(^{-1}\) FYM + Bio-fertilizer) | 7.5                           | 29.9   |
| T5:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 9.8                           | 30.4   |
| T6:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.0                          | 46.9   |
| T7:       | RPP (RDF+ 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.7                          | 47.3   |
| T8:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 15.0                          | 65.5   |
| T9:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 16.4                          | 72.8   |
| Manganese |                               |                               |
| Grain     | Stover                        | Total                         |
| T1:       | Absolute control              | 2.7                           | 10.2   |
| T2:       | RDF (30:15:15 kg ha\(^{-1}\)) | 8.0                           | 17.0   |
| T3:       | Vermicompost 2.5 t ha\(^{-1}\) | 6.0                           | 20.0   |
| T4:       | RPP (RDF+ 6 t ha\(^{-1}\) FYM + Bio-fertilizer) | 7.5                           | 29.9   |
| T5:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 9.8                           | 30.4   |
| T6:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.0                          | 46.9   |
| T7:       | RPP (RDF+ 2.5 t ha\(^{-1}\) Vermicompost + Bio-fertilizer) + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 13.7                          | 47.3   |
| T8:       | RDF+ Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 15.0                          | 65.5   |
| T9:       | Vermicompost 2.5 t ha\(^{-1}\) Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS | 16.4                          | 72.8   |
N:P_2O_5:K_2O ha^{-1}) + 2.5 t ha^{-1} Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T_{11}). It was on par with the treatment T_{10} RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 6 t ha^{-1} FYM + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS grain (243.7, 651.4 and 895.1 g ha^{-1}, respectively) as compared to absolute control (T_1).

Significantly higher uptake of zinc in grain, stover and total uptake (75.1, 153.0 and 228.0 g ha^{-1}, respectively) was recorded in the treatment where RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 2.5 t ha^{-1} Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T_{11}). It was on par with the treatment T_{10} which received RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 6 t ha^{-1} FYM + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS grain (68.2, 139.1 and 207.3 g ha^{-1}, respectively) as compared to absolute control (18.5, 36.9 and 55.4 g ha^{-1}, respectively) (T_1).

Significantly higher uptake of copper in grain, stover and total uptake (52.9, 107.4 and 160.3 g ha^{-1}, respectively) was recorded in the treatment RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 2.5 t ha^{-1} Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T_{11}). It was on par with the treatment T_{10} which received RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 6 t ha^{-1} FYM + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS grain (50.4, 99.3 and 149.8 g ha^{-1}, respectively) as compared to absolute control (T_1).

Significantly higher uptake of copper in grain, stover and total uptake (15.0, 65.5 and 80.5 g ha^{-1}, respectively) was recorded in the treatment where RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 2.5 t ha^{-1} Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T_{11}). It was on par with the treatment T_{10} which received RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 6 t ha^{-1} FYM + Bio-fertilizer + Foliar Spray of 19:19:19 @ 1% at 15, 30 and 45 DAS grain (13.6, 59.5 and 72.8 g ha^{-1}, respectively) as compared to absolute control (T_1).

Increased micronutrient uptake by foxtail millet was with application of RDF (30:15:15 kg N:P_2O_5:K_2O ha^{-1}) + 2.5 t ha^{-1} Vermicompost + Bio-fertilizer + Foliar spray of 19:19:19 @ 1% at 15, 30 and 45 DAS (T_{11}) which could be attributed to production of natural chelating agents from the organic materials which helped in keeping micronutrients in soluble and more available forms for plants. Similar results are also represented by Antil et al. (1989) [2], Ramsakal (2001) [10] and Chideshwari and Krishnaswamy (1998) [7].

**Conclusion**

Low cost technology like organic sources of nutrients and use of Foliar sprays of NPK can help in augmenting yield and quality of produce. The Foliar sprays of 19:19:19 @ 1% at 15, 30 and 45 DAS increased yield to the up to 20.10%. This study on effect of nutrient management in Foxtail millet is useful for deciding the suitable combination of nutrient sources for sustainable production and profitability.

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