**Evaluating the Impact of Liquid Biofertilizers on Nutrient Acquisition and Soil Fertility after Harvesting Finger Millet**

 **ABSTRACT**

A field experiment entitled “Response of liquid biofertilizer and their mode of application on growth and yield of finger millet (Eleusine coracana L.)” was carried out during Kharif 2020 in randomized block design with 3 replications involving 11 treatments to find out the effect of liquid biofertilizer on growth and yield of finger millet. The factors under study comprised of different liquid biofertilizer practices. the variety of finger millet (RAU-8) was sown on 28th July 2020. A common recommended dose of fertilizer of 40N:20 P2O5:20 K2OKg ha-1 was applied. The maximum available nitrogen (185.25 kg ha-1), phosphorus (19.21 kg
ha -1) and potassium (132.78 kg ha-1) and in term of dehydrogenase activity (gTPFg-1 dry soil 24h-1 in soil were observed with T1 - 100% RDF + seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit. mix with 500kg/ha FYM applied in furrows ),which was found to be at par with treatment T10 - RDF (40:20:20, N: P2O5:K2O Kg ha -1 ) and lower available nitrogen (121.52 kg ha -1 kg ha-1), phosphorus (10.40 kg ha -1 ) and potassium (84.78 kg ha -1 ) in soil were estimated with T11 -(control) has noted maximum post-harvest availability of total N, P2O5, K2O of finger millet has shown significantly higher availability of nutrient.

***Keywords:*** liquid biofertilizer, Finger Millet, Microorganisms

**Introduction**

 Finger millet [*Eleusine coracana* (L.) Gaertn.] commonly known as ragi, which is one of the major staple food crops of Southern region and also an ideal food for patients suffering from diabetes. It occupies the highest area under cultivation among the small millets. The grains are rich in calcium and iron besides being rich in carbohydrate and protein. In India, it is grown in an area of 1.19 million hectares with the production of 1.98 million tonnes and the productivity is 1661 kg ha -1 (Sakamma *et al.,* 2018). Karnataka is the largest producer of finger millet in India followed by Tamil Nadu, Andra Pradesh, Orissa, Jharkhand, Maharashtra and Uttaranchal. Millets exhibit unique characteristics amongst cereals. These can grow well under dry and aberrant weather conditions, can cope with relatively poor soils and require comparatively less external inputs than major cereals, namely rice, wheat and maize. Millets are a staple food with superior nutritional qualities and used both as food and fodder. In addition, millets sequestrate carbon, thereby adding to CO2 abatement opportunities, contribute to enhanced agro-biodiversity by their rich varietal diversity, ecologically beneficial (Brahmachari *et al*. 2018), allow for mutually beneficial intercropping with other important crops (Maitra *et al.* 2000). Under the changing scenario of global warming and climate change, cultivation of ecologically sound and hardy millets may be a wise alternative for optimum output with food and nutritional security. India is the largest producer of various kinds of millets. Biofertilizers are products that contain living microorganisms that are used in agriculture for N2 fixation, P absorption and nutrient mobilisation to improve soil quality and agricultural production. Despite the fact that the potential of biofertilizers in boosting crop yield has been fully researched and confirmed in recent years, biofertilizer technology has yet to be widely adopted. Most manufacturers in India are currently producing carrier-based inoculants with carriers include charcoal, lignite and coal. The cost of manufacturing carrier-based inoculants, on the other hand, is high since it is a time-consuming and labor-intensive procedure that includes transportation, mining, drying, milling, sieving, sterilizing, and pH correction. Some of the issues associated with carrier-based inoculants were addressed by liquid inoculant formulations. Liquid inoculants are one-of-a-kind mixtures of live cells of desired microorganisms in a nutritional medium including cell protectant chemicals. Inoculant compositions with cell protectant ingredients increase cell viability throughout storage and after seed or soil application.

**Material and method**

**Experiment site**

The aforementioned TCA, Dholi (Muzaffarpur), is located on the Burhi Gandak's southern bank, at an elevation on 58 metres above sea level, it is located at 25.590 North latitude & 85.350 East longitudes. The monsoon has a tremendous impact on the humid sub-tropical climate zone.

**Observation:**

**Collection of plant sample**

Five plant was plucked at random from every plots adjacent to the border row. in grain and straw samples. Uprooting was done with care, using a *khurpi* to dig around the plant and remove the adhering sand without serious injury to root that topsoil was derived from plant roots including rootlets were cleaned with an underwater jet, and the grain sample had been baked in a drying oven to dry at 78°c and crushed to 40 mesh size.

**Nitrogen content and uptake**

After digestion in concentrated H2SO4, the nitrogen content of finely grind (40 meshes) plant materials in grains and straw was evaluated using the micro Kjeldahl method. The following formula was used to calculate nitrogen uptake by grains, as well as straw:

N uptake by grain (kg ha-1) = Grain yield (kg ha-1) × N content (%) × 10-2

N uptake by straw (kg ha-1) = Straw yield (kg ha-1) × N content (%) × 10-2

**Phosphorus content and uptake**

After digestion in tri-acid, the concentration of phosphorus in finger millets plant, grain, and straw after harvesting of crop was evaluated using the molybdovanado phosphoric acid yellow color method (Page, 1982). The following equation was used to calculate the P uptake by grains, as well as straw:

P uptake by grain (kg ha-1) = Grain yield (kg ha-1) × P content (%) ×10-2

P uptake by straw (kg ha-1) = Straw yield (kg ha-1) × P content (%) ×10-2

**Potassium content and uptake**

After tri-acid digestion, the potassium concentration in finger millets plants, grains, and straw was assessed by using Flame photometric technique (Jackson,1967), while K absorption through wheat crops, grain, and straw were calculated from the following.

K uptake by grain (kg ha-1) = Grain yield (kg/ha-1) × K content (%) ×10-2

K uptake by straw (kg ha-1) = straw yield (kg/ha-1) × K content (%) ×10-2

**Soil reaction (pH) & electrical conductivity (EC)**

The pH as well as EC of the soils was measured doing it with a pH metre and a conductivity bridge in a 1:2.5 soil-water ratio.

**Organic carbon (%)**

When soil's organic carbon contained were calculated using the “Walkley and Blacks technique (1934) as stated by Jackson (1973)” and represented as a percentage.

**Available N, P and K as initial soil status**

**Available Nitrogen (kg ha-1)**

The “alkaline permanganate method” (Subbiah and Asijas, 1956) was used to determine the amount of available nitrogen.

**Available Phosphorus (kg ha-1)**

Total available phosphorus has been calculated using the technique given by Olsen and Watanable (1965).

**Available Potassium (kg ha-1)**

The accessible K content of soil was separated to use a ‘neutral normal ammonium acetate solution (pH-7.0) and soil extract was prepared in a 1:5 ratio. whereas, K has been measured in an extracted using a flame photometer was reported in Jackson (1973) and the results were adjusted to kg/ha.

**Results and Discussion.**

 Maximum nitrogen uptake by grain (28.43 kg ha-1) and (31.98 kg ha-1) straw was registered in treatment T1 -100%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. Respectively after crop harvest under different seed treatment with liquid biofertilizer treatment in the experimental plot. But, it was at par with T3 -100%RDF + soil application with liquid biofertilizer and T4- 85%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. The minimum nitrogen uptake by grain (8.95kg ha-1) and straw (8.83 kg ha-1) was found in T11 ­-(control) (Table 3). This find supported from the work of Bekere *et.al.* (1954).

 The maximum phosphorus uptake by grain (8.51 kg ha-1) and straw (9.95 kg ha-1) was recorded under T1 -100%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. However, it was at par with T3 -100%RDF + soil application with liquid biofertilizer and T4- 85%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. The minimum phosphorus uptake by grain (2.73 kg ha-1) and straw (2.63 kg ha-1) was registered under T11 ­(control), it was noticed by table 3 . The present findings are similar to the finding of Koushik and Singh (2008).

 The maximum potassium uptake by grain (9.71kg ha-1) and straw (60.68 kg ha-1) was recorded under T1-100%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. However, it was at par with T3 -100%RDF+soil application with liquid biofertilizer and T4- 85%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. The minimum potassium uptake by grain (2.75 kg ha-1) and straw (18.27 kg ha-1) was found under T11 -­(control). Similar observation was recorded by Korla *et al.* (2019).

The maximum value of NPK grain and straw content (%). was observed T1 -100%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow. Nitrogen content in the grain (1.20%) and straw (0.66%), phosphorus content in grains (0.36 %) and straw (0.094%) and potassium content in grain (0.41%) and straw (1.25%) respectively and minimum nitrogen content recoded in grain (0.95) and straw (0.42 %) and phosphorus content in grain (0.29%) and straw (0.046%) and potassium content in grain (0.29%) and straw (0.92 %) was registered with T11 -(control) Table 2. This conclusion has been assisted more by finding with Pallavi *et al.* (2016).

After a thorough examination of mean data on PH, EC (dsm-1) and organic carbon (%) it was found that liquid biofertilizers had a non-significant impact on post-harvest soil as compared to initial soil parameters. However, which acts as a medium for EC and OC, hence EC and OC of the post-harvest soil is higher than initial soil parameters. The outcome was explained and represented in (Table 1 and 4), Similarly, findings were also reported by Meena *et al* (2015).

An appraisal of data revealed that available NPK (kg ha-1) content in the soil after harvest of finger millet were significantly affected by varying treatments. The maximum nitrogen content (185.25 kg ha-1) and phosphorus (19.21kg ha-1) and potassium content (132.78 kg ha-1) in soil was observed with T1 -100%RDF+seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit., mix with 500 kg/ha FYM and apply in-furrow and the minimum nitrogen content in soil was observed under T11 -(control) (Table 5). This finding is quite similar to that of (Singh *et al.* 2009) and (Thind *et al.*).

**Conclusion**

The maximum NPK grain and straw content (%) and that available NPK (kg ha-1) content in the soil after harvest of finger millet and maximum grain and straw yield were observed with T1 - 100% RDF + seed treatment with liquid biofertilizer (5 ml kg-1 seed) followed by soil application of liquid biofertilizer (2.5 lit. mix with 500 Kg FYM applied in furrows), which was found to be at par with treatment T10 - RDF (40N:20P2O5:20K2OKg ha‑1) and minimum NPK grain and straw content (%) and available NPK (kg ha-1) content in the soil after harvest of finger millet and grain and straw yield in soil were estimated with T11 -(control) has noted maximum post-harvest availability of total N, P2O5, K2O

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**Table 1 Chemical soil characteristic (0-20cm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl. No** | **Particulars** | **Value obtained** | **Method adopted** | **References** |
| 1 | EC (dSm-1 at 25o C) | 0.34 | Conductivity bridge | (Jackson, 1973) |
| 2 | pH (1: 2.5 water suspension) | 8.33 | Glass electrode pH meter | (Jackson,1973) |
| 3 | Organic carbon (%) | 0.44 | Walkley and black method | (Walkley & Black,1934) |
| 4 | Available N (kg ha- 1) | 169.40 | Alkaline permanganate method | (Subbaih and Asija,1956) |
| 5 | Available P2O5 (kg ha-1) | 15.95 | Olsen’s method and Watanable | (Olsen & watanabe,1965) |
| 6 | Available K2O (kg ha-1) | 126.40 | Flame photometer method | (Jackson,1973) |

**Table 2 : Response of liquid biofertilizer and their mode of application on NPK content in grain and straw of Finger millet.**

| **Treatment No.** | **Treatment** | **Grain (%)** | **Straw (%)** |
| --- | --- | --- | --- |
| N | P | K | N | P | K |
| T1 | 100%RDF+seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 1.20 | 0.36 | 0.41 | 0.66 | 0.09 | 1.25 |
| T2 | 100%RDF +seed treatment with liquid biofertilizer  | 1.09 | 0.35 | 0.38 | 0.59 | 0.09 | 1.18 |
| T3 | 100%RDF+ soil application with liquid biofertilizer  | 1.17 | 0.35 | 0.40 | 0.64 | 0.09 | 1.23 |
| T4 | 85%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 1.16 | 0.35 | 0.40 | 0.64 | 0.09 | 1.24 |
| T5 | 85%RDF + seed treatment with liquid biofertilizer  | 1.06 | 0.34 | 0.38 | 0.56 | 0.08 | 1.19 |
| T6 | 85%RDF + soil application with liquid biofertilizer  | 1.12 | 0.35 | 0.39 | 0.62 | 0.09 | 1.20 |
| T7 | 70%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer | 1.03 | 0.34 | 0.37 | 0.53 | 0.07 | 1.16 |
| T8 | 70%RDF + seed treatment with liquid biofertilizer  | 1.00 | 0.34 | 0.37 | 0.52 | 0.07 | 1.14 |
| T9 | 70%RDF + soil application with liquid biofertilizer  | 1.02 | 0.34 | 0.37 | 0.53 | 0.07 | 1.15 |
| T10 | RDF (40:20:20,N:P2O5:K2O Kg ha ‑1 ) | 1.08 | 0.35 | 0.38 | 0.58 | 0.08 | 1.17 |
| T11 | Control | 0.95 | 0.29 | 0.29 | 0.42 | 0.04 | 0.92 |
|  |  S.Em.±  | 0.034 | 0.004 | 0.005 | 0.02 | 0.003 | 0.015 |
|  |  CD (P=0.05)  | 0.101 | 0.013 | 0.015 | 0.055 | 0.010 | 0.044 |

Seed treatment = (Bio- NPK liquid biofertilizer @ 5ml/kg seed)

Soil application = liquid biofertilizer (bio-NPK @ 2.5 lit.) mixed with 500 Kg ha-1 FYM applied in furrow

**Table 3 : Response of liquid biofertilizer and their mode of application on NPK and uptake by grain and straw of Finger millet.**

| **Treatment No.** | **Treatment detail** | **Grain (kg ha-1)** | **Straw (kg ha-1)** |
| --- | --- | --- | --- |
| **N** | **P** | **K** | **N** | **P** | **K** |
| T1 | 100%RDF+seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 28.43 | 8.51 | 9.71 | 31.97 | 9.95 | 60.68 |
| T2 | 100%RDF +seed treatment with liquid biofertilizer  | 21.17 | 6.81 | 7.50 | 22.67 | 7.42 | 45.41 |
| T3 | 100%RDF+ soil application with liquid biofertilizer  | 27.00 | 8.25 | 9.41 | 30.15 | 9.28 | 57.78 |
| T4 | 85%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 24.94 | 7.68 | 8.75 | 28.46 | 8.35 | 54.82 |
| T5 | 85%RDF + seed treatment with liquid biofertilizer  | 19.38 | 6.34 | 7.06 | 20.41 | 6.39 | 43.47 |
| T6 | 85%RDF + soil application with liquid biofertilizer  | 23.54 | 7.37 | 8.25 | 26.37 | 7.80 | 51.06 |
| T7 | 70%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer | 17.35 | 5.83 | 6.39 | 18.72 | 5.88 | 40.87 |
| T8 | 70%RDF + seed treatment with liquid biofertilizer  | 14.25 | 4.91 | 5.31 | 15.89 | 4.93 | 34.74 |
| T9 | 70%RDF + soil application with liquid biofertilizer  | 15.54 | 5.27 | 5.71 | 17.08 | 5.34 | 37.02 |
| T10 | RDF (40:20:20,N:P2O5:K2O Kg ha ‑1 ) | 20.51 | 6.65 | 7.25 | 22.13 | 7.16 | 44.57 |
| T11 | Control | 8.95 | 2.73 | 2.75 | 8.83 | 2.63 | 19.27 |
|  |  S.Em.±  | 1.56 | 0.32 | 0.41 | 1.24 | 0.34 | 2.21 |
|  |  CD (P=0.05)  | 4.63 | 0.97 | 1.22 | 3.70 | 1.02 | 6.56 |

Seed treatment = (Bio- NPK liquid biofertilizer @ 5ml/kg seed)

Soil application = liquid biofertilizer(bio-NPK @ 2.5 lit.) mixed with 500 Kg ha-1 FYM applied in furrow

**Table 4 : Response of liquid biofertilizer and their mode of application on Post harvest soil physic-chemical properties of Finger millet.**

| **Treatment No.** | **Treatment detail** | **EC (dsm-1)** | **pH** | **Organic Carbon (%)** |
| --- | --- | --- | --- | --- |
| T1 | 100%RDF+seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 0.36 | 8.31 | 0.45 |
| T2 | 100%RDF +seed treatment with liquid biofertilizer  | 0.37 | 8.33 | 0.44 |
| T3 | 100%RDF+ soil application with liquid biofertilizer  | 0.36 | 8.31 | 0.45 |
| T4 | 85%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 0.36 | 8.31 | 0.45 |
| T5 | 85%RDF + seed treatment with liquid biofertilizer  | 0.37 | 8.33 | 0.44 |
| T6 | 85%RDF + soil application with liquid biofertilizer  | 0.36 | 8.31 | 0.46 |
| T7 | 70%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer | 0.35 | 8.3 | 0.46 |
| T8 | 70%RDF + seed treatment with liquid biofertilizer  | 0.36 | 8.33 | 0.44 |
| T9 | 70%RDF + soil application with liquid biofertilizer  | 0.35 | 8.3 | 0.47 |
| T10 | RDF (40:20:20,N:P2O5:K2O Kg ha ‑1 ) | 0.37 | 8.33 | 0.44 |
| T11 | Control | 0.34 | 8.31 | 0.45 |
|  |  S.Em.±  | 0.006 | 0.123 | 0.007 |
|  |  CD (P=0.05)  | NS | NS | NS |

Seed treatment = (Bio- NPK liquid biofertilizer @ 5ml/kg seed)

Soil application = liquid biofertilizer(bio-NPK @ 2.5 lit.) mixed with 500 Kg ha-1 FYM applied in furrow

**Table 5: Response of liquid biofertilizer and their mode of application on post-harvest soil of Finger millet.**

| **Treatment No.** | **Treatment** | **N (kg ha-1)** | **P2O5 (kg ha-1)** | **K2O (kg ha-1)** |
| --- | --- | --- | --- | --- |
| T1 | 100%RDF+seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 185.25 | 19.21 | 132.85 |
| T2 | 100%RDF +seed treatment with liquid biofertilizer  | 184.94 | 18.75 | 132.35 |
| T3 | 100%RDF+ soil application with liquid biofertilizer  | 182.93 | 18.30 | 131.68 |
| T4 | 85%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer  | 170.15 | 15.75 | 127.87 |
| T5 | 85%RDF + seed treatment with liquid biofertilizer  | 176.18 | 15.27 | 128.05 |
| T6 | 85%RDF + soil application with liquid biofertilizer  | 172.15 | 16.08 | 118.83 |
| T7 | 70%RDF+ seed treatment with liquid biofertilizer followed by soil application of liquid biofertilizer | 150.42 | 14.23 | 119.90 |
| T8 | 70%RDF + seed treatment with liquid biofertilizer  | 155.55 | 15.01 | 119.75 |
| T9 | 70%RDF + soil application with liquid biofertilizer  | 153.43 | 14.54 | 132.30 |
| T10 | RDF (40:20:20,N:P2O5:K2O Kg ha ‑1 ) | 181.92 | 18.06 | 132.78 |
| T11 | Control | 121.52 | 10.40 | 84.78 |
|  |  S.Em.±  | 6.07 | 1.08 | 1.38 |
|  |  CD (P=0.05)  | 17.92 | 3.21 | 4.12 |

Seed treatment = (Bio- NPK liquid biofertilizer @ 5ml/kg seed)

Soil application = liquid biofertilizer(bio-NPK @ 2.5 lit.) mixed with 500 Kg ha-1 FYM applied in furrow