Original Research Article

Agronomic response of System of Finger millet Intensification technique on growth and yield of organic finger millet (*Eleusine coracana*L.)

ABSTRACT:

The experiment was carried out during *Kharif* season 2016 and 2017 at Crop Research Farm, SHUATS Model of Organic Farm (SMOF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) to study the 'Agronomic response of System of Finger millet Intensification technique on growth and yield of organic finger millet (*Eleusine coracana* L.)'.The pooled data recorded that SFMI technique has significant and highest plant height (86.12 cm),maximum number of tillers/ hill (13.08), higher plant dry weight (22.946g/ hill), maximum number of effective tillers/ hill (12.14), longest spike length (4.01 cm), highest number of grains/ spike (1913.63), highest grain yield (3.23 t/ ha), highest straw yield (7.34 t/ ha)and higher harvest index (43.86%). The pooled data also recorded that CTFMhas significant and highest crop growth rate (17.853 g/ m^2/ day) at 75 to 90 DAS intervals. Considering poultry manure (16 t/ ha) pooled data showed significant andhighest plant height (85.89 cm), maximum number of tillers/ hill (12.88),higher plant dry weight (22.946g/ hill), maximum number of effective tillers/ hill (11.97), longest spike length (3.98 cm), highest number of grains/ spike (1908.46), higher grain yield (3.25 t/ ha), highest straw yield (7.38 t/ ha) and higher harvest index (44.01%). The data also recorded highest benefit cost ratio by System of Finger millet Intensification technique along with organic sources of nutrient by Poultry manure (1.7 t/ ha) during both the years and in average.

Keywords: Organic finger millet, SFMI technique, planting methods, organic sources of nutrient, growth, yield attributes,yield and economics.

Introduction

Millets are important but underutilized crops in tropical and semiarid regions of the globe due to their greater resistance to pests and diseases, good adaption to a wide range of environment and their good yield of production, can withstand significant levels of salinity, short growing season, resistant to water logging, drought tolerant, requires little inputs during growth and with increasing world population and decreasing water supplies represents important crops for future human use. The drought tolerance of finger millet may be attributed to an efficient antioxidant potential and increased signal perception. Being as hardy crop it is relatively easy to grow finger millet under stressful regimes, without hampering the net productivity (Chandrasekara and Shahidi, 2010).The global millets production was estimated at 27.8 m t. India is the largest global producer with a 41.04% global market share (BUSINESS WIRE, 2018). Finger millet contains rich amounts of calcium (0.38%), protein (6% – 13%) and carbohydrates (65% – 75%). The seeds are abundant source of dietary fiber (18%), minerals (2.5% – 3.5%), essential amino acids, *viz*., isoleucine, leucine, methionine, phenylalanine, phytates, tannins, phenolic compounds, trypsin inhibitory factors and also gluten-free (Sood *et al.*, 2016; Chandra *et al.*, 2016).India has the largest area among finger millet growing countries and stands first in production. It produces 1.82 m t of finger millet (*ragi*) in an area of 1.13 m ha with the productivity of 1.61 t/ ha (GOI, 2018).In India, *ragi* is widely grown in Rajasthan, Karnataka, Andhra Pradesh, Tamil Nadu, Orissa, Maharashtra, Kumaon region of Uttarakhand and Goa; of which, Maharashtra, Tamil Nadu and Uttarakhand produce the bulk of *ragi* in the country.

Organic farming is one of the significant practices to make the production system more sustainable without adverse effects on the natural resources and the environment (Stockdale *et al.*, 2001). Organic farming is being practiced in more than 181 countries of the world with 2.9 million producers. In India, organic production is practiced in 1.8 m ha (2.6% of the total organic cultivation area of 69.8 m ha). India ranked first in terms of the number of organic producers among over 181 countries and eight in terms of the area under organic agriculture. India ranked 11^{th} in organic product exports (FiBL and IFOAM-OI, 2019). The global total land used for cereals (including rice, wheat, barley, finger millet) is 4.5 m ha. India produced around 2.75 m t of certified organic products of all varieties of food products including cereals & millets (APEDA, 2019).

In the last decades or 2, India has evinced a sharp decline in the area and productivity of finger millet or *ragi* due to various factors. The cultivated area was highly neglected and about 46% has decreased under finger millet, due to given rise more important to other crops (maize, sorghum, including oilseed and pulse crops). The productivity of finger millet is also decreasing due to inappropriate agronomic management practices, adoption of direct sowing method, improper use of production inputs (seeds and fertilizers), utilization of forest land for cultivation, poor soil fertility (low in organic carbon) and improper planting geometry. Millet crops are reported to be most tolerant to moisture stress but even for short period of moisture stress during critical growth stages, markedly reduces the yield (Udayakumar *et al.*, 1986). Further, rising incomes, growing urbanization and government policies favouring the production and consumption of major food cereals like rice and wheat are other factors of declining in finger millet production (Rao and Basavaraj, 2015).

The System of Finger millet Intensification (SFMI) technique has a great potentiality to increase finger millet or *ragi* productivity and creates a suitable growing condition through manipulation of soil environment. SFMI technique is based on the principles and practices of System of Rice Intensification method of transplanting which has the potential to provides sufficient aeration, water, light energy and available nutrients, leading to vigorous root system development from initial stage of crop growth to harvest. System of Finger millet Intensification technique (SFMI) is the system of modified agronomic management practices such as reduced seed rate, transplanting of single seedlings per hill, wider and square spacing, minimum use of external inputs, minimum use of irrigation, cycle weeding with reduced labours requirement, resulting in increased growth parameters and yield attributes character, thus enhanced yield of *ragi* or finger millet. Seed treatment with organic formulations like *jeevamruth*, cow urine and jaggery also plays an important role in early and healthy germination of seedling in SFMI technique.

The nutrients required by the plants can be supplied through organic sources of nutrients such as farm yard manure, poultry manure,*vermicompost*, green manure and foliar spray of organics such as cattle urine.

Poultry manure is an outstanding organic source and acts as a good soil amendment, as it contains high available nitrogen, available phosphorus, available potassium and other essential nutrients and can also increase the soil and leaf N, P, K Ca, and Mg concentrations (Duncan, 2005; Agbede*et al.*, 2008). Poultry manure supplies phosphorus more readily to plants than other organic manure nutrient sources (Garg and Bahla, 2008).

Organic matter in soil improves soil structures, bulk density, nutrient retention, porosity, water holding capacity and water infiltration. Long term addition of organic materials to soil results in increased soil organic matter, crop productivity and soil biological activity (Collins *et al.*, 1992), also quality of the produce (Deshpande and Devasenapathy, 2010). Application of organic manures for improving soil fertility and crop productivity has gained importance in recent years due to speedy increasing the cost and adverse impact of continuous and indiscriminate use of synthetic fertilizers. Incorporation of organic manures has been given rise a hope to reduce the cost of cultivation and minimize adverse effects of inorganic fertilizers especially on deterioration of soil structure, soil health and environmental pollution. Utilization and scientific management of FYM, poultry manure, *vermicompost* and green manures may be a good organic source for producing quality products and also maintaining environmentally-friendly sustainable agriculture.

In the light of the constraints and probable solutions stated above, the present investigation entitled, "Agronomic response of System of Finger millet Intensification on growth and yield of organic finger millet (*Eleusine coracana* L.)", is carried out at SHUATS Model Organic Farm, Crop Research Farm of Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj during the *Kharif* season of 2016 and 2017.

Materials and Methods

The experiment was carried out during *Kharif* season 2016 and 2017 at Crop Research Farm, SHUATS Model of Organic Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.). SHUATS Model Organic Farm (SMOF) was developed under the National Project on Organic Farming (NPOF) by the Department of Agronomy, with Dr. Thomas Abraham, Professor (Agronomy) as it's Principal Investigator. The 2 hectares (5 acres) area has been Certified by Lacon Quality Certification (P) Ltd. [Accreditation No. NPOP/NAB/006, Ministry of Commerce, Govt. of India] till 2017 the field was in its 9^{th}year of conversion. The soil of the experimental plot was sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potash with 7.68 soil pH. The experiment was laid out in split plot design with three replications, having three planting methods, *viz.*, System of Finger millet Intensification [SFMI (30 DAS), 25 × 25 cm] technique, Conventional Transplanted Finger millet [CTFM (30 DAS), 25 × 10 cm]andLate Conventional Transplanted Finger millet [LCTFM (40 DAS), 25 × 10 cm);

threeorganic sources of nutrient, *viz*.,Poultry manure (1.7 t/ ha), Farm yard manure (10 t/ ha) and *Vermicompost* (2.5 t/ ha) were studied. Green manure *dhaincha* (*Sesbania aculeata* L.) was grown during *zaid* season and organic liquid manure (*Panchagavya*and Fish Amino Acid) was sprayed in all the treatment; and the crop seeds were treated with *jeevamruth* organic formulation. There were total 9 treatment combinations in all. The net plot size was 5 × 4 m and net experimental area 540 m^2. The agronomic practices, *viz*., weeding with cycle weeder in SFMI technique, manual and hand weeding in CTFM and LCTFM methods were done and irrigation was given according to the schedules for all treatments. The finger millet variety 'VL Mandua-352 (VL 352)' was sown.The Meteorological data observation maximum & minimum temperatures during the finger millet crop season ranged from 30.25^{0}C to 35.85 ^{0}C and 14.70^{0}C to 27.41^{0}C, respectively in 2016 and 27.60^{0}C to 36.95^{0}C and 9.00^{0}C to 30.40 ^{0}C, respectively in 2017.Data on plant height, number of tillers/ hill, plant dry weight (g/ hill), CGR (g/ m^2/ day), RGR (g/ g/ day),number of effectivetillers/ hill,spike length (cm), number of grains/ spike, grain yield (t/ ha), straw yield (t/ ha), harvest index (%) and economicswere recorded. Data recorded on crop growth parameters and yield parameters were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976.

Results and Discussion

Plant height (cm)

Perusal of the mean data showed significant variation in plant height among different planting methods at 90 DAT. Significantly tallest plant height (86.29 cm, 85.95 cm and 86.12 cmrespectively) was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS) during both the years and pooled (Table 1). Plant height increased generally in treatment with SFMI technique, which might be due to wider spacing with single seedlings resulted in less competition between plants for solar radiation, space, water and increased effective utilization of available resources for better growth. These results corroborate with the findings of Chittapur*et al.*, (1994); Somashekhar and Loganandhan (2020).

Data pertaining to organic sources of nutrient showed significant variation in plant height at 90 DAT. It further revealed that S_1 (Poultry manure, 1.7 t/ ha) produced significantly tallest plant height (86.01 cm, 85.78 cm and 85.89 cm respectively) than to rest of the treatments during both the years and in pooled (Table 1).The plant height increased with poultry manure might be due to greater availability of nitrogen and phosphorus to the crops. The similar, findings are in conformity with Eltilib*et al.* (2006).

Perusal of the data also reveals that interaction effect of planting methods and organic sources of nutrient did not affected the plant height of finger millet during both the years and in pooled.

Number of tillers/ hill

A close scrutiny of mean data on number of tillers revealed that the planting methods exerted significant influence on number of tillers/ hill at 90 DAT during both the years and pooled analysis. Significant and maximum number of total tillers/ hill (12.87, 13.29 and 13.08) was recorded in the treatment M_1 (System of Finger millet Intensification technique, 30 DAS) during both the years and pooled respectively. However, M_3 (Late Conventional Transplanted Finger millet) was registered statistically at par with M_1 (System of Finger millet Intensification technique, 30 DAS) in 2017 (Table 1). Maximum number of tillers/ hill generally registered with System of Finger millet Intensification technique, which may be due to the change of management practices by pulling of a straight round wood over the plants by bending them over gently four time from different sides, this gentle trolling, by bending the plants over at the base, might have stimulated the growth of tillers and roots of the plant. Further, wider spacing facilitate more absorption of light energy, water and nutrients to produce massive root system resulting higher number of tillers/ hill. Similar, findings was in accordance with Somashekhar and Loganandhan (2020).

Organic sources of nutrient showed statistical variation on number of total tillers/ hill over poultry manure during both the years of experiment and in pooled. Among the organic sources of nutrient, S_1 (Poultry manure, 1.7 t/ ha) produced maximumnumber of tillers/ hill (12.51, 13.24 and 12.88) in comparison to all the other treatments at 90 DAT during both the years and in pooled respectively, though, it was found non significant during both the year and but found significant in pooled analysis. However, S_2 (Farm yard manure, 10 t/ ha) was registered statistically at par with S_1 (Poultry manure, 1.7 t/ ha) in pooled(Table 1).The organic source of nutrient such as poultry manure might have encouraged effective nitrogen supply which is essential for vegetative growth resulting maximum number of tillers/ hill. This result was partially supported by Saha *et al.* (2013).

Perusal of the data also reveals that interaction effect of planting methods and organic sources of nutrient did not affected the number of total tillers/ hill of finger millet during both the years and in pooled.

Plant dry weight (g/ hill)

Mean data on plant dry weight revealed that there was significant difference in plant dry weight (22.964, 24.119 and 22.946 g/ hill) of finger millet in the treatment M_1 (System of Finger millet Intensification technique, 30 DAS) at 90 DAT during both the years of investigation and also in pooled respectively, which was superior to M_2 (Conventional Transplanted Finger millet, 30 DAS) and M_3 (Late Conventional Transplanted Finger millet, 40 DAS). However, data further revealed that M_2 (Conventional Transplanted Finger millet, 30 DAS) was found to be statistically at par with M_1 (System of Finger millet Intensification technique, 30 DAS) at 90 DAT in 2016 and pooled analysis (Table 1).Higher plant dry weight with SFMI technique which might have induced both greater and deeper root growth, thereby contributing to increased nutrient uptake throughout the crop cycle (Barison and Uphoff, 2011). Further, higher total dry matter production might have attributed to better plant growth which resulted in higher dry matter accumulation in leaves and stem at initial growth stages and better translocation to ear heads during later stages (Somashekhar and Loganandhan, 2020). These results are in conformity with the findings of Mishra *et al.*, (1973).

Among the different organic sources of nutrient significant influence on plant dry weight was recorded at 90 DAT in2017 and also in pooled. S_1 (Poultry manure (1.7 t/ ha) produced significantly more plant dry weight (23.651 g and 22.946 g) compare to other organic source treatment in 2017 and in pooled respectively.Further, highest plant dry weight (22.241 g) was recorded in the treatment S_1 (Poultry manure (1.7 t/ ha) at 90 DAT in 2016, though it was registered non significant.However, S_2 (Farm yard manure, 10 t/ ha) was found to be statistically at par with S_1 (Poultry manure (1.7 t/ ha) at 90 DAT in 2017 and pooled(Table 1).Higher plant dry weight with organic source of nutrient such as poultry manure, which may be due to the maximum growth and tillering of plant. Although tillers mortality and senescence occurred but reproductive parts contributed a considerable amount of dry matter production in plant (Hasanuzzaman*et al.*, 2010). Further, application of poultry manure may have enhanced the nutrient availability and suitable soil environment for luxuriant growth of plant as well as higher number of tillers/ hill by reducing the losses of nutrients and hence produced the higher plant dry weight (Rahman *et al.*, 2007).

Perusal of the data also reveals that interaction effect of planting methods and organic sources of nutrient did not affected the plant dry weight of finger millet during both the years and in pooled.

Crop Growth Rate (g/ m^2/day)

A close scrutiny of mean data on crop growth rate revealed that the planting methods exerted significant influence on crop growth rate at 75 to 90 DAT intervals during both the years and pooled. The maximum crop growth rate was recorded by M_2(Conventional Transplanted Finger millet, 30 DAS) in 2016 and pooled analysis.Further, it was registered significantly higher crop growth rate by M_3 (Late Conventional Transplanted Finger millet, 40 DAS) in 2017. However, M_2 (Conventional Transplanted Finger millet, 30 DAS) was observed to be statistically at par with M_3 (Late Conventional Transplanted Finger millet, 40 DAS)at 75 to 90 DAT intervals(Table 1).The higher CGR with closer spacing (CTFM) may be attributed to the small ground area subtended by the individual plant which might have ensured early canopy ground cover, thus capturing more solar energy and utilization of soil moisture and available nutrients under Conventional Transplanted Finger millet (CTFM). This is in line with the findings of Daisy *et al.* (2013) in castor and Caliskan *et al*. (2004) in sesame.

Data showed that organic sources of nutrient does not affected the crop growth rateat 75 to 90 DAT intervals. Among the organic sources of nutrient, S_1 (Poultry manure, 1.7 t/ ha) was recorded highest crop growth rate (15.190 g/ m^2/ day) at 75 to 90 DAT interval in 2017 andby S_3 (*Vermicompost*, 2.5 t/ ha) in 2016 and pooled; and though it was registered non significant(Table 1).

Appraisal of the data on crop growth rate did not showed interaction between planting methods and organic sources of nutrient at different intervals of finger millet during both the years and in pooled.

Relative Growth Rate (g/ g/day)

The data recorded highest RGR in the treatment M_2 (Conventional Transplanted Finger millet, 30 DAS) in 2016, by M_1 (System of Finger millet Intensification technique, 30 DAS) and M_2 (Conventional Transplanted Finger millet, 30 DAS) in pooled and by M_1 (System of Finger millet Intensification, 30 DAS), M_2 (Conventional Transplanted Finger millet, 30 DAS) and M_3 (Late Conventional Transplanted Finger millet, 40 DAS) in 2017 at 75 to 90 DAT intervals, though it was registered non significant(Table 1).

The mean data also recorded the highest on relative growth rate in the treatment S_3 (*Vermicompost*, 2.5 t/ ha) in both the years and pooled; and by S_1 (Poultry manure, 2.6 t/ ha) and S_2 (Farm yard manure, 10 t/ ha) it was registered exactly same values in 2016, though it was found non significant(Table 1).

Appraisal of the data on relative growth rate remained unchanged with planting methods and organic sources of nutrient of finger millet during both the years and in pooled.

Number of effective tillers/ hill (at 90 DAT)

Perusal of the mean data showed significant variation in number of effective tillers/ hill among different planting methods at 90 DAT. Maximum number of effective tillers/ hill (11.82 in 2016 and 12.47 in 2017) was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years of experiment and in pooled. However, M_3 (Late Conventional Transplanted Finger millet, 40 DAS) was registered statistically at par with M_1 (System of Finger millet Intensification technique, 30 DAS) in 2017 (Table 2). Maximum number of effective tillers realized with System of Finger millet Intensification technique may be due to the use of younger seedlings and wide spacing, which provided more room for more canopy and root growth. More canopies utilize higher light radiation, which increases the expression of effective tillers. It corroborates with the findings of Hugar *et al*. (2009) and Debbarma *et al.* (2015) in rice.

Data pertaining to organic sources of nutrient showed significant variation in number of effective tillers/ hill at 90 DAT. It further revealed that S_1 (Poultry manure, 1.7 t/ ha) produced significantly maximum number of effective tillers/ hill (11.49 in 2016 and 12.44 in 2017) then all the other treatments during both the years and in pooled. However, S_2 (Farm yard manure, 16 t/

ha) remained at par to S_1 (Poultry manure, 1.7 t/ ha) in pooled analysis(Table 2). Maximum number of effective tillers with organic source of nutrient such as poultry manure may be due to adequate supply of balanced nutrition to the plants especially micronutrients. Further, organic manure application improved organic matter, nitrogen, phosphorus and exchangeable cation concentration of soil which could benefit growing crops resulting maximum number of effective tillers/ hill. These results are in accordance with the findings of Miller, (2007) and Audu *et al.* (2015).

It is clear from the data that interaction effect of planting methods and organic sources of nutrient did not affect the number of effective tillers/ hill of finger millet during both the years and in pooled.

Spike length (cm)

A close scrutiny of mean data on spike length revealed that the planting methods exerted significant influence on spike length during both the years of experiment and pooled. The significantly longest spike length (3.99 cm in 2016 and 4.04 cm in 2017) was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS). It is evident from the data that M_1 (System of Finger millet Intensification technique, 30 DAS) was found to be significantly superior to other planting methods during both the years of experiment and in pooled. Data also envisage that M_3 (Late Conventional Transplanted Finger millet, 40 DAS) had least spike length in both the years and in pooled analysis (Table 2).Spike length was significantly longest in System of Finger millet Intensification technique may be due to the lower rate of leaf senescence in plants that have larger amounts of cytokinins transported into their canopies from the roots. This was reported by (Soejima*et al.*, 1995) in rice.

Among the organic sources of nutrient, S_1 (Poultry manure, 1.7 t/ ha) was recorded significantly longerspike length (3.96 cm in 2016 and 4.00 cm in 2017) with respect to all the other treatments during both the years and in pooled. However, data further revealed that S_2 (*Vermicompost*, 2.5 t/ ha) remained at par to S_1 (Poultry manure, 1.7 t/ ha) in 2016(Table 2). Spike length was significantly longest with the application of poultry manure, which may be due to higher concentration of macro and micro nutrients into the soil resulting in increased availability of nutrients in root zone, thus more uptake by the crop resulting in better yield attributing character, *i.e.*, longer spike length. These results are in conformity with the findings of Poornesh *et al.* (2004) and Jagadeesha*et al.* (2010).

Appraisal of the data on spike length remained unchanged with planting methods and organic sources of nutrient of finger millet during both the years and in pooled.

Number of grains/ spike

Significant and maximum number of grains/ spike (1911.31 in 2016 and 1915.96 in2017) was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years of trial and pooled. Further, statistically lowest below was registered by M_3 (Late Conventional Transplanted Finger millet, 40 DAS) in compare to other methods during both the years and in pooled (Table 2). Number of grains/ spike was significantly highest in System of Finger millet Intensification technique may be due to a larger root system to capture some of the essential nutrients like zinc, manganese, boron and other nutrients for their essential synthesis of the enzymes for plant growth. In addition, cycle weeding could also contribute to the biological N fixation dynamism. Deeper root growth encourages higher nutrient absorption subsequently higher assimilation which will favour higher number of grains/ spike. (Rajaonarison, 2001). Similar findings are reported by Vijayakumar *et al.* (2006) in rice.

Data pertaining to organic sources of nutrient showed significant variation in number of grains/ spike. It further revealed that S_1 (Poultry manure, 1.7 t/ ha) produced significantly maximum number of grains/ spike than all the other treatments during both the years and in pooled. Further, S_2 (Farm yard manure, 10 t/ ha) was registered statically lower below during both the years and in pooled analysis(Table 2).Number of grains/ spike significantly highest with application of organic source of nutrient such as poultry manure, which might have attributed to higher concentration of nutrients and faster mineralization, improvement in soil physico-chemical and biological properties (Jha *et al.*, 2001). Further, poultry manure furnished the plant with its nutrient and the uptake and import of assimilates produced in other vegetative parts of the plant was probably directed to the spike and more spikelet formation on the tiller hence resulted in increased number of grains/ spike. These findings are in support by Damar *et al.* (2016).

Evaluation of the data on number of grains/ spike remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Grain yield (t/ ha)

Significant and higher grain yield of 3.19 (t/ ha),3.26 (t/ ha) and 3.23 (t/ ha) was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years of experiment and pooled analysis respectively. However, M_2 (Conventional Transplanted Finger millet, 30 DAS) was recorded statistically at par with M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years. Further, statistically lower below was registered by M_3 (Late Conventional Transplanted Finger millet, 40 DAS) in compare to other methods in both the years and pooled analysis(Table 2).The data apparently point that under SFMI technique single seedling, with a wider spacing, effectively reduced inter-plant competition for better nutrients specially nitrogen, which resulted better yield attributing characters like more number of effective tillers/ hill, longer spike length and number of grains/ spike ultimately higher grain yield. Similar findings were also reported by Narasimha Murthy and Hegde (1981) and Adhikari *et al.* (2018). In addition the technology using of special designed drill namely wooden marker and placement of FYM and the line transplanting of finger millet might also have contributed in growth and yield attributing characters. Verma and Patel (2013) also reported that this technology has potential of promoting organic cultivation of millets.

Data pertaining to organic sources of nutrient showed significant variation in grain yield. It further revealed that S_1 (Poultry manure, 1.7 t/ ha) produced significantly higher grain yield (3.23 t/ ha in 2016 and 3.27 t/ ha in 2017) than all the other treatments during both the years and in pooled. However, S_2 (Farm yard manure, 10 t/ ha) was found to be statistically at par to S_1 (Poultry manure, 1.7 t/ ha) during both the years and in pooled analysis. Further, S_3 (*Vermicompost*, 2.5 t/ ha) was registered statistically lower below in both the years and pooled(Table 2).Significantly higher grain yield with application of poultry manure might have attributed on physical, chemical and biological properties of soil. Further, poultry manure released synergistic effect of nutrients which was in synchrony with crop demand at different growth stages. This could be attributed to capability of plants to absorb the required nutrients as per its demand for growth and yield components resulting in higher grain yield of finger millet (Jagadeesha*et al.*, 2010 and Devegowda, 1997).

Results of the data on grain yield remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Straw yield (t/ ha)

Significant and higher straw yield (7.24 t/ ha in 2016 and 7.44 t/ ha in 2017)was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years and pooled. However, M_2 (Conventional Transplanted Finger millet, 30 DAS) was recorded statistically at par with M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years of trial. Further, statistically lower below was registered by M_3 (Late Conventional Transplanted Finger millet, 40 DAS) in compare to other methods in both the years and pooled(Table 2). The higher dry matter production and accumulation in stem may have led to the higher straw yield under the System of Finger millet Intensification technique reported by Manjunatha *et al.* (2010) in rice.

Data pertaining to organic sources of nutrient showed significant variation in straw yield. It further revealed that S_1 (Poultry manure (1.7 t/ ha) produced significantly maximum straw yield (7.31 t/ ha in 2016 and 7.44 t/ ha in 2017) than all the other treatments during both the years and in pooled. However, S_2 (Farm yard manure, 10 t/ ha) was found to be statistically at par to S_1 (Poultry manure, 1.7 t/ ha) during both the years. Further, S_3 (*Vermicompost,* 2.5 t/ ha) was registered statistically lower below in both the years and in pooled(Table 2).Higher straw yield with organic source of nutrient such as poultry manure, which might have attributed on greater nutrients for plant growth and biomass production, resulting higher straw yield. Saha *et al.* (2013) also reported that straw yield was increased with application of poultry manure in rice.

Results of the data on straw yield remained unchanged with planting methods and organic sources of nutrient of finger millet during both the years and in pooled.

Harvest Index (%)

Significant and higher harvest index (43.94% in 2016 and 43.77% in2017) was recorded by M_1 (System of Finger millet Intensification technique, 30 DAS) in both the years of experiment and pooled. However, M_2 (Conventional Transplanted Finger millet, 30 DAS) was recorded statistically at par with M_1 (System of Finger millet Intensification technique, 30 DAS) during both the years and in pooled analysis. Further, statistically lower below was registered by M_3 (Late Conventional Transplanted Finger millet, 40 DAS) in compared to other methods in both the years and pooled (Table 2). Harvest index of cereal crop is controlled by partition of photosynthates between harvesting and non-harvesting organs during crop growth period. The variation in harvest index of finger millet might have variation in partitioning of photosynthates in grain and vegetative organs of the different treatment (Pooniya and Shivay, 2011).

Data pertaining to organic sources of nutrient showed significant variation in harvest index. It further revealed that S_1 (Poultry manure, 1.7 t/ ha) produced significantly higher harvest index (44.14% in 2016 and 43.87% in 2017) than all the other treatments during both the years and in pooled. Further, S_2 (Farm yard manure, 10 t/ ha) was found to be at par with S_1 (Poultry manure, 1.7 t/ ha) in the both the years and pooled. Further, S_3 (*Vermicompost*, 2.5 t/ ha) was registered statistically lower below during both the years and in pooled (Table 2).The significantly higher harvest index with the application of poultry manure might be due to more economic yield caused by more availability of nutrients (Saha*et al.*, 2013). Channabasavanna and Biradar (2001) stated that better grain yield with corresponding biological yield increased harvest index.

Results of the data on harvest index remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Gross return (₹)

Mean data on gross return revealed that highest gross return (₹ 142086.67 and ₹ 145293.33) was recorded in the treatment M_1 (System of Finger millet Intensification technique) followed by M_2 (Conventional Transplanted Finger millet) during both the years and in average. However, M_3 (Late Conventional Transplanted Finger millet) was recorded the lowest gross return (₹ 123773.33 and ₹ 128466.67) during both the years of experiment and in average(Table 3).

Appraisal of the mean data on different organic sources of nutrient, S_1 (Poultry manure, 1.7 t/ ha) was recorded highest gross return (₹ 143686.67 and ₹ 145553.33) compare to other organic sources of nutrient during both the years and in average. Data also showed that the lowest gross return (₹ 121333.33 and ₹ 127733.33) was found in treatment S_3 (*Vermicompost*, 2.5 t/ ha) during both the years and in average(Table 3).

Cost of cultivation (₹)

A close scrutiny of mean data on cost of cultivation revealed that highest cost of cultivation (₹ 48143.33 and ₹ 50393.33) was recorded with exactly same values by M_2 (Conventional

Transplanted Finger millet) and M_3 (Direct Seeded Rice) during both the years and in average. The data also recorded the lowest cost of cultivation (₹ 48063.33 and ₹ 50313.33) by M_1 (System of Finger millet Intensification technique) during both the years of experiment and in average(Table 3).

Among the different organic sources of nutrient, S_3 (*Vermicompost*, 2.5 t/ ha) was recorded highest cost of cultivation (₹ 53583.33 and ₹ 55833.33) during both the years and in average. Data also showed that the lowest cost of cultivation (₹ 42183.33 and ₹ 44433.33) was found in treatment S_1 (Poultry manure, 1.7 t/ ha)during both the years and in average(Table 3).

Net return (₹)

Perusal of the mean data on net return revealed that highest net return (₹ 94023.33 and ₹ 94980.00) was recorded in the treatment M_1 (System of Finger millet Intensification technique) followed by M_2 (Conventional Transplanted Finger millet) during both the years and in average. However, M_3 (Late Conventional Transplanted Finger millet) was recorded the lowest net return (₹ 75630.00 and ₹ 78073.33) during both the years of experiment and in average(Table 3).

Data pertaining to organic sources of nutrient showed that highest net return (₹ 101503.33 and ₹ 101120.00) was recorded by S_1 (Poultry manure, 1.7 t/ ha) during both the years and in average. Data also showed that the lowest net return (₹ 67750.00 and ₹ 71900.00) was found in treatment S_3 (*Vermicompost*, 2.5 t/ ha) during both the years and in average(Table 3).

Benefit cost ratio (BCR)

Perusal of the mean data on benefit cost ratiorevealed that highest benefit cost ratio(3.00 and 2.92) was recorded in the treatment M_1 (System of Finger millet Intensification technique) followed by M_2 (Conventional Transplanted Finger millet) during both the years and in average. However, M_3 (Late Conventional Transplanted Finger millet) was recorded the lowest benefit cost ratio(2.62 and 2.59) during both the years of experiment and in average(Table 3).The higher grain and straw yield under the System of Finger millet Intensification technique may have led to enhanced net returns and benefit cost ratio. Further, highest net return and BCR with System of Finger millet Intensification technique may be because of the reduced labourrequirement by using cycle weeder as compared to normal farmers practice. These results are corroborates with Anitha and Chellappan (2011) in rice.

Data pertaining to organic sources of nutrient showed that highest benefit cost ratio(3.41 and 3.28) was recorded by S_1 (Poultry manure, 1.7 t/ ha) during both the years and in average. Data also showed that the lowest benefit cost ratio(2.26 and 2.29) was found in treatment S_3 (*Vermicompost*, 2.5 t/ ha) during both the years and in average(Table 3).Highest net returns and benefit cost ratio were obtained under organic production system with organic source of nutrient such as poultry manure may be due to better soil health resulted in better plant growth, yield components, yield and higher prices of organic produce. This statement is in support by Yadav *et al.*, 2009 in rice.

Conclusion

The findings of two year study of organic finger millet demonstrate that System of Finger millet Intensification (SFMI) technique, with the principles and practices of System of Rice Intensification (SRI) method of transplanting is more beneficial than other planting methods. The application of poultry manure has been found to be the best for obtaining vigorous and healthy growth parameters, yield attributes, quality yield and higher benefit cost ratio of organic finger millet than the application of other organic sources of nutrient.

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Table 1.Agronomic response of System of Finger millet Intensification technique ongrowth parametersof organic finger millet

Treatment	Plant height (90 DAT)			Number of tillers/ hill (90 DAT)			Plant dry weight (g/ hill) (90 DAT)			Crop growth rate (g/ m^2/ day) (75 to 90 DAT)			Relative growth rate (g/ g/day)(75 to 90 DAT)		
	2016	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**	**Pooled**
Planting methods															
M_1	86.29	85.95	86.12	12.87	13.29	13.08	22.964	24.119	22.946	6.859	7.896	7.378	0.022	0.024	0.023
M_2	85.93	85.20	85.56	12.60	12.93	12.77	22.595	22.766	22.708	17.586	18.120	17.853	0.023	0.024	0.023
M_3	85.43	85.09	85.26	11.82	13.20	12.51	20.680	22.922	22.370	13.892	18.210	16.051	0.019	0.024	0.021
SE(d) ±	0.19	0.10	0.11	0.04	0.07	0.05	0.293	0.140	0.161	0.857	0.588	0.460	0.002	0.001	0.001
CD (P=0.05)	0.53	0.28	0.30	0.10	0.19	0.13	0.813	0.389	0.447	2.379	1.631	1.276	NS	NS	NS
Organic sources of nutrient															
S_1	86.01	85.78	85.89	12.51	13.24	12.88	22.241	23.651	22.946	12.350	15.190	13.770	0.020	0.024	0.022
S_2	86.04	85.64	85.84	12.42	13.16	12.79	22.089	23.327	22.708	12.672	14.791	13.732	0.021	0.024	0.022
S_3	85.60	84.82	85.21	12.36	13.02	12.69	21.910	22.829	22.370	13.314	14.245	13.780	0.023	0.024	0.023
SE(d) ±	0.16	0.17	0.13	0.06	0.10	0.07	0.224	0.172	0.126	0.819	0.467	0.438	0.001	0.001	0.001
CD (P=0.05)	0.36	0.37	0.27	NS	NS	0.14	NS	0.375	0.274	NS	NS	NS	NS	NS	NS
Interaction(PM × OS)															
SE(d) ±	0.29	0.29	0.22	0.11	0.17	0.11	0.388	0.298	0.218	1.419	0.808	0.759	0.003	0.001	0.001
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M_1 –System of Finger millet Intensification (SFMI, 30 DAS) technique;M_2 – Conventional Transplanted Finger millet (CTFM, 30 DAS);M_3 – Late Conventional Transplanted Finger millet (LCTFM, 40 DAS); S_1 – Poultry manure (1.7 t/ ha);S_2 – Farm yard manure (10 t/ ha);S_3 – *Vermicompost* (2.5 t/ ha) (at 25, 35 and 50 DAT); DAT – Days after transplanting; NS – Non-significant; SEd (±): Standard error of deviation;CD: Critical difference

Table 2. Agronomic response of System of Finger millet Intensification technique onyield attributes and yield of organic finger millet

Treatment	Number of effective tillers/ hill (90 DAT)			Spike length (cm)			Number of grains/ spike			Grain yield (t/ ha)			Straw yield (t/ ha)			Harvest Index (%)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Planting methods																		
M_1	11.82	12.47	12.14	3.99	4.04	4.01	1911.31	1915.96	1913.63	3.19	3.26	3.23	7.24	7.44	7.34	43.94	43.77	43.86
M_2	11.53	12.11	11.82	3.82	3.96	3.89	1886.40	1901.00	1893.70	3.04	3.12	3.08	7.06	7.23	7.14	42.95	43.01	42.98
M_3	10.82	12.40	11.61	3.76	3.78	3.77	1882.20	1886.93	1884.57	2.76	2.87	2.81	6.69	6.90	6.79	41.13	41.40	41.27
SE(d) ±	0.05	0.07	0.05	0.05	0.02	0.03	1.89	2.34	1.82	0.08	0.08	0.04	0.09	0.12	0.03	0.93	0.66	0.46
CD (P=0.05)	0.13	0.20	0.13	0.14	0.05	0.07	5.25	6.50	5.06	0.21	0.22	0.10	0.25	0.34	0.09	2.57	1.84	1.29
Organic sources of nutrient																		
S_1	11.49	12.44	11.97	3.96	4.00	3.98	1905.18	1911.73	1908.46	3.23	3.27	3.25	7.31	7.44	7.38	44.14	43.87	44.01
S_2	11.38	12.33	11.86	3.72	3.93	3.83	1881.62	1900.04	1890.83	3.06	3.13	3.09	7.08	7.27	7.17	43.04	42.94	42.99
S_3	11.31	12.20	11.76	3.88	3.86	3.87	1893.11	1892.11	1892.61	2.71	2.85	2.78	6.60	6.87	6.73	40.85	41.37	41.11
SE(d) ±	0.07	0.10	0.06	0.05	0.03	0.03	5.40	3.61	3.08	0.16	0.15	0.08	0.23	0.20	0.09	1.30	1.10	0.78
CD (P=0.05)	NS	NS	0.13	0.11	0.05	0.06	11.77	7.86	6.70	0.35	0.32	0.18	0.49	0.43	0.20	2.83	2.40	1.70
Interaction(PM × OS)																		
SE(d) ±	0.13	0.17	0.11	0.09	0.04	0.05	9.36	6.25	5.33	0.27	0.26	0.14	0.39	0.34	0.16	2.25	1.91	1.35
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M_1 –System of Finger millet Intensification (SFMI, 30 DAS) technique;M_2 – Conventional Transplanted Finger millet (CTFM, 30 DAS);M_3 – Late Conventional Transplanted Finger millet (LCTFM, 40 DAS); S_1 – Poultry manure (1.7 t/ ha);S_2 – Farm yard manure (10 t/ ha);S_3 – *Vermicompost* (2.5 t/ ha) (at 25, 35 and 50 DAT); DAT – Days after transplanting; NS – Non-significant; SEd (±): Standard error of deviation;CD: Critical difference

Table 3.Agronomic response of System of Finger millet Intensification technique oneconomics oforganic finger millet

Treatments	Gross return (₹)			Cost of cultivation (₹)			Net return (₹)			Benefit cost ratio		
	2015-16	2016-17	Average	2015-16	2016-17	Average	2015-16	2016-17	Average	2015-16	2016-17	Average
Planting methods												
M_1	142086.67	145293.33	143690.00	48063.33	50313.33	49188.33	94023.33	94980.00	94501.67	3.00	2.92	2.96
M_2	135580.00	139133.33	137356.67	48143.33	50393.33	49268.33	87436.67	88740.00	88088.33	2.86	2.80	2.83
M_3	123773.33	128466.67	126120.00	48143.33	50393.33	49268.33	75630.00	78073.33	76851.67	2.62	2.59	2.61
SE(d) ±	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-
Organic sources of nutrient												
S_1	143686.67	145553.33	144620.00	42183.33	44433.33	43308.33	101503.33	101120.00	101311.67	3.41	3.28	3.34
S_2	136420.00	139606.67	138013.33	48583.33	50833.33	49708.33	87836.67	88773.33	88305.00	2.81	2.75	2.78
S_3	121333.33	127733.33	124533.33	53583.33	55833.33	54708.33	67750.00	71900.00	69825.00	2.26	2.29	2.28
SE(d) ±	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)	-	-	-	-	-	-	-	-	-	-	-	-

M_1 –System of Finger millet Intensification (SFMI, 30 DAS) technique;M_2 – Conventional Transplanted Finger millet (CTFM, 30 DAS);M_3 – Late Conventional Transplanted Finger millet (LCTFM, 40 DAS); S_1 – Poultry manure (1.7 t/ ha);S_2 – Farm yard manure (10 t/ ha);S_3 – *Vermicompost* (2.5 t/ ha) (at 25, 35 and 50 DAT); SEd (±): Standard error of deviation;CD: Critical difference