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Effect of integrated nutrient management on growth and yield of finger millet (*Eleusine coracana* L.): A review

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Abstract
Millets are ancient cereals cultivated by humans, considered "cereals of the poor". They are small-seed crops cultivated for food and fodder purposes. They are the future crops well adapted to the harsh environment (soil and climate) of arid and semi-arid regions. They are nutritionally rich in carbohydrates, proteins, fats, fiber, vitamins, and minerals. They have superior micronutrient profile and bioactive flavonoids, low glycemic index, prevent diabetes, are a good source of iron, zinc, and calcium, gluten-free, can be consumed by celiac disease patients, prevent CVD and hyperlipidemia, reduce weight, high blood pressure, increases amino acids uptake, used for food, fodder and reduces carbon footprint. Finger millet is one of our country's most important millet crops, having the highest productivity among millets. But in our nation, its productivity has dropped significantly. Low soil fertility, poor methods of farming, and poor nutrient management are the main causes of low productivity. These millets are the sole crop that will handle critical challenges in the future such as fuel, feed, health, climate change, and India's growing malnutrition problem. So, for this, there is a need to improve production and productivity of millets and this can only be achieved through proper integrated nutrient management (INM) practices with the application of both organic and inorganic nutrient sources. The development and yield characteristics of finger millet were shown to be strongly impacted by INM. The advantages of using INM on finger millet have also been highlighted by numerous studies.

Keywords: Integrated nutrient management (INM), growth, yield, productivity, and finger millet

Introduction

Due to their climatically adaptive nature and exceptional nutritional profile, millets have gained recognition as "super cereals". They can guarantee food and nutritional security and hold considerable promise in the fight against hunger and malnutrition. These crops are frequently disregarded despite their admirable traits and crucial role in terms of nutrition and food safety. Because they can be kept in storage for a long time, finger millet grains are referred to as "famine reserves". Despite having a significant impact on rural residents' diets, finger millet has lost some of its importance as a cereal crop as a result of the increasing demand for other cereals such as rice, wheat, and maize. Finger millet is a cereal that traditional farmers highly value because it requires little fertilizer input, but it produces less when grown in soils with limited resources and low levels of macro- and micronutrients. This is mostly caused by improper agricultural practices, continuous cropping, a lack of mineral fertilizer use, and a low rate of application of organic matter, and continuous cropping. Higher yields can be attained and maintained with the help of proper nutrient management and the application of Integrated Nutrient Management (INM). The goal of the current study was to evaluate how INM affected the yield and growth of finger millet. For a complete understanding of the subject, the study on this topic is examined in this chapter along with studies on related millets and grains. As a result, this study intends to shed light on millets' potential to address issues with food and nutritional security as well as the significance of proper nutrient management for achieving this potential.

Effect of integrated nutrient management on finger millet

INM is a comprehensive system approach that aims to mobilize and manage all potential sources of nutrients available both onsite and offsite, with equal emphasis on each resource. However, the promotion of organic nutrition is hampered by inadequate availability, imbalanced and inconsistent nutrient content, and high transportation costs. As a result, the conjunctive use of chemical fertilizers and organic materials is considered an alternative approach to overcome the adverse impacts of agrochemicals, as suggested by Palaniappan and Annadurai (1999) [18]. To enhance soil fertility and agricultural productivity, the integrated nutrient management approach emphasizes the judicious use of all available nutrient resources. This approach considers all aspects of nutrient management, including nutrient acquisition, conservation, and recycling, as well as the use of different nutrient sources, such as organic materials, bio-fertilizers, and chemical fertilizers. In conclusion, the integrated nutrient management approach is a promising solution for sustainable agriculture. By optimizing the use of all available nutrient resources, this approach can help reduce the dependence on chemical fertilizers and enhance the soil fertility and productivity of agroecosystems.

Effect of integrated nutrient management on growth and growth attributes

The growth of finger millet in various types of soil and environmental conditions has been the subject of numerous studies. In Bapatla, Babu (2006) [29] found that applying farm yard manure (FYM) at a rate of 3 t ha^{-1} in conjunction with the advised amount of NPK fertilisers significantly improved plant height, the number of tillers, and dry matter output Similar conclusions were reached by Govindappa *et al.* (2009) [9], who discovered that adding FYM (7.5 t ha^{-1}) and 100% of the RDF at 50:40:25 kg NPK ha^{-1} to the red sandy loam soils of Bengaluru boosted total dry matter output. In a different study, Saunshi (2012) [23] found that supplementing FYM with bio-digested liquid manure, rock phosphate, and poultry manure equivalent to 60 kg N ha^{-1} led to plants that were taller (141.1 cm), had more leaves (1886.3 cm^2), had a higher leaf area index (6.29), and accumulated more dry matter overall (43.08 g per plant). In eastern India, Dass *et al.* (2013) [6] found that switching 50% RDF for FYM during two of the three study years considerably improved the growth characteristics of finger millet. Similar findings were made by Nevse *et al.* (2013) [17] who discovered that combining 150% FYM and RDF led to higher plants in finger millet that had more tillers, functioning leaves, and dry matter accumulation per hill. Thimmaiah *et al.* (2016) [24] observed that top dressing with vermicompost and composted coconut fronds each at 3.75 t ha^{-1} at 25 days after transplanting increased plant height (145.27 cm), leaf area (1177.30 cm3 per plant), and tiller count. Raman and Krishnamoorthy (2016) [20] discovered that finger millet responded well to the substitution of vermicompost + recommended doses of P and K in addition to biofertilizer (Azospirillum + Phosphobacteria) for 50% of the recommended dose of N, as measured by plant height, leaf area index, and dry matter production. Similar findings were made by Gani *et al.* (2016) [7], who discovered that applying RDF and poultry manure at a rate of 5 t ha^{-1} led to noticeably better plant height, leaf area index, and relative growth rate. According to Prabhakar *et al.* (2017) [30], applying FYM in a sufficient amount (7.5 to 10 t ha^{-1}) accelerated finger millet's root growth and development. In a 2017 study, Mahapatra evaluated the effects of various organic sources and chemical fertilizers on finger millet and discovered that the maximum plant height, tiller production, leaf area, and dry matter were produced at all observational stages when nutrients were applied at the prescribed 100% concentration as inorganic fertilizers. Similar results were reported by Goudar *et al.* (2017) [8] who discovered that adding organic manures to finger millet plants increased their height (81.11 cm), leaf area index (2.61), tillers per hill (4.96), and SPAD (27.93) significantly. They ascribed this to improved soil qualities and increased nutrient availability. Hebbal *et al.* (2018) [11] highlighted the importance of integrated nutrient management (INM) and found that applying FYM (7.5 t ha^{-1}) along with the advised dose of fertilisers (50:40:37.5 kg NPK ha^{-1}) resulted in noticeably higher plant height (68.7 cm), tiller count (10.8), leaf area (1934 cm2), and dry matter production (39.74 g per hill) than when FYM has been applied alone on a N equivalent basis. Last but not least, Ullasa *et al.* (2020) [27] discovered that the recommended dose of FYM in combination with vermicompost (4 t ha^{-1}) produced plants that were noticeably taller (83.4 cm), had more leaves (52.8), and had a higher Leaf Area Index (LAI) at 90 days after transplanting and a higher production of dry matter (35.8 g per hill) at harvest. Himanshi and Shroff (2020) [12] found that finger millet developed taller plants at the grand growth stage and maturity with the application of 25% nitrogen as vermicompost + Azosprillum + 50% nitrogen as inorganic fertiliser in Anand (Gujarat) during the kharif season.

Effect of integrated nutrient management on yield and yield attributes

Numerous studies have shown that mixing inorganic and organic nutrition sources can enhance the growth and production of finger millet. For instance, Jagathjothi *et al.* (2008) [13] found that such integration improved the productive tiller count and finger length of finger millet in the clay loam soils of Coimbatore. Adesemoye *et al.* (2008) [1] found that Plant Growth Promoting Rhizobacteria (PGPR) enhanced plant growth, yield, and nitrogen content in grain. Govindappa *et al.* (2009) [9] found that superior grain and straw yields were obtained in red sandy loam soils of Bengaluru when fertilisers were treated as inorganic and combined with a recommended amount of FYM (7.5 t ha^{-1}). According to Sankar *et al.* (2011) [22], finger millet yields were significantly greater when FYM at 10 t ha^{-1} was combined with a dose of chemical fertilisers that was half as recommended for NPK. According to Ahiwale *et al.* (2011) [2], the addition of FYM (5 t ha^{-1}) and biofertilizers, together with 75% RDF, increased the yield metrics of finger millet. INM does not appear to have a substantial impact on finger millet, according to Tsado *et al.* (2016) [25]. However, they discovered that using 100% of the advised amount of nutrients in the form of inorganic fertilizers led to the longest fingers, the greatest number of fingers, the most seeds per ear, and the highest grain yield. Thimmaiah *et al.* (2016) [24] found that applying the recommended volumes of NPK and FYM (7.5 t ha^{-1}) + PGPR (2 kg ha^{-1}) followed by a top dressing of vermicompost + coconut frond compost (3.75 t ha^{-1}) at 25 DAT resulted in higher yields of grain and straw. According to Pallavi *et al.* (2016) [19], combining inorganic and organic nutrient sources improved plant metabolism and growth, which increased grain yields. According to Ullasa *et al.* (2017) [26], finger millet yields were significantly greater when FYM (7.5 t ha^{-1}) was applied as well as the full recommended dose of NPK applied as vermicompost based on nitrogen equivalence + FYM (7.5 t ha^{-1}). According to Naik *et al.*

(2017) [16], applying FYM (10 t ha^{-1}) together with the corresponding amount of biodigester liquid manure in two splits at 70 kg N ha^{-1} boosted panicle weight, thousand-grain weight, grain yield, straw yield, and harvest index considerably. According to Hatti *et al*. (2018) [10], the use of 100% of the approved dose of NPK combined with FYM at a rate of 7.5 t ha^{-1} markedly boosted grain and straw yields. Finger millet grain and straw yields significantly increased when FYM and biofertilizers were added to varied inorganic fertilizer doses, according to Roy *et al*. (2018a) [21]. Finger millet responded to the application of 100% RDF as organic or the use of organics in combination with inorganic nutrient sources with higher growth and production, according to Maitra *et al*. (2020) [15]. Ullasa *et al*. (2020) [27] found that utilising FYM (7.5 t ha^{-1}) and substituting vermicompost on a N equivalent basis for the recommended amount of nutrients significantly enhanced the number of productive tillers, the number of fingers per ear head, the length of the fingers, and the yield. Last but not least, Aravind *et al*. (2020) [3] examined the effects of organic supplements on the productivity of finger millet and found that the notable yield increase in response to organics was brought on by improved nutrient availability to crops through the mineralization and solubilization effects of organic manures.

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