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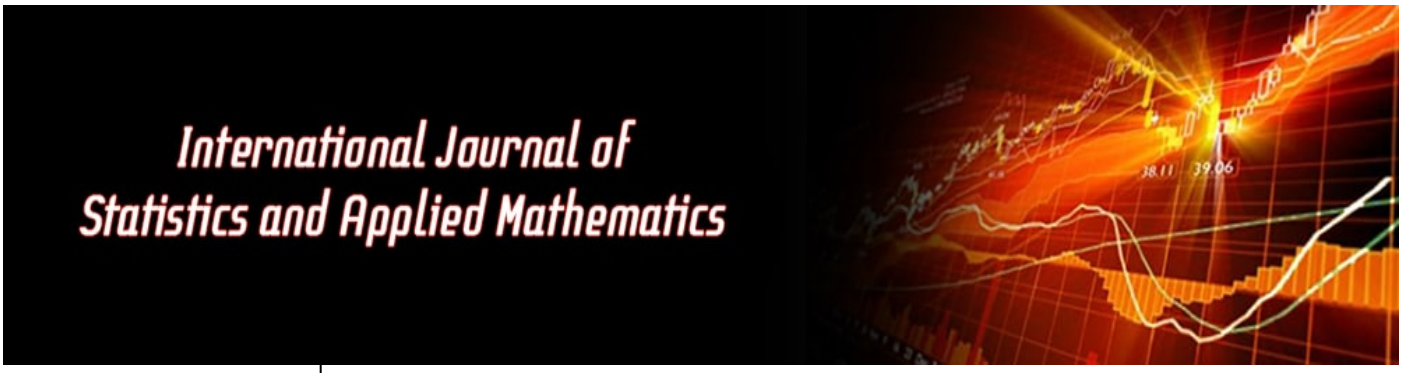

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Response of integrated nutrient management on Sweet Potato: A review

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Abstract
Sweet potato [*Ipomoea batatas* (L.) Lam] is a dicotyledonous, major tuber crops belongs to the family Convolvulaceae. It has the highest rate of dry matter production per day and is major calorie contributors. Sweet potato find an important place in the dietary habits of small and marginal farmers especially in the food security of tribal population. Sweet potato cultivated round the year for its tuber. Region wise cultivation practices differed and nutrient input has direct impact on tuber yield. So, integrated nutrient supply, usage or managing systems (INM) encompasses effective and prudent supply, usage or supervision of all the major elements of plant nutrient resources: chemical fertilizers in concurrence with animal manures, compost, green manures, legumes in cropping system, bio-fertilizers, crop residues, or recyclable waste and other locally available nutrient resources for nurturing soil fertility, health and production. The integrated supply and usage of plant nutrients from chemical fertilizers and organic manures has been demonstrated to generate higher crop yields than when each one is applied unaccompanied. Several studies revealed that INM enriches crop yields compared with conventional practices, improves water-use efficiency, and the economic returns to farmers.

Keywords: Sweet potato, INM, tuber yield

Introduction
Sweet potato [*Ipomoea batatas* (L.) Lam] is an important tuber crop belongs to family Convolvulaceae and originated from South America. It is the seventh largest food crop, grown in tropical, subtropical, and warm temperate regions in the world. It is cultivated for its tuber over all in India. It can be grown all around the year under suitable climatic conditions. It is the cheapest source of carbohydrate, calories and starch. It also provides substantial amounts of vitamins and minerals.

The demand of the crop is significantly increasing with the increase in population, which emphasizes the use of chemical fertilizers. As a result growers indiscriminately use the inorganic sources of plant nutrients, which posed the serious threat to the soil health, environment and on the health of millions of people throughout the world and more importantly declining the productivity of soil. Organic manures like farm yard manure, bio-compost, poultry manure, *neem* cake, vermicompost etc. were regarded as important, but it was obvious that they were not available in sufficient quantity to drastically increase food production. Therefore, maximizing the usage of organic waste combining it with chemical and bio-fertilizers in the form of integrated manner found to be the best alternative. There is an ample scope for organic production in tuber crops as they respond well to organic manures (Suja *et al*., 2009) [26]. It is needed to adopt integrated nutrient management system for sweet potato production so that yield cannot be compromised without disrupting the soil health. Adopting integrated fertilizer management, which not only improves soil nutrient status but also helps to improve various physical, chemical, and biological properties of soil, leading to improved soil fertility and fertilizer use efficiency, is one way to achieve a sustainable increase in production.

A review of integrated nutrient management on sweet potato is being presented under the following sub heads:

1. Effect of INM on growth of sweet potato.
2. Effect of INM on yield and yield traits of sweet potato.

3. Effect of INM on quality of sweet potato.
4. Economics viability of INM for sweet potato.
5. Effect of INM on soil health of sweet potato.

1. Effect of INM on growth of sweet potato

Plant growth characters are major factors that responsible for yield in every crop. In sweet potato plant types, vine growth, no. of branches, dry matter production these are important characters that directly or indirectly contributes for tuber yield. Growth of vegetative plant parts mainly depends upon field management, fertilizer input, irrigation and other agronomic practices as well as planting season and weather conditions. Hartemink *et al*., (2000) [7] have observed that high vegetative growth results in low root yield and subsequently lower harvest index. For sweet potato economic part is tuber and for that it is important to translocate all the food material towards tuber production. So it is important to provide only that much nutrient which is sufficient for tuberization.

Marimuthu *et al*., (2002) [12] observed increase in plant growth characters with the application of vermicompost, poultry manure and azotobacter in combination with 50% or 100% RDF might be due to better availability of plant nutrients and maintenance of balanced C:N ratio throughout the growing period of the sweet potato. While, Onwudike (2010) [15] recommended integrated application of cowdung @ 3 t/ha along with $N:P_2O_5:K_2O$ @ 100:100:100 kg/ha for improvement of plant growth, tuber yield and soil fertility. Laxminarayan *et al*., (2011) observed the integrated use of nitrogen, phosphorus, and potassium and farmyard manure recorded a significantly higher tuber yield (18.7 Mg ha−1) followed by lime + farmyard manure + neem cake + green manure (17.7 Mg ha−1). Incorporation of organics and 100% nitrogen, phosphorus, and potassium showed a yield response of 23%, 2%, and 10% in respect of farmyard manure, neem cake, and green manure over nitrogen, phosphorus, and potassium. A yield response of 12%, 10%, and 13% was observed due to incorporation of lime along with ½ nitrogen, phosphorus, and potassium and organics (farmyard manure, *neem* cake, and green manure) over that of un limed plots. Singh *et al*., (2017) [22] observed that earliest initiation of buds in 7.93 days when FYM @ 20 t/ha applied. While recommended dose of FYM (10 t/ha) and NPK (50:25:50)} was identified as a good combination for number of leaves per plant, leaf area, foliage weight per plant, number of vine per plant, inter nodal length, number of tuber plant, fresh weight of tuber per plant, length of tubers and yield per hectare. However for all organic sources, FYM @ 10 t / ha + Poultry manure @ 2.5 t/ha + Azospirillum (5 kg/ha) + PSB (5 kg/ha) could be used for improving growth and yield along with related traits of sweet potato. Hence, it is suggested that these remunerative treatment of organic doses help in successful crop production of sweet potato. Rao *et al*., (2020) [31] observed increase in plant growth characters with the application of vermicompost, poultry manure and azotobacter in combination with 50% or 100% RDF. It might be due to better availability of plant nutrients and maintenance of balanced C:N ratio throughout the growing period of the crop. Ayobami *et al*., (2021) [32] observed that when NPK fertilizer applied at the rate of 100kg ha^{-1} it produced the highest number of leaves per plant (178, 233); number of branches/plant and vine length per plant. Also, poultry manure at 10t ha-1 produced the highest number of leaves/pant number of branches/plant and vine length.

Many researchers observed the significant interactions between NPK fertilizer and organic manures on biomass weight and total tuber weight. It was an affirmation of the fact that combined applications of both organic and inorganic manure is essential for increased growth and yield. Hussien and Ghazi (2002) [33] showed that the effect of nitrogen levels (25, 50, 75 and 100%) and Azotobacter sp. on canopy fresh weight, storage root fresh weight and dry matter of storage root percent. The results indicated that, there was significant effect of *Azotobacter* sp. inoculation and N- fertilizer levels as well as interaction between of them on all studied characteristics. Application of seedlings inoculation with 75% N- fertilizer of recommended dose increased canopy fresh weight by 20.89 & 19% and increased storage roots fresh weight by 23.37 & 16.18% as well as dry matter of storage root by 8.55 & 9.8% over the control (100% nitrogen fertilizer without inoculation) during the two growing seasons respectively. Muktar *et al*., (2010) [13] observed the significant increased in the weight of sweet potato tubers as a result of increased application of poultry and NPK fertilizers. This may be attributed to the fact that, after incorporation poultry manure into the soil and addition of NPK (20:10:10) fertilizer, macronutrients were readily available within the soil for plant uptake. This resulted in the synthesis of more photo-assimilates, which is used in dry matter (DM) accumulation in sweet potato tubers. Laxminarayana (2013) [13] found effectiveness of conjunctive use of organic manures, *viz*. either farmyard manure @ 4 t/ha, neem-cake @ 0.5 t/ha or green manuring along with $N:P_2O_5$: K_2O @ 75:22:62.5 kg/ha and lime @ 0.5 t/ha, could increase crop yields, efficiency of applied nutrients and sustained soil fertility under the sweet potato green gram sequence. Sheth *et al*., (2017) [21] observed that application of 50% RDN through inorganic fertilizers + 50% RDN through vermicompost had shown significant impact on growth parameters studied like vine length at 60, 90 DATP and at harvest (78.98 cm, 120.17 cm and 175.87 cm, respectively) and the highest number of leaves at harvest i.e. 138.80 per vine. Singh *et al*., (2020) [24] reported that combined application of 50% RDF and 50% vermicompost + inoculation with Azotobacter and 50% RDF and 50% poultry manure + inoculation with Azotobacter both proved to be most superior treatment combinations in terms of vine length (cm) and number of branches per vine. Conjunctive use of organic manures along with balanced fertilizers not only produces higher crop yields but also enhanced the efficiency of added nutrients and sustains the soil fertility.

2. Effect of INM on yield and yield traits of sweet potato

Fresh weight of canopy is one of most important factor for determining yield and yield of storage root especially duration of tubers forming and filling and transfer of stored to tubers and efficiency of photosynthesis. The Favorable environment like provide proper aeration for roots, more food material around roots might be the possible reasons for better bacterial activity resulting in more nitrogen fixation and higher growth attributes with the cuttings inoculation as compare to soil inoculation of Azotobacter. The yield and its component obtained by the applied of 75% N fertilization of recommended dose and seedlings inoculation and soil inoculation with Azotobacter sp. With respect to low cost of Azotobacter, application of biofertilizer is completely economical. On the other hand, seedlings inoculation with Azotobacter showed significant increase on the previously mentioned parameters, compared to control. Therefore, it accomplished that Azoto bacter could be one of the bio

fertilizer options for sustainable and environmental eco friendly for sweet potato production where chemical fertilizer is limited. Also, biofertilizer have positive effect on active of microbes and enzymes in soil healthy (Hussien and Ghazi, 2002) [33].

Hartemink (2003) [7] reported poultry manure in combination with mineral fertilizer increased the marketable root yield of sweet potato. Yeng *et al*., (2012) [30] obtained higher marketable root yield of sweet potato with integrated application chicken manure and inorganic manure. Sheth *et al*., (2017) [21] observed that integrated nutrient sources (mainly vermi-compost, FYM and biocompost) and bio-fertilizers were effective in improving the growth parameters which had reflected in producing higher number of tuberous roots per vine, tuber weight and ultimately producing the highest yield. Singh *et al*., (2017) [23] reported that FYM and NPK (10 t/ha and 50:25:50 kg NPK/ha could be more significant for number of tuber per plant, fresh weight of tubers per plant, length of tubers and yield per hectare. Koodi *et al*., (2017) [9] recorded the higher value for fresh weight of tuber, maximum length of tuber in combination of organic and inorganic fertilizer. The increase in length of root might be due to increase in nutrient use efficiency by the organic fertilizer along with chemical fertilizer. Vermicompost increased weight, length and finally yield of tuber because it contains higher amount of nutrients than FYM and other compost. It was observed that the application of 50% RDF + 50% vermicompost along with Azotobacter proved to be the most superior treatment in terms of the highest tuber yield (327.35 q ha^{-1}) and growth parameters of sweet potato (Singh *et al*., (2020) [24]. Ayobami *et al*., (2021) [32] reported that when 100kg ha^{-1} of NPK fertilizer and 10t ha^{-1} poutry manure applied it produced the highest tuber weight.

3. Effect of INM on quality of sweet potato

β-carotene content of sweet potato governed by the genetic factor, agronomic factors like source and quantity of nutrients significantly influenced the content. Also the increase in the carotenoid content of the orange fleshed sweet potato might be as a result of improvements in the total nitrogen contents of the soil (Nedunchezhiyan *et al*., 2010) [14]. N fertilizer application significantly increased the carotenoid and crude protein content of sweet potato with increasing N application up to 120 Kg/ha. This indicates that nitrogen stimulates carotene biosynthesis (Ukom *et al*., 2009) [29]. Application of 50% RDN + 50% N from vermicompost can lead to increase starch content and sugar content in sweet potato (Sheth *et al*., 2017) [21]. Anedo *et al*., (2018) [2] reported that β-carotene content of orange fleshed sweet potato and yield improved by application of 4t/ha composite manure + 400kg/ha NPK or 4t/ha. For improved carotenoid content application of 8t/ha composite manure + 200kg/ha mineral fertilizer or 6t/ha composite manure is recommended. Composite manure is recommended for good root yield of orange fleshed sweet potato in this area.

4. Economics viability of INM for sweet potato

INM in sweet potato is economic as combination of both organic and inorganic profitable for sweet potato cultivation, tuber yield along with soil health. Application of desired level of integrated nutrients holds the key to enhanced growth and root yield of sweet potato. It maximize yields and reduce cost on applied soil nutrient inputs. It was reported by Allolli *et al*., (2011) [1] when combined application FYM @ 10 tones ha-1+ 50:25:50 kg NPK ha-1given in sweet potato, higher gross returns (Rs. 18658.7/ha), net returns (Rs.67100/ha) and B:C ratio (3.6) were recorded. It was also observed when 75% nitrogen fertilizer of recommended dose and seedlings inoculation with Azotobacter sp. and soil application applied in sweet potato, it scored the best records of gross income, benefit – cost ratio net return. Sweet potato farmers will maximize profits and minimize costs with the application of 2t/ha of composite manure despite 4t/ha composite manure + 400kg/ha mineral fertilizer recording the best root yield (Anedo *et al*.,2018) [2].

INM has direct effect on B:C ratio. When combination of poultry manure and the RDF applied @10t h-1 + 50 per cent R.D.F exhibited gross income (Rs. 2,79.666), net income (Rs 163914) and B: C ratio (1:41). Sharma & Rattan (2022) [19]. It is because of increased yield of sweet potato tuber. Sheth *et al*., (2017) [21] reported that the application 50% RDN through FYM along with combination of bio-fertilizers gives highest benefit: cost ratio.

5. Effect of INM on soil health of sweet potato

The crop response to applied fertilizers depends on soil organic matter which could be enriched either by natural returns through roots, stubbles, and crop wastes, as well as application of various organic resources (Ayoola & Adeniyan, 2006) [5]. The supplementary and complementary use of organic manures and inorganic chemical fertilizers augment the efficiency of both the substances to maintain a high level of soil productivity (Thakuria *et al*., 1991) [28].

Combining the available animal manure sources such as cow dung, swine waste and poultry manure with mineral fertilizer or application of organic manure or combined application of organic manure and mineral fertilizer improved soil organic improved (Anedo *et al*., 2018) [2]. Incorporation of organic manures provide conducive physical environment mainly by improving the bulk density of soil which helps in better root extension, tuber bulking and absorption of nutrients from the soil as well as from nutrient sources (Arriage and Lowery, 2003) [3]. Application of vermicompost and FYM had favoured the activity of soil micro flora, besides supplementing the nutrients (Saravaiya *et al*., 2010) [18]. When 50% RDN + 50% N from vermicompost along with RDF of P & K applied to sweet potato, it was found that soil organic carbon content significantly increased (0.603%) (Sheth *et al*., 2018) [20].

Conclusion

Conjunctive use of organic manures and inorganic chemical fertilizers not only enhanced the crop productivity but also improved the quality parameters and soil fertility. It can be concluded from the present investigation that the integrated use of organic manures, bio-fertilizers and inorganic fertilizers is efficient than application of inorganic fertilizers alone in improving growth and yield in sweet potato cultivation.

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