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POTENTIALITY OF INTEGRATED NUTRIENT MANAGEMENT FOR FEASIBLE PRODUCTION OF AONLA: A REVIEW

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ABSTRACT

Aonla (*Emblia officinalis*), is one of the most nutrient-dense fruits owing to its therapeutical, post-harvest and industrial value. Aonla cultivation is becoming more and more common these days due to its high market demand, low maintenance cost and broad adaptability in a variety of agro-climatic conditions. Soil type, fertility and nutrient management are important for its commercial cultivation. The two most critical problems are ensuring soil health and sustainability in high-quality output. An important method is Integrated Nutrient Management (INM), a system that incorporates utilization of inorganic fertilizers in conjunction with organic manure/wastes with inputs through biological processes in order to improve and maintain soil fertility for long-term increase in crop output. Now-a-days the quality of the crop and the soil fertility are all negatively impacted by the indiscriminate use of chemical fertilizers, pesticides etc. Under these circumstances, more attention on crop nutrition management for greater soil health and improved productivity is needed. Consequently, to maintain the aonla crop's production as well as the soil's fertility and the ecosystem's overall health, there is an urgent requirement for developing suitable nutrition programme which may include a rational integration of inorganic, organic and biofertilizers.

Key words: Aonla, biofertilizer, soil health, quality production, Integrated Nutrient Management (INM), sustainable development

Introduction

Belonging to the subfamily phyllanthoideae under the Euphorbiaceae family (Anonymous, 2005), Aonla (*Emblia officinalis* Gaertn. L.: 2n=28), is a crucial minor fruit crop of the 21st century that is native to the Indian subcontinent (Mishra *et al.*, 2023). In terms of both acreage and productivity of this crop, India leads the world. Sri Lanka, Puerto Rico, the United States (Florida

and Hawaii), Iran, Iraq, China, Malaysia, Pakistan, Bhutan, Vietnam, Thailand, the Philippines, Trinidad and Japan are among the countries in the globe where trees grow naturally, in addition to India (Dharani and Mishra 2020; Singh *et al.*, 2023a). The fruit is highly valued as food, medicine and hair dye, according to the Vedas, Ramayana, Charak Samhita and other ancient Indian texts. In India, aonla is primarily grown in eastern

Table 1: Showing the percentage of different element exists on aonla pulp.

Elements	Percentage on fruit pulp basis
Moisture content	70.5%
Protein	0.75%
Acidity	3.28%
Soluble solids	23.8%
Total sugar	5.09%
Reducing sugar	5.08%
Tannin content	2.73%
Pectin content	0.59%
Potassium	0.37%
Magnesium	0.25%
Phosphorus	0.03%
Calcium	0.06%

Himalayas (Assam, Manipur, Meghalaya, Mizoram and Tripura) and northwest Himalayas (Himachal Pradesh, Jammu and Kashmir and Uttarakhand). Maharaja Kashi took the initiative to begin domesticating Aonla in Varanasi, Uttar Pradesh (Mishra *et al.*, 2023). Some popular vernacular names for this fruit include Amla, Amalakamu, Ambala, Amali, Amlika and the Indian Gooseberry (Chadha, 2001; Sharma *et al.*, 2023). The nutraceutical potentialities of the fruit have earned it the name of the 'Amrit Phal' or the 'Wonder Drug'. The fruit itself is one of the richest sources of Vitamin-C (around 650-900 mg/100 g), second to none but Barbados Cherry (Sharma *et al.*, 2023).

The pulp of Aonla is abundant in beneficial constituents that serve multiple nutraceutical purposes (Table 1 & Fig. 1). The plants are native to the Indian subcontinent, making them suitable for cultivation across a wide range of subtropical agroecosystems. These traits, accompanied by hardy nature, high productivity (approximately 15-20 tonnes/ha) and tolerance to wastelands make Aonla production very profitable even for marginal and small farmers (Kour *et al.*, 2019a; Mishra *et al.*, 2023). Aonla fruit pulp is a key component of Chayvanprash and Triphala powder which have several medical applications. Aonla can be grown under diverse soil-climatic situations and also in marginal and sites effectively by right technological assistance. The price of inorganic fertilizers is currently gradually rising. Regular as well as excessive usage of pure chemical fertilizers such as urea, SSP, MOP and other similar fertilizers can cause numerous nutrient shortages in fruit crops. When inorganic fertilizer is used frequently and carelessly, the biological dynamism of the soil declines. The dynamic concept of adjusting the flow of nutrients to the plants for preserving targeted yield of the crop and maintaining soil physico-chemical and microbiological

health is known as Integrated Nutrient Management (INM). Farm Yard Manure may increase cell permeability through hormone growth action, hasten the respiratory process or a combination of these methods to increase crop yields. By giving the plants nitrogen, phosphorous, potassium and sulphur in forms that are readily available to them through organic decomposition, it helps to increase soil's ability to store water. Vermicompost is a chemical free, environment friendly natural fertilizer made from biodegradable organic waste. N₂ fixers, P-solublizers and other helpful microflora are abundant in vermicompost. Urban wastes and other organic manures with high soil organic matter concentration are also employed to provide plant nutrients (Srivastava and Ngullie, 2009). Combining effect of organic and inorganic fertilizers successfully increase higher nutrient utilization efficiency, which reduces nutrient losses from the soil and increases fruit yield. Biofertilizers serve an important part in boosting fertility of the soil by fixing atmospheric nitrogen, with or without the assistance of plant roots. Additionally, it solubilizes insoluble soil phosphate as well as produces soil compounds that aid in plant development, making it an environmentally friendly crop production tool. Hazarika and Ansari (2007) observed that biofertilizers assisted to mobilise nutrients, restore lost microflora and increase soil health. Furthermore, INM uses waste recycling and manure production to help farmers increase profitability from on-farm nutrition sources. Jat *et al.*, (2015) observed that green manures as well as grain legumes when integrates into cropping systems, they can cover more than half of the N₂ demand of the crops, lowering fertilizer costs. Under these circumstances, to restore soil health as well as the productivity of the aonla crop, there is need for developing suitable nutrition programme which may include a rational integration of inorganic, organic and biofertilizers.

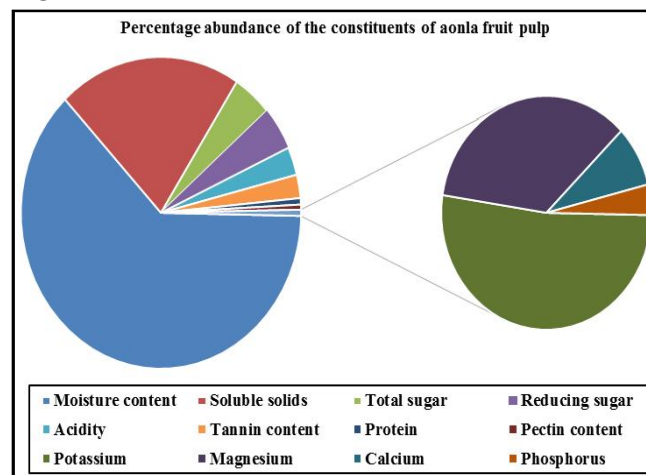
**Fig. 1:** Pie chart representation of the percentage abundance of several constituents of aonla pulp in par with Table 1.

Table 2: Various components of INM and their impacts.

Components of INM	Impacts	Remarks
Mineral Fertilizers	The inorganic fertilizers that supply one or several plant nutrients.	Three types of mineral fertilizers are there such as straight fertilizers, complex fertilizers and mixed fertilizers.
Organic manures	Organic matters produce these products which are obtained from biological decomposition of plant or animal waste products.	Generally, two categories of organic manures exist i.e., concentrated organic manures and bulky organic manures.
Bio-fertilizers	Bio-fertilizers comprise active or dormant cells of effective microbes that boost nitrogen uptake by crop plants through rhizosphere interactions.	Some nitrogen fixing biofertilizers are <i>Rhizobium</i> , <i>Azolla</i> , <i>Azotobacter</i> etc. and phosphate solubilizing biofertilizers are <i>Bacillus</i> , <i>Pseudomonas</i> , <i>Aspergillus</i> etc.
Crop rotation	Crop rotation is a crucial practise for ensuring nutrient supply.	Various crops are planted consecutively on a plot of land to avoid soil exhaustion.
Crop residue	They are residues remaining from crop harvesting and it can increase the soil fertility and control the soil erosion.	Some crop residues that are generally used to prepare compost are stalks, stems, leaves, bagasse etc.

Basic concept of Integrated Nutrient Management (INM)

INM aids to prevent emergent micro-nutrient shortages as well as restore and maintain crop productivity. Moreover, it makes fertilizer use more cost-effective and efficient. The term “Integrated plant nutrient management” can also apply to maximize the advantages from all plant nutrition sources in order to maintain crop productivity by maintaining optimal soil fertility and plant nutrient delivery. By enhancing the soil’s organic matter content with bio fertilizer, FYM, vermicompost, organic mulch and other INM techniques, soil degradation is prevented and its physical, chemical and biological properties are enhanced (Table 2).

Advantages of INM

A well-prepared soil along with its maximum capacity to withhold water, to give increased productivity and above all to have all kind of macro and micro nutrient is a crucial target as well as it is a complicated process that is the consequence of numerous factors working together, it is essential to have a sufficient amount of nutrients in the soil that are easy for plants to absorb at the precise moment that plants need them. With or without minimal environmental risk, a good nutrient management package can help most crops grow and yield at appropriate levels in various agro-ecological zones (eco-friendly strategy). The principal advantages of INM, as depicted by Selim (2020) are as follows:

- 1) INM can enhance the native nutrients in the soil and boost the solubility and accessibility of fertilizers.
- 2) Use the nutrients’ harmonious behaviour and match them to the crops’ nutritional needs.

- 3) Provide the crops with a nutritional balance to minimize aggressive effects brought on by nutrient imbalance and nutrient fractions.
- 4) Improve and maintain the physico-chemical as well as biological processes that occur in soil.
- 5) By maximizing carbon capture and minimizing nutrient losses to ground and surface water forms, as well as environmental pollutants, the pace of soil degeneration, water contamination and ecosystem degradation can be reduced.
- 6) Minimize increased production costs overall and raise the farmers’ returns.
- 7) INM can help plants become more resilient or less susceptible to a variety of biotic as well as abiotic stressors.
- 8) An efficient technique of agricultural operations to assure wholesome food, meeting population food demands and various repercussions on the environment and the land, particularly in nations with high population increase.
- 9) Awareness shifts among farmers toward seasonal climate variations that have greater ecological effects in order to produce healthy food rather than seeking for better yields in order to increase profit.

Present status of INM

Considering the significance of organic resources, numerous studies on integrated nutrient management have been conducted over the past 20 years (Table 3). This investigation has led to:

- 1) Development of integrated nutrient management

Table 3: Different nutrient-microbe synergy suggested for various fruit plants.

Crop	Nutrient-microorganisms synergy	Reference
Guava	Farm Yard Manure (50 kg/plant) along with <i>Azospirillum sp.</i> (50 g/plant) and <i>Azotobacter sp.</i> (50 g/plant)	Ram and Rajput (2000)
Apricot	75% Recommended Dose of Fertilizer and rest 25% of RDF is replaced with equivalent amount of Farm Yard Manure	Shah <i>et al.</i> , (2006)
Sapota	75% Recommended Dose of Fertilizer and rest 25% of RDF is replaced with equivalent amount of vermicompost	Hebbara <i>et al.</i> , (2006)
Mosambi	N:P:K @300:250:300 g/plant and 10 g of Arbuscular Mycorrhizal Fungi/plant along with 25 g <i>Azospirillum sp.</i> /plant	Patel <i>et al.</i> , (2009)
Strawberry	75% N as Recommended Dose of Fertilizer and rest 25% of N is replaced with Farm Yard Manure and <i>Azotobacter sp.</i>	Umar <i>et al.</i> , (2009)
Banana	As an organic nutrient source 12 kg Farm Yard Manure/plant can be applied along with biofertilizers such as Phosphate Solubilizing Bacteria (50 g/plant), <i>T. harzianum</i> (50 g/plant), <i>Azospirillum sp.</i> (50 g/plant)	Hazarika and Ansari (2010)
Papaya	N:P:K @150:200:200 g/plant (as 75% Recommended Dose of Fertilizer) and Vermicompost (20 kg/plant) along with rhizosphere (50 g/plant)	Kirad <i>et al.</i> , (2010)
Mango	N:P:K @500:250:250 g/plant along with Farm Yard Manure (50 kg/plant) and 250 g <i>Azospirillum sp.</i> /plant	Singh and Banik (2011)
Litchi	N:P:K @500:250:500 g/plant along with 50 kg Farm Yard Manure/plant, 150 g <i>Azotobacter sp.</i> /plant and 100 g Vesicular Arbuscular Mycorrhiza/plant	Dutta <i>et al.</i> , (2010)
Pomegranate	N:P:K @400:100:300 g/plant along with Farm Yard Manure (20 kg/plant)	Ghosh <i>et al.</i> , (2012)
Lemon	525 g N/plant along with Farm Yard Manure (150 kg/plant) and <i>Azotobacter sp.</i> (18 g/plant)	Khehra and Bal (2014)
Peach	75% N as Recommended Dose of Fertilizer and rest 25% of N is replaced with equivalent amount of Farm Yard Manure	Shah <i>et al.</i> , (2014)
Aonla	N:P:K @100:25:150 g/plant along with Farm Yard Manure (10 kg/plant) as well as Phosphate Solubilizing Bacteria (50 g/plant)	Mandal <i>et al.</i> , (2013)

techniques and practical application in important crops.

- 2) Recognizing how organic manures improve input use efficiency as a result of their positive impact on the soil's physical, chemical as well as biological condition.
- 3) Showing advantageous effects of integrated organic manure use in enhancing nutrient cycle in various production systems on different types of soils.
- 4) INM plays a positive impact in enhancing the chemical, physical and biological quality of soil to support sustainable crop production.

Effect of INM on aonla's vegetative growth

The use of fertilizers, both inorganic and organic, at the recommended and appropriate doses is a crucial choice and critical aspect for increasing crop development and nutrient uptake as well as an essential part in maintaining the crop life cycle. The use of chemical fertilizers may result in a growth period extension, a delay in flowering as well as physiological maturity by 1-2 weeks, ultimately a reduction in fruit yield quality and

quantity. As a result, INM emerges as one of the most fundamental techniques that can replace the conventional approaches. Numerous studies show that INM has exceptional advantages and may influence crop growth as well as sustainable development with regard to environmental implications. Aseri *et al.*, (2009) stated that the most efficient bio-inoculants for increasing the concentration of different metabolites and nutrients were discovered to be *Azotobacter chroococcum* and *Glomus mosseae*; these organisms aided in the better establishment of the aonla plant in outdoor circumstances. In field conditions, five-year-old aonla plants showed a notable upliftment of plant height, plant canopy growth and collar diameter. According to Mandal *et al.*, (2013), aonla cv. NA-7 trees that were given 100:25:150 g NPK along with 50 g PSB and 10 kg FYM per plant had maximum plant height (323.00 cm) as well as highest number of branches (15.30). The reason may be that biofertilizers that of *Azospirillum*, *Pseudomonas* and *Azotobacter*, those are liable for fixing atmospheric N₂ enhances vegetative development by providing growth hormones and vitamins to host plants. According to Kumar *et al.*, (2014) the grafted AMF + *Azospirillum*

plants of aonla developed more leaves, roots and shoot length, which may have sped up photosynthesis. According to Tiwari *et al.*, (2015), due to the strong vegetative development and higher chlorophyll content, which jointly sped up photosynthesis and improved the availability of carbohydrates to plants, the aonla cv. Francis yield significantly increased when organic and inorganic nutrients were applied. An investigation was conducted by Kour *et al.*, (2019b), where the implementation of 100% nitrogen through urea and *Azotobacter* with the advised dose of Single Super Phosphate and Muriate of Potash resulted in the greatest increases in the vegetative characters of plant height (10.92%), canopy volume (40.32%) and plant spread (13.91% N-S and 13.88% E-W). The observations showed, when 25 percent nitrogen is applied with FYM and 75 percent with urea supplemented with *Azotobacter*, aonla's use of chemical fertilizers can be decreased.

Effect of INM on aonla's fruit quality and yield

Numerous studies have demonstrated that neither organic nor inorganic sources alone can increase crop productivity (Biramo, 2018). Higher fruit production and better fruit quality depend heavily on the soil receiving a balanced mix of organic as well as inorganic nutrient sources. In comparison to fertilizers alone, long-term trials have shown that organic manures may sustain higher crop yield over a lengthy period of time (Prasad, 2008). A fertilizer application that is out of balance can cause a number of issues with fruit production, such as excessive vegetative growth that delays maturation due to high nitrogen availability. Kumar *et al.*, (2003) stated that the impacts of N fertilizer rate on the quality and yield of aonla (*E. officinalis* [*Phyllanthus emblica*])-*Dichanthium annulatum* cropping system were studied where the evaluation of aonla fruit quality showed that pure aonla recorded the highest average glucose content (120.43 mg/g dry weight), whereas aonla + *D. annulatum* + 40 kg N/ha registered the greatest fruit weight (37.9 g), volume (34.8 cc) and size (3.71 × 4.07 cm). According to Korwar *et al.* (2006), the maximum vitamin-C content (143.7 mg/100 g tissue) and yield were produced by combining the application of vermicompost and FYM. According to Katiyar *et al.*, (2010), total soluble solid and ascorbic acid contents of aonla cv. 'Banarasi' fruit, as well as their retention, size and quality features, improved with the administration of NPK @50:25:50 g combined with FYM @100 kg + boron @100 g/tree. Additionally, this treatment decreased fruit acidity, avoided fruit premature drop and increased fruit yield by 58.06 percent in contrast to the control. Singh *et al.*, (2012) observed that FYM and regular doses of NPK produced

the highest yield/plant (32.15 kg). Mandal *et al.* (2013) examined maximum number of fruits (73.17) of aonla cv. NA-7 in application of NPK + vermicompost + PSB. According to Mustafa *et al.*, (2013), implementation of 25 kg FYM + 1/2 NPK + ZnSO₄ + CuSO₄ + FeSO₄ resulted in the highest fruit yield (47.75 Kg) of aonla cv. NA-7 as well as nutrient contents of the fruits. Kour *et al.*, (2019a) reported that application of *Azotobacter* along with FYM and urea resulted highest concentration of fruit nitrogen (0.14%), phosphorous (0.03%), calcium (0.03%) and magnesium (0.02%). According to Kour *et al.*, (2019b), number of fruits per tree (2389.57) and was obtained highest when 25 percent of nitrogen was implemented as FYM and 75 percent was implemented as urea combined with *Azotobacter* application. While fruits receiving 50 percent nitrogen through FYM and 50 percent in the form of urea combined with *Azotobacter* had highest levels of TSS (11.26°Brix) and total sugar (6.72%), the highest levels of ascorbic acid was estimated highest (625.23 mg/100g of pulp) with cent percent nitrogen by implementation of FYM combined with *Azotobacter*. Sharma *et al.*, (2023) demonstrated that, except ½ of the Recommended Dose of Fertilizer (RDF; Set at NPK @ 1000:500:500 g/tree as control) + FYM + *Azotobacter* + *Azospirillum* + PSB (Phosphate Solubilising Bacteria), the application of ¾th of the RDF + FYM + *Azotobacter* + *Azospirillum* + PSB was significantly superior to all other treatments and produced the highest aonla fruit yield (159.60 and 161.68 kg/tree). The reason for this could be that the application of FYM and biofertilizers (*Azotobacter*, *Azospirillum* and PSB) greatly enhanced the utilisation of inorganic fertilizers. The application of biofertilizers in conjunction with varying doses of FYM and NPK was successful in preserving soil's nitrogen content since the microbial population was significantly increased under these treatments, increasing the soil's fertility and consequently, fruit output. Coupled with the carbohydrates in leaves, the absorbed nitrogen may cause the creation of proteins, amino acids, nucleic acids, chlorophyll, alkaloids and amides. These metabolites are linked to several metabolic processes and play a role in the formation of new tissues. It is well known that biofertilizers improve the availability of various nutrients to plants and enrich the soil through biological N-fixation (Singh *et al.*, 2018; Singh *et al.*, 2019; Singh *et al.*, 2021; Sharma *et al.*, 2023). The experiments conducted by Singh *et al.*, (2023a) on 28-year-old and healthy aonla trees of "Francis" variety demonstrated that, the application of 75% RDF + 30 kg Vermicompost + 250 g *Azotobacter* + 250 g PSB produced the highest fruit set and fruit retention percentage, matching 75% RDF + 30

kg Vermicompost. Singh *et al.*, (2023b) studied the effects of INM influencing the soil's nutrient profile where 28-year-old aonla plants were growing healthy and well-maintained across two consecutive years. Treatment T7: 75% RDF + 30 kg Vermicompost + 250g *Azotobacter* + 250g PSB recorded the highest fruit yield. According to Mishra *et al.*, (2023) the application of treatment T10 Poultry Manure (7.5 kg/tree) + RDF 50% + *Azospirillum* (10 ml/tree) + PSB (10 ml/tree) produced the highest fruit set percentage (78.56%). With a maximum fruit yield of 129.79 kg per tree, it also showed that applying Poultry Manure (10 kg/tree) + RDF 50% + *Azospirillum* (10 ml./tree) + PSB (10 ml./tree) was by far the best treatment. Similar outcomes were obvious in assessing the Fruit width, specific gravity and Economic Feasibility of the cultivation. Such observations concurred that the application of poultry manure (7.5 kg/tree) + RDF 50% + *Azospirillum* (10 ml/tree) + PSB (10 ml/tree) produced the highest physical and economic features, including fruit set percentage, fruit retention percentage, fruit yield (kg/tree), fruit weight (g), fruit width (cm), and cost-benefit ratio. Such studies reinforced the positive contribution of the quantitative as well as qualitative fruit yield improvement in aonla with the help of Integrated Nutrient Management on multiple occasions via demonstrating mutually conforming reproducible outcomes.

Effect of INM on nutritional status of leaves of aonla

The leaf is the hub of a plant's physiological activity and translocated minerals play a key role in many of its critical functions like photophosphorylation and the synthesis of proteins, amino acids, nucleic acids, chlorophyll etc. and therefore, any dietary shortfall would have a significant impact on the linked activity. Bala *et al.*, (2011) reported that leaf N, P, K as well as Cu contents of aonla cv. Baranasi were highest under the treatment consists of NPK + biofertilizers. The highest leaf Zn and B contents were obtained under $\frac{1}{2}$ of the NPK rates + 100 kg FYM per tree + *Azotobacter*, *Azospirillum* and PSB. Kour *et al.*, (2019a) studied that the combination of *Azotobacter* with 25% nitrogen applied as FYM and 75% nitrogen applied as urea resulted the maximum concentrations of nitrogen (2.78%), phosphorous (0.22%), calcium (2.33%) and magnesium (0.47%) in the leaves of aonla cv. NA-7, while the highest potassium content (2.44%) of leaf was observed with 50% nitrogen applied as FYM + 50% nitrogen applied as urea.

Effect of INM on soil nutrient status

INM is essential for maintaining the soil's fertility. As well as preserving the soil's physical, chemical and biological functions, collective implementation of the

nutrition sources also contributes to improving the fruit's quality and productivity. FYM treatment improves the soil's ability to retain water in addition to adding various nutrients to the soil (Biramo, 2018). In addition to increasing the amount of soil organic carbon, moisture-retention capacity as well as water-stable aggregates, the use of NPK fertilizers, organic manure, biofertilizers and lime also affects the physical qualities of soil (Saha *et al.*, 2010). Simultaneous application of nitrogenous fertilizers and bio-fertilizers enhances the effectiveness of fertilizer use while enhancing soil health (Vishwakarma *et al.*, 2017). The population of soil microbes, such as the number of fungi, bacteria, *Bacillus* and actinomycetes, is easily influenced by INM-based treatments (Srivastava *et al.*, 2019). The number of microbes present is directly correlated with soil health. In addition to adding nutrients to the soil, several INM components also make the soil's natural nutrients more accessible. Korwar *et al.*, (2006) reported that earthworm treatment resulted in the highest EC (0.265 ds/m) and saturated hydraulic conductivity (0.91 cm/h) of the soil in the aonla orchard. Biswas *et al.*, (2012) stated that application of vermicompost (@ 2t ha⁻¹) improved the amount of soil organic carbon (by twenty nine percent in five years) as well as the amount of available nitrogen, phosphorus, manganese, iron and copper. Vermicompost has proven to be the most effective organic sources for enhancing soil qualities and ensuring the long-term viability of the investigation's agri-horticulture system. Various organic nutrition sources considerably enhanced the soil's EC, pH, bulk density, hydraulic conductivity as well as organic carbon characteristics. By using various sources of organic nutrients, significant improvement of physical as well as chemical characteristics of soil were seen in aonla orchard, as reported by Singh *et al.*, (2012). Tiwari *et al.* (2015) observed that various organic fertilizers and manures added in the aonla orchard soil increased its physical, chemical as well as biological activities. This resulted in greater plant nutrient uptake and a higher yield. According to Kour *et al.*, (2019a), the highest *Azotobacter* numbers (27.3×10^4 cfu g soil), bacterial numbers (28.5×10^6 cfu g soil) and fungal numbers (24.9×10^5 cfu g soil) were obtained when a full dose of nitrogen was delivered using FYM and *Azotobacter*. Such interpretations were deemed beneficial for the aonla cultivators of India.

Constraints of INM

Main key factors contributing to an irreversible decline in plant output include soil corrosion, deterioration from mining, loss of fertility and degradation. Therefore, resolving the issue of low soil productivity is crucial in

order to maintain the soil health as well as restore soil production. It is important to pay great attention to the requirements of the subsequent crop and the balance of nutrients in the soil, including those taken up by the current crop. It's important to constantly keep track of changes in the soil fertility to evaluate nutrient loss due to crop absorption, leaching and erosion as well as to reflect soil balance since rapid soil fertility depletion and reduction in organic matter of the soil would be predicted. Moreover, the integrated nutrition management is currently encountering various obstacles. Organic matter has a high concentration of insoluble substances, such as cellulose, lignin etc., which slow down the procedure of decomposition and make it difficult to provide plants with the necessary nutrients when they are needed. Due to their short shelf lives, accessibility, cautious handling, storage etc., biofertilizers are only employed in a few locations. It is necessary to create strains that are particular to each location. Because of the significant decline in animal domestication, it is also difficult to employ INM because of the availability of FYM and vermicompost. Most of the farmers generally lack knowledge of the cutting-edge field research and technology currently being used. As a result, the utilization of INM is limited by their ignorance. There are little connections and contacts between researchers, extension services and NGO staff. Lastly, the application of INM is also constrained by the lack of soil testing facilities.

Conclusion

This paper highlights how integrated nutrient management can be a practical approach that can provide aonla plants with an adequate supply of macro and micro-nutrients while simultaneously lowering the dosage of chemical fertilizers, prepare favourable soil physio-chemical conditions as well as healthy environment, remove the obstacles, protect the soil's long-term nutrient balance, create an optimal level for maintaining the target crop yield and finally, develop secure ways to dispose of agricultural waste. After harvesting, a large amount of crop waste is left behind as organic manure that can be used as additional fertilizer for the following crop; together these materials will decompose quickly, producing high-quality compost that can swiftly enhance soil characteristics and aid in increasing active organic microorganisms in soil and stable organic matter, which can be used as a prime method to prevent soil erosion. Using both organic and inorganic fertilizers together can provide equivalent orchard income, making it more effective than just inorganic production. The recommended level of nutrient fertilization for fruit production can be replaced with biofertilizers in a long-

term, cost-effective manner. INM aids in the reduction of numerous nutrient shortages in plants by providing secondary, micro and beneficial nutrients in addition to basic nutrients. Keeping this view, it is recommended that for sustainable production of aonla and to maintain soil health of the orchard. INM should be practiced and followed frequently by farmers for maintaining a sustainable crop productivity as well as for providing balanced nutrition to the crop.

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