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Integrated nutrient management in arid zone fruit crop production - a review

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ABSTRACT

The indiscriminate use of chemical pesticides along with improper nutrient management is deleterious to the plant health, environment and human being. The quality attributes of different fruits are badly affected due to indiscriminate application of inorganic agro-chemicals which results in quality deterioration with less consumer preference and low returns to the growers. It also causes soil health deterioration and disturbs the soil microorganisms. Such practices are also common among the fruit growers. Due to these practices, the plants also become susceptible to several biotic and abiotic stresses. Therefore, it is a holistic approach based on usage of all possible sources of plant nutrients in an integrated manner is considered as alternative source to maintain soil fertility and plant nutrient supply for sustaining the desired crop productivity.

Introduction

The world population (7.87 billion) is currently growing at a rate of 1.03% per year and is expected to reach around 9.6 billion in 2050. India has 1.38 billion people accounting for 17.5% of the world population, with a meagre 2.4% of the world surface area (UN, 2021). Now a days, the greatest challenge is to provide this burgeoning population with stable, safe and nutritious quality food. In the current Global Hunger Index (GHI), India stands at position 101 of 116 countries; this presents a gloomy situation in combating malnutrition, eventually affecting the socio-economic progress (Grebmer *et al.,* 2020). The World Health Organization (WHO) has also indicated that hungriness is the most serious problem worldwide, particularly for African countries and India. Therefore, 195 nations have decided to adopt sustainable development goals (SDG) for addressing the serious malnutrition problems with a holistic approach by the year 2030 (Anonymous, 2016). Consumer awareness about the health benefits of fruits offers great thrust for their regular consumption as part of a balanced diet. Worldwide demand of nutrient-dense fruit has increased immensely in recent years not only for enhancing people's nutritional status but also for their positive effects on immune and metabolic health. This is particularly interesting considering the COVID-19 pandemic scenario. In India, major fruit crops, such as mango, banana, citrus, guava and apple, account for

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more than 72% of the total area under fruit crops, while indigenous (native) fruit crops contribute only 6.56% of the area (0.437 mha) with quite high productivity *i.e.* 11.47 tons/ ha (NHB, 2019). Climate change is inducing a rise in air temperatures, UV radiation levels and in the frequency of extreme events, such as drought or flood, which, especially in arid or semi-arid areas, can result in an intensification of the negative impact of salinity, mineral deficiency/toxicity and of diseases and insect-pest attacks on crops (Sanwal *et al.,* 2022). Consequently, climate change represents a great threat to obtaining the sustainable production of major commercial fruits (Gora *et al.,* 2019). Under such environmental conditions, the fulfilment of the consumers' choice and nutritional food security at an affordable and sustainable level is a major concern for the researchers as well as the growers. Under the given circumstances, specific growing areas may be utilized for exploiting the potential of underutilized crops producing edible fruits that meet the food and nutritional demand of local population. It is necessary to explore some biotic and abiotic resistant/ tolerant native underutilized fruit crops that could be resilient to certain climatic variations and adapt to a wide range of agro-climatic conditions. The indigenous fruit crops are not only proven to be superior in terms of wider adaptability to environmental conditions but are also known for their nutritional value (Berwal *et al*., 2019). However, a limited amount of research has been carried out for the development of production protocols and utilization of these underutilized fruit species. Moreover, the limited number of identified varieties, the low availability of quality planting materials and the inadequate availability of suitable cultural and post-harvest management practices are still major limitations challenging the systematic cultivation of these underutilized crops. The vegetation of arid areas includes a large number of edible fruit-bearing and food producing species. In the Indian arid zone, around 30 plant species are known for their different edible uses, and around 19 of them bear edible fruits and possess horticultural importance (Rathore, 2009). Many of the underutilized fruit crops can be used as fresh fruit but also for culinary and medicinal purposes providing important nutrients, and some of them also have ornamental values. Local people are aware of their medicinal and nutritional properties. Indeed, most indigenous underutilized fruit crops, such as ber, kair, aonla, lasora and phalsa are rich in minerals, antioxidants and phytonutrients compared to many commercial fruit crops. Moreover, these underutilized fruits are not very popular and are sold at very low prices in the local markets because of the lack of (a) people's awareness about their nutritive values, (b) consumption habits, (c) limited research, and (d) developmental policies by the government agencies for their potential exploitation. Considering the importance of these tree crop species in traditional medicine, their nutritional richness and wide adaptability, the Government of India, under their centrally sponsored scheme, *i.e.* Mission on Integrated Development of Horticulture (MIDH, then 'National Horticulture Mission', NHM) during 2005–2006 gave a special impetus to establish orchards of underutilized fruit species. Now days, inorganic fertilizers are one of the most expensive inputs in orchard management. Besides, continuous application of huge amount of chemical fertilizers hampers the soil health, soil productivity, environment, quality of produce and human being who consume them. In view of above facts, there is need to increase the production and productivity through Integrated Nutrient Management (INM).

What is Integrated Nutrient Management?

It involves the combined use of inorganic, organic and biological sources of essential plant nutrients to sustain optimum crop yield and also improve or maintain the physico-chemical properties of soil. It provides crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. The principal aim of the integrated approach is to utilize all the possible sources of plant nutrition in a judicious and efficient manner.

Objectives of INM

- To reduce the dependence on chemical fertilizers.
- To reduce inputs cost by conserving locally available resources & utilize them in an efficient manner.
- To maintain productivity on sustainable basis without affecting soil health.
- To increase the fertilizer use efficiency.
- To utilize the potential benefits of green manures, leguminous crops and biofertilizers
- To prevent degradation of the environment.
- To meet the social and economic aspirations of the farmers without harming the natural resource base of the agricultural production.

Requirement of INM

It is required due to the following reasons

- The decline in productivity can be attributed to the appearance of deficiency in secondary and micronutrients.

- Consistent increasing cost of chemical fertilizers.
- Unavailability of fertilizers as per requirement.
- Environmental pollution and its ill effects on soil, animals and human being due to continuous and excessive use of chemical fertilizers.
- Continuous depletion of soil nutrients.
- Without an integrated supply and use of plant nutrients from chemical fertilizer and organic sources, better production is not possible.
- The fertilizer production in our country is less than the required amount.

Therefore, organic manures and biofertilizers have to be looked for as alternate sources to meet the nutrient requirement of fruit crops and to bridge the gaps. Such integrated approach will help to maintain soil health, productivity and improving farmer's profitability. The INM involves the following components.

i. **Organic manures:** Organic manures defined as materials which are organic in nature and derived from plant and animal origin used to improve fertility and productivity of soil. The manures contain organic matter in large proportion and plant nutrients in small quantities. They are mostly used to improve the soil productivity by correcting soil physical, chemical and biological properties. e.g. FYM, vermicompost, compost, oil cakes, green manure etc. Green decomposed material used as manure is called green manure. It is obtained in two ways by growing green manure crops or collecting green leaf (along with twigs) from plants grown in wasteland, fields, bunds and forest. Green manuring is practised in the field plants which usually belong to leguminous family and incorporate into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops. Crop residues are materials left in an agricultural field or orchard after the crop has been harvested and after mostly leaf fall stage in case of fruit crops. These residues include stalks and stubble (stems), leaves, seed pods, *etc*. These are also very valuable animal feed. Sometimes poultry manure/ droppings are mixed with other additives and used as fish or cattle feed. Management of crop residues is either through removal, burning or incorporation into soil. Burning is a minor practice in India. Crop residues are an important source of organic matter that can be returned to soil for nutrient recycling, and to improve soil physical, chemical and biological properties (Kumar and Goh, 2000).

ii. **Biofertilizers:** The products containing living cells of different types of microorganisms which have an ability to mobilise nutritionally important elements from non-usable to usable form through biological process. e.g. N-fixing bacteria (*Rhizobium, Azotobactor, Azospirillium, etc.*) phosphorus solublising bacteria (PSB), potassium solublising microorganisms (KSM), Vesicular Arbuscular Mycorrhizae (VAM), *etc*.

iii. **Chemical fertilizer:** Fertilizers are the materials which are used to fertilize (to provide one or more essential nutrients) the crops are generally termed as fertilizers but now a days; the term fertilizer is widely used for commercially manufactured inorganic fertilizers. Thus, chemical fertilizers defined as the any material (solid, liquid or gas) containing one or more nutrient elements in the form of chemical compounds of the organic or inorganic nature.

iv. **Management of problematic soils:** Problematic soils such as saline soils, alkali soils, acid soils, waterlogged soils are known to decrease the productivity of the soil. These soils should be regularly managed and reclaimed through the application of soil amendments such as gypsum for alkali soils, lime for acid soils, use of good quality water for saline soils and use of other organic and inorganic materials based on soil test results. It helps to improve soil fertility and productivity and sustain the crop yield.

v. **Irrigation water management:** Plants absorb the nutrients from the soil only in a dissolved state and sufficient moisture is therefore required for utilizing the nutrients of the soil. Management of moisture in the soil by improved and modern irrigation techniques like drip or sprinkler or basin where the rainfall is low and draining the soil where it is subjected to stagnation of water helps to increase water and nutrient availability to the crops.

Major steps in INM

- Evaluate the field for potential of crop yield.
- Determine residual nutrient availability and major yield limiting factors for each field.
- Based on soil and leaf nutrient analysis, correction of nutrient deficiency will result in higher yield.
- Evaluate availability of on-farm nutrients from plant residues, green manures, cover crops, animal manures, symbiotic N-fixation by legumes and nutrients in irrigation water.
- Estimate and prioritize supplemental nutrient requirements for each field and crop.
- Establish the most efficient nutrient application programme with respect to crop, nutrient source, time of application, placement method and quantity.

- Regularly evaluate the results of nutrient application in terms of yield and quality responses of crop, residual nutrient levels and changes in soil quality.

Custard apple

Asheesh Sharma *et al.* (2014) conducted an experiment on the effect of organic and inorganic fertilizers along with bio-fertilizers on plant environment variables of custard apple cv. Arka Sahan during 2010-11. Treatment T_{10} comprising 50% recommended dose of fertilizers+50% N through vermicompost and biofertilizers (*Azotobacter* 50 g+PSB 50 g+VAM 20 g) was found significantly superior over other treatments with respect to plant environment variables *viz.*, Photosynthetic rate (μmolm^{-2} s^{-1}), Transpiration rate (mmolm^{-2} s^{-1}), Stomatal conductance (mmolm^{-2} s^{-1}), Photosynthetic Active Radiation (mmolm^{-2} s^{-1}), Internal CO_2 concentration (ppm). Vapour Pressure Deficit (mb), Leaf temperature (^{o}C) and Relative Humidity (%) in custard apple cv. Arka Sahan. Jangid *et al.* (2021) reported that Effect of different sources of nitrogen on fruit quality and shelf life of custard apple (A*nnona squamosa* L.) cv. Sindhan soil application of 50% RDN from Urea+25% RDN from Poultry manures + 10 ml *Azotobacter* per plant treatment was recorded significantly maximum total soluble solids (25.19^{o}Brix), reducing sugar (18.83%), non-reducing sugar (6.20%), total sugar (24.98%) and ascorbic acid (21.05 mg/100 g pulp). Rikshita *et al.* (2023) studied that Impact of Integrated Nutrient Management on the Growth and Yield of Sugar apple (*Annona squamosa* L.) cv. Sindhan. The highest incremental plant height (66.00 cm), incremental canopy spread (north-south) (84.33 cm), incremental canopy spread (east-west) (90.67 cm), and maximum fruit weight (224.10 g), fruit length (7.58 cm), fruit girth (7.50 cm), the maximum number of fruit per tree (129.83), fruit yield per tree (27.87 kg) and fruit yield per hectare (7.72 tons) were observed under application of 2.5 kg of vermicompost, 50 ml of Azotobacter, and 50 ml of PSB per plant, along with 75% the recommended fertilizer dose (RDF). Anjali Massey *et al.* (2021) studied the effects of organic manures and green manuring practices on growth, yield attributes, quality and economics of lemongrass (*Cymbopogon flexuosus* L.) under custard apple (*Annona squamosa* L.) based agri-horti system. The highest growth, yield attributes and yield as well as oil composition, soil nutrient status, microbial populations as well as economics of crop cultivation were significantly increased due to the use of both organic manures and green manuring. The significant higher results were obtained with vermicompost (2.5 t/ha)+*Azotobacter,* which was found superior over other practices. Suchismita Naik conducted the experiment on custard apple application of RDF (25%) + Vermicompost (75%) was found best in terms of growth parameters *viz.*, plant height (30.68 cm), number of leaves per plant (25.67), number of branches per plant (2.40), plant spread (37.18 cm), stem girth (2.71 cm), leaf area (28.16 cm^2), days taken to emergence of 1st new leaf after treatment (6.47 days) and chlorophyll content (35.55%). The maximum chlorophyll content (39.55%) of custard apple cv. NMK-1 Golden was observed with treatment T_3. Moreover, the treatment T_3 also showed 100% establishment of the custard apple plants cv.NMK-1 Golden.

Phalsa

Verma *et al.* (2014) revealed that the application of FYM+75 per cent NPK+*Azotobacter*+PSB+$ZnSO_4$ (0.4%) recorded maximum plant growth and fruit yield (5.06 kg per plant and 5.23 kg per plant) in both the year, respectively. Similarly, maximum physical characters *viz.*, fruit length (1.13 and 1.15 cm), fruit breadth (1.37 and 1.35 cm), weight of fifty fruits (38.63 and 39.10 g) and juice per cent (51.11 and 51.92%) and pulp/stone ratio (1.60 and 1.62) as well as maximum chemical characters *viz.*, TSS (27.64 and 27.91%), ascorbic acid (38.51 and 38.21 mg/100 ml juice), reducing sugars (19.38 and 19.40%), non reducing sugars (2.37 and 2.38%) and total sugars (21.74 and 21.78%) along with minimum acidity (2.24 and 2.20%) were obtained in the same treatment during both the years respectively. Mani *et al.* (2013) studied that application of *Azotobacter* inoculated treatment with 75% N substitution by phosphate solubilizing bacteria and remaining 25% through inorganic fertilizer in two equal splits at establishment and before flowering stage increased length of shoot, number of shoot, number of leaves per shoot, internodal lengths, number of fruit per node, number of fruiting node per shoot, fruit yield, fruit length, fruit width, juice per cent, pulp stone ratio and acidity. Basith *et al.* (2018) concluded that pruning of phalsa bushes around 20th December has resulted in morenumber of fruit clusters and yield under the Southern Telengana Agro-climatic conditions. Integrated application of 50% RDF along with organic manure and biofertilizers is best option to obtain higher yields and superior fruit quality in phalsa.

Bael

Singh *et al.* (2014) studied the response of organic manures, inorganic fertilizers, biofertilizers and their combination with foliar spray of 0.4 per cent boron on yield, physico-chemical characters and economic feasibility of bael cv. Narendra Bael-9. The physical characters of fruit *viz.*, maximum fruit length(17.21 cm), width (16.45 cm), weight 2.21kg, volume 2422 cm^3, reduction of skull thickness (1.78 mm), fibre content (56.25 g/kg pulp), number of seed per fruit (80), mucilage content (13.08%), time of fruit maturity (261 days), maximum advancement of fruit maturity (6.0 days) and fruit yield (6600 kg/tree). However, the chemical composition of fruit *viz*., maximum TSS(41.12°Brix), Acidity (0.146%) ascorbic acid (23.83 mg/100g pulp), reducing sugars (4.120%), non-reducing sugar (13.0%), total sugars (17.130%) and minimum acid content were recorded with the application of T_{10} (100% NPKB+biofertilizers+biopressmud+FYM).

Shararath *et al*. (2016) investigated experiment on the effect of organic and inorganic fertilizers on Bael grown in Gangetic alluvial soil. The highest fruit yield of 14.7 kg, Pulp content was maximum (74.9%), TSS content (48.0°Brix), Ascorbic acid content (10.78 mg/100 g) in the fruit pulp, fruit weight (1220 g) was observed in the treatment plant treated with FYM (16 kg)+mustard cake (2.4 kg). Vishwakarma *et al.* (2017) showed that maximum fruit length, fruit width, fruit weight, pulp weight, TSS and ascorbic acid were recorded with application of 50 kg FYM + 100% NPK+200 g each (*Azotobacter*+PSB).

Manila Tamarind

Arthi *et al.* (2023) revealed that application of 50% of NPK+5 kg vermicompost+10 kg FYM+phosphobacteria 100 g followed by (T_4) FYM 10 kg+vermicompost 5 kg+ phosphobacteria 100 g increased the fruit weight (g), fruit length (cm), fruit girth (cm), weight of the peel (g), number of arils, weight of the aril with seed (g), fruit yield (kg/tree/year) of Manila tamarind**.**

Ber

Bohane and Tiwari (2014) conducted an experiment at College of Horticulture, Mandsaur on five years old trees of ber cv. Gola and revealed that the application of 50 per cent recommended dose of NPK as vermicompost+50 per cent RDF NPK+50 g *Azotobacter*+50 g PSB significantly increased the fruit length and diameter, fruit volume, pulp weight, stone weight, TSS, ascorbic acid, reducing sugar, non-reducing sugar, total sugars, TSS/acid ratio and chlorophyll content in leaves over other treatments.

Aonla

Korwar *et al.* (2006) stated that the growth, yield and quality of aonla were influenced by different sources of nutrients. Combination of organics and inorganic nutrients increased the fruit yield and quality. Application of vermicompost improved the fruit quality. Mandal *et al.* (2013) concluded that the application of 100: 25:150 g NPK/plant+10 kg FYM+50 g PSB/ plant is beneficial for increasing vegetative growth as well as improving yield and yield attributing characters of aonla cv. NA-7 under red and lateritic region of West Bengal. Aal *et al.* (2020) study the "Effect of integrated nutrient management on quality and shelf life of Aonla (*Emblica officinalis* Gaertn.) cv. Gujarat Aonla-1. Among all the treatments, T_9 (50 % RDF through chemical fertilizer+25 % RDN through vermicompost+10 ml Anubhav Bio NPK Consortium/ tree) treatment was found most effective treatment and recorded significantly maximum in pulp weight at maturity stage, pulp:stone ratio at maturity stage, total soluble solids, ascorbic acid, shelf life and minimized the acidity in Aonla fruits.

Aal *et al.* (2020) reported that of two successive years of investigation revealed that growth of the plant in terms of height, basal girth and plant spread towards East-West and North-South direction was maximum in the plant received yearly application of mustard cake at 4 kg followed by the plant with FYM 16 kg+Mustard cake 2.4 kg. Highest fruit yield of 14.7 kg /plant was recorded from the plant received yearly application of FYM 16 kg+Mustard cake 2.4 kg this was associated with foliar N and P values of 1.60 and 0.46 percent respectively. The lowest yield was obtained from the control plants. Highest organic carbon content of soil (0.84%) was recorded from the plots of the treatment with FYM 16 kg+Mustard cake 2.4 kg/ plant. TSS and ascorbic acid content of the fruit were more in the plant received the treatment of FYM 16 kg+Mustard cake 2.4 kg. The acidity content in the pulp of different treated plants did not vary significantly 50 % RDF through chemical fertilizer+25 % RDN through vermicompost+10 ml Anubhav Bio NPK Consortium/tree was found beneficial to increases the fruit length (3.42cm), fruit diameter (3.96cm), fruit weight (41.06g), fruit volume (39.87cc), number of fruits per tree (2496) and fruit yield (16.34 t/ha) in aonla cv. Gujarat Aonla-1.

Sneha Singh *et al*. (2021) conducted a field experiment on evaluate the effect of integrated nutrient management on economic return for aonla production. Themaximum yield attributing characters such asfruit weight, fruit size, fruit volume, pulp: stone ratio, fruit yield, and economics *viz* total cost, gross return, the net return, and benefit: cost ratio were noted under the treatment T_7: 75% RDF+30 kg Vermicompost+250g *Azotobacter*+250g PSB.

Pomegranate

Hiwale (2009) mentioned about an experiment carried out at CHES, Vejalpur on pomegranate crop and reported that fruit characteristics of pomegranate like fruit weight (188.75 g), fruit length (69.72 mm), fruit retention per plant (57) and fruit yield (10.75 kg/ plant) were significantly observed maximum when plants treated with 50 per cent N through FYM+25 per cent N through castor cake+25 percent N through urea. Dighe *et al.* (2014) reported that total number of fruits per tree (86.27), marketable fruit yield (27.95 kg/ tree or 20.68 ton/ ha) and total fruit yield (31.06 kg/ tree or 22.98 ton/ha) were found significantly maximum when pomegranate plants treated with GRDF while average weight of fruit (370 g) were found significantly maximum in 50% RDN and 50% N through FYM treatment. Dutta Ray *et al.* (2014) investigated that the fruits of pomegranate treated with 300 g nitrogen+1 kg neem cake plant per hectare showed significantly maximum fruit weight (239.83 g), fruit length (7.75 cm), fruit yield (6.94 kg/plant), juice content (75.63%), total soluble solid (12.29°Brix), TSS/ acid ratio (31.36), reducing sugar (9.78%) and total sugar (10.74%) with minimum acidity (0.39%). Greeshma *et al.* (2017) carried out an experiment on pomegranate crop at Kaladagi village of Bagalkot district, Karnataka and recorded the highest number of hermaphrodite flowers (139.0), number of fruit (98.01) and marketable fruit yield (26.43 kg/plant & 19.56 t/ha) with application of 50% RDN & P_2O_5 (200: 100: 200 N:P_2O_5:K_2O g per plant)+20 kg oil cakes+bioinoculants treatment. Whereas, fruit weight (294.20 g) and size (77.19 & 102.55 mm fruit diameter and length) was noticed maximum in 75% RDN & P2O5 (300: 150: 200 N: P_2O_5:K_2O gram per plant)+10 kg oil cakes+bioinoculants treatment. Kirankumar *et al.* (2018) conducted an experiment on pomegranate at the farmer's field of Somerhalli village, Hiriyurtaluk of Chitradurga district, Karnataka and revealed that application of 100% recommended dose of fertilizers (RDF) along with vermicompost+poultry manure+*Azospirillum*+PSB+KSB has recorded the maximum aril weight (212.47 g), aril per cent (72.53%) and lowest seed: aril ratio (0.016). Whereas, maximum TSS (15.30°Brix), TSS/TA ratio (46.48%), reducing sugars (12.79%), non-reducing sugars (1.65%) total sugars (14.39%) and lowest titratable acidity (0.33%) was recorded in 100% recommended dose of fertilizers (RDF) along with vermicompost+poultry manure+*Azospirillum*+PSB+KSB.

Conclusion

Based on the research conducted by several researchers on various arid zone fruits on INM; it may be concluded that application of biofertilizers and organic manure along with recommended dose of fertilizers improved the overall plant growth, yield and quality parameters in arid zone fruit crops. It also increases fertilizer use efficiency, ecological safety and maintain soil health on long term basis.

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