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Accomplish of Integrated Nutrient Management in Fodder Crops: A Review

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Review Article

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ABSTRACT

The availability of quality fodder in good quantity is necessary to improve the productivity of the animal. Since India place 2nd in population around the world, so to address the need for milk, the requirement of good quality fodder is necessary. In our country, there is a shortage of quality fodder due to less work being done to improve its quality and availability of lesser areas of land for its cultivation. This review paper goes through the previous work done to analyse the effect of combined nutrient sources. The application of inorganic nutrients with the combination of organic nutrients leads to improve crop yield with improvement in soil health and its productivity without deteriorating the environmental conditions. Soil is the primary source of nutrients for crops, and any degradation of the soil can result in a decrease in crop yield. Therefore, it is necessary to implement Integrated Nutrient Management (INM) practices to ensure the sustainability of natural resources and increase crop productivity.

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1. INTRODUCTION

Fodder crops belongs to those agriculture foodstuffs which are used to feed the livestock includes cattle, goat, sheep, horse, pigs, chickens. Fodder crops grow well in good drainage facilities and have a medium to a high amount of rainfall in their growing period. They have the capacity to tolerate acidic and waterlogged conditions. Fodder crops have a multi-cut nature which reduces the cost of feeding to livestock and generates income. Fodder crops prevent soil erosion and increase soil health by adding an excessive amount of organic matter in the soil.

Since Indian farmers are poor, cheap fodder crops like Teosinte are used to feed the animal and get good returns by reducing the cost of feeding. Due to the continuous increase in the demand for milk by the increase in the human population, it is a good opportunity for farmers to raise income by starting dairy production along with crop cultivation. As it is difficult to meet the demand for milk for a higher population, it's important to feed the cattle with good nutritive food, so that they gave their best yield. According to the government data, the demand for milk in 2014-15 was 146.3 million tonnes and 198.4 million tonnes in 2019-20. A study conducted by National Dairy Development Board (NDDB), and it was found out that the demand of milk and its based product is going to increases by 266.5 million metric tonnes. So, providing good quality feed to animal leads to give a good yield and quality of milk.

The intensive use of inorganic fertilizers in agricultural fields has resulted in environmental pollution. To produce high-quality fodder crops without damaging the environment, it is necessary to adopt Integrated Nutrient Management (INM). INM involves the use of a combination of organic, inorganic, and biological components to enhance soil fertility and provide essential nutrients to plants. INM has been shown to improve the physical, chemical, and biological properties of the soil, while also increasing the availability of both native and applied nutrients. By utilizing INM, it is possible to promote sustainable agriculture and ensure that the environment is not negatively impacted by chemical fertilizers.

Application of organic matter in the soil every year leads to upgrade the soil conditions by improving the soil structure, enlarge soil CEC, expand the availability of plant nutrients in the soil, increasing humus content, and providing the base on which microorganism live and perform microbial activities [11]. Nitrogen plays important role as it is vital constituent of protein, nucleic acid, enzyme, co-enzyme, chlorophyll and cell wall. Phosphorus plays an essential role in crop production as it is present in CO2 fixation, sugar metabolism, energy storage, and transfer [73].

2. CURRENT POSITION OF FODDER PRODUCTION IN INDIA

Fodder crop production varies throughout India, with its utilization dependent on factors such as cropping patterns, socio-economic conditions, and the type of livestock being raised. Fodder crops are used to feed the animal in the form of hay (dehydrated), silage (preserved under anerobic conditions), forage (slash green and fed fresh). Egyptian clover (1.9 M ha), Sorghum (2.6 M ha) account for 54% of entire raise area in India [17]. Currently there is a total shortage of 35.6% green feed, 10.95% dry forage and 44% concentrate feed material [31].

By the year 2050, the request for dry feed and green will be 631 and 1012 million tonnes respectively (Fig. 1). With the present speed of enlargement in forage supplies, by the year 2050 there will be an 13.2% shortfall in dry fodder and 18.4% deficient in green fodder. To satisfy the deficiency, green fodder must supply at a rate of 1.69% per annum, however there are only 4% (8.4 million ha) of area under fodder cultivation in India [17,50].

3. EFFECT OF ORGANIC MANURE AND BIO-FERTILIZERS IN COMBINATION WITH CHEMICAL FERTILIZERS ON OATS (*Avena Sativa* L.)

OAT, scientifically known as Avena sativa L., is a type of winter crop from the Avena genus that is commonly used as animal feed in the form of green fodder, straw, hay, or silage. The oat grains are rich in dietary fibre and provide a good source of protein, typically containing 10-12 percent protein and 30-35 percent dry matter, making it a suitable food source for a variety of livestock, including cattle, sheep, and poultry. Oat grow best in cool and moist weather. It requires 15-25 degree Celsius for optimum growth.

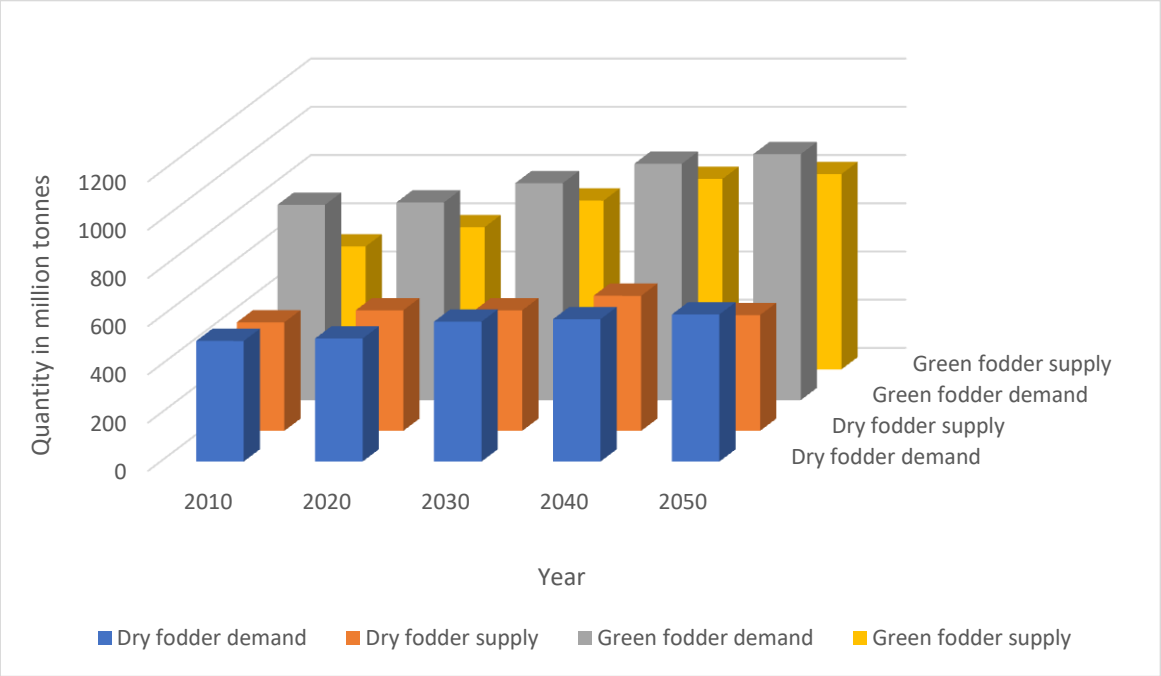

Fig. 1. Year wise demand and supply of green and dry fodder in India
(Source: IGFRI Vision, 2050)

Oat can exhibit high nutrient uptake when cultivated after kharif rice. Specifically, the study by Roy et al. [58] found that this could be achieved using 50% recommended dose of fertilizer (RDF) and 10 tons per hectare of farmyard manure (FYM). Based on these findings, it could be suggested that farmers consider cultivating oat after kharif rice and applying 50% recommended dose of fertilizer (RDF) and 10 tons per hectare of farmyard manure (FYM) to improve nutrient uptake and crop yield. The use of organic fertilizers such as vermicompost and FYM, along with a controlled application of synthetic fertilizers like RDF can have a positive impact on crop yield and quality. However, it is important to note that these findings are specific to single cut oat and may not be generalizable to other crops based on the suggestion provided by researchers [44]. They found that the application 5 tons per hectare of vermicompost, 5 ton per hectare of farm yard manure (FYM) and application of 50% nutrient from RDF gave higher yield and gave quality fodder from single cut oat.

A suggestion could be made to farmers and agricultural practitioners to consider using a combination of organic and inorganic sources of fertilizers for their crops. This can help to improve the overall yield and quality of the fodder produced. However, it is important to note that the specific combination and amount of organic and inorganic sources may vary depending on the crop and local soil conditions, so it is recommended to consult with experts and conduct soil testing before applying fertilizers. This suggestion was supported based on the studies by researchers [50,5]. It can be concluded that the use of a combination of organic and inorganic sources of fertilizers can lead to higher yields and better-quality fodder. Meena et al. [50] found that a combination of vermicompost and sheep manure led to maximum protein production, dry fodder yield and yield of green fodder while Backiyavathy et al. [5] observed that a combination of vermicompost and 75% recommended dose of inorganic fertilizer led to maximum green and dry fodder yields.

A suggestion could be made to farmers and agricultural practitioners to consider the application of the optimal levels of N and P for their green fodder production. Soil testing and analysis can help determine the specific nutrient requirements for their crops, which can aid in making informed decisions about the appropriate fertilizers to use. It is also important to note that excessive use of fertilizers can have negative impacts on the environment, such as soil degradation and water pollution, so it is essential to apply fertilizers judiciously and responsibly

which was proved from the study to investigate the impact of various levels of nitrogen (N) and phosphorus (P) application on green fodder yield. The study revealed that the application of 150 kg N/ha and 60 kg P/ha resulted in the highest yield of 74.67 t/ha in comparison to other treatments [3]. These results suggest that N and P are crucial nutrients for green fodder production and that their optimal levels can lead to increased yield.

The use of beneficial microorganisms in combination with the optimal use of fertilizers to improve the growth and yield of oats and other crops. It is also important to note that soil testing and analysis can help to determine the specific nutrient requirements for crops which can aid in making important decisions about the appropriate fertilizers and microbial treatments to use. The use of beneficial microorganisms such as Azotobacter and PSB (phosphate solubilizing bacteria) can improve the growth and yield of oats, as well as increase the efficiency of nitrogen utilization. Oat seeds treated with Azotobacter and combined with 40 kg N/ha showed the best nitrogen utilization efficiency [65]. Deva (2015a) observed that the use of PSB and Azotobacter with the recommended dose of fertilizer led to a significant increase in the population of soil bacteria, actinomycetes, and fungi [21]. Combination of Azotobacter and oats seeds resulted in increased tillers, plant height and dry matter yield of the fodder crop, indicating the potential for nitrogen fixation [22].

The use of bio-fertilizers (Azotobacter + PSB) in combination with 100% recommended dose of fertilizer (RDF) can result in increased yield of green and dry fodder. Additionally, the study found that this combination also led to the highest benefit-to-cost (B:C) ratio, indicating the economic viability of this approach. Based on these findings, it could be suggested using a combination of bio-fertilizers and RDF to improve the yield and economic viability of their crops [23].

4. EFFECT OF ORGANIC MANURE AND BIO- FERTILIZERS IN COMBINATION WITH CHEMICAL FERTILIZERS ON BERSEEM (*Trifolium alexandrinum* L.)

Berseem is considered a significant winter forage crop that is cultivated in several countries worldwide. It has a high nutritional value, as it contains approximately 20% crude protein and 70% dry matter. Additionally, Berseem is a rich source of essential minerals such as calcium and phosphorus. Cultivation of berseem loosen compact soil make better soil aggregation and increase chemical properties like nitrogen, organic carbon, and available phosphorus. It also reduces the weed infestation.

Use a combination of fertilizers and organic sources like poultry manure and farmyard manure to improve plant growth and development. The combination of organic sources like poultry manure and farmyard manure with fertilizers can have a positive impact on plant growth and development. Specifically, the combination of 75% recommended dose of fertilizer with 25% nitrogen through poultry manure and the application of 75% recommended dose of fertilizer with 25% nitrogen through farmyard manure resulted in the maximum number of nodules per plant [45]. Using farmyard manure in a rice-berseem cropping system could also help improve crop yield. The application of 10 tons per hectare of farmyard manure in a rice-berseem cropping system, along with 100% of the recommended dose of nitrogen, phosphorus, and potassium, resulted in an increase in the green yield of fodder berseem and rice yield [6]. This finding suggests that the use of farmyard manure can be beneficial in improving crop yield in a rice-berseem cropping system. Adopt the recommended dose of nutrients application for better yield and quality of fodder crops. Proper fertilization can play a crucial role in the growth and development of forage crops, and it is important to ensure that the nutrient requirements of the crop are met to achieve maximum yield and quality. The implementation of the recommended dose of nutrients resulted in higher green foliage, dry matter and crude protein yield in berseem compared to other treatments [9] and it was proved by the study conducted by researcher as they concluded that applying the recommended dose of fertilizer is essential for achieving higher yields of green fodder and dry matter [74].

A combination of organic and inorganic fertilizers can positively impact the growth of berseem crop. Specifically, the implementation of 50% Nitrogen through farmyard manure and 50% through inorganic nutrients resulted in higher growth parameters [28]. Inoculating the seed with rhizobium and using a combination of organic and inorganic fertilizers, including nitrogen, to increase the protein and ash content and

improve the fibre quality of the crop, this suggestion is supported by the study and found that the inoculation of seed with rhizobium and application of 25kg N/ha together can increase the crude protein and ash content of the crop and have a drastic effect on the acid and neutral detergent fibre [60].

The application of 30kg N/ha and cutting at 5cm stubble height resulted in the highest yield of forage from berseem. Additionally, the yield of berseem was found to be highest (60t/ha) when basal (20kgN/ha) + 10kg N after the first cut was applied [7]. Based on these findings, it is suggested that farmers and agricultural practitioners consider using this application and cutting methods to maximize the yield of berseem in their fields.

5. EFFECT OF ORGANIC MANURE AND BIO- FERTILIZERS IN COMBINATION CHEMICAL FERTILIZERS ON SORGHUM (*Sorghum bicolor)*

Sorghum is placed on 4th position as major foodgrain in the world and rank 3rd as the major food grain crop of our country. It is the important food of millions of peoples of Africa and Asia. Despite being a major staple food for humans, it is a best source for cattle feed and fodder. Sorghum contains 10-12% protein, 3% fat and 70% carbohydrates. So, it is satisfactory used as a feeding programme for dairy cattle, poultry and swine. Sorghum has a well-developed root system and sorghum root is more fibrous than maize. Several introduced fodder varieties of sorghum are quite juicy and sweeter than grain varieties. Application of 2.0-ton castor cake/ha had a significant positive effect on several parameters, including the number of leaves, leaf stem ratio, stem diameter, and nutrient uptake. In addition, the protein content of the sorghum was found to be higher in the treatment group that received castor cake [52].

The inoculation of Azospirillum can have a positive impact on the yield of both green and dry fodder of sorghum. In addition, the application of 25% nitrogen through farmyard manure (FYM) in combination with 75% recommended dose of fertilizer (RDF) and Azotobacter was found to be an effective treatment combination to enhance the yield of both green and dry matter compared to other treatment combinations. Furthermore, the study found that the application of 15 tons per hectare of FYM alone resulted in an increase in the crude protein content of sorghum [42]. Similarly, researchers conducted a study to examine the effect of different doses of fertilizer on the green fodder yield and nutrient use efficiency of sorghum and they revealed that the application of 50% recommended dose of nutrients (RDN) through chemical fertilizer and 50% N through FYM resulted in higher green fodder yield and nutrient use efficiency compared to other treatments [64]. The use of an inorganic source of 80kg N/ha can have a positive impact on the growth and yield of summer fodder sorghum in the region of Udaipur, Rajasthan. The study found that this level of nitrogen application led to increased plant height, stem diameter, dry matter production, and number of leaves per plant, which are important indicators of the quality and quantity of the yield [66]. Application of 125% recommended dose of fertilizer (RDF) is an effective strategy for maximizing the growth and yield of crops in the region of Udaipur, Rajasthan. The study found that this level of nutrient application led to the highest plant height, stem girth, leaf stem ratio, leaves per plant, and dry matter accumulation compared to lower levels of RDF [68]. Additionally, it is important to consider the economic and environmental sustainability of using high levels of fertilizers, as excessive nutrient application can lead to negative impacts on soil health, water quality, and greenhouse gas emissions.

6. EFFECT OF ORGANIC MANURE AND BIO- FERTILIZERS IN COMBINATION WITH CHEMICAL FERTILIZERS ON PEARL MILLET (*Pennisetum typhoides* L.)

Pearl millet (Pennisetum typhoides L.) is an important crop commonly known as "bajra". This crop is particularly significant as it serves as a staple food for the less fortunate. Pearl millet is widely cultivated in Africa and Asia, and it is the major millet grown in India due to its ability to withstand unfavourable weather conditions, making it a drought-tolerant crop. Pearl millet is a superior source of nutrition compared to sorghum, as it contains 11.6% protein, 5% fat, 67% carbohydrates, and 2.7% minerals. It is commonly consumed as "chapatis" in cooked form and it is also used as green fodder for cattle and feed for poultry. The versatility of pearl millet makes it a valuable crop for both human and animal consumption. From the study, it can be concluded that the combination of poultry

manure or cow dung with biofertilizers can have a significant impact on plant growth biometrics. Their findings suggest that the combined use of these fertilizers resulted in the highest plant height, number of tillers, shoot biomass and root biomass. This study highlights the potential benefits of using organic and biofertilizers in combination for optimizing plant growth and yield [1]. It suggests that such combinations can be an effective alternative to synthetic fertilizers, which can have negative impacts on the environment and human health. Furthermore, the use of organic and biofertilizers can contribute to sustainable agriculture by improving soil health and reducing the use of chemical fertilizers. This study provides valuable insights for farmers and agricultural practitioners looking to optimize plant growth and yield while minimizing the use of synthetic fertilizers. By incorporating organic and biofertilizers in combination, they can improve soil health and promote sustainable agriculture.

By incorporating organic manure, farmers and agricultural practitioners can improve soil health, increase crop yield and reduce the use of synthetic fertilizers, which can have negative impacts on the environment and human health and researcher concluded that drilling of vermicompost is a better method compared to incorporation [51]. The study found that drilling 2.0t/ha of vermicompost resulted in more effective tillers, longer ear length and more seeds per ear. Similarly, from the study, it can be concluded that applying 50% of the recommended dose of fertilizer (RDF) and the remaining 50% of nitrogen through organic manure can improve soil health and crop yield. The study found that this method increased soil organic carbon content and improved accessibility of nitrogen, phosphorus and potassium in pearl millet-pigeon pea cropping systems [75].

The higher levels of nitrogen, phosphorus and potassium present in poultry manure compared to other organic sources of nutrients may contribute to its effectiveness in improving soil health and crop yield and combination of different types of organic manure can have synergistic effects in promoting soil health and fertility. The benefits of incorporating vermicompost, FYM and poultry manure farmers and agricultural practitioners can improve soil health, increase crop yield, and reduce the use of synthetic fertilizers and the combination of vermicompost, farmyard manure (FYM), and poultry manure can result in the highest organic carbon content in the soil [16]. Additionally, the study found that applying 50% of the recommended dose of nitrogen (RDN) through inorganic fertilizer and 50% of the RDN through poultry manure led to the highest nitrogen, phosphorus and potassium levels in the soil. Combination of synthetic and organic fertilizers can be effective in promoting plant growth and improving crop yield and implementing 75% of the recommended dose of fertilizers with 10 tons per hectare of farmyard manure can result in higher plant height in fodder bajra [46].

There is a potential benefit of utilizing a combination of synthetic and organic fertilizers to improve crop yield and productivity. By using optimal amounts of synthetic fertilizers and supplementing them with organic sources like farmyard manure, farmers can promote plant growth while reducing the use of synthetic fertilizers. Additionally, the use of nitrogen fertilizer can have a significant impact on the yield of pearl millet, emphasizing the importance of using optimal amounts of fertilizers for different crops and it was found that applying an additional nitrogen rate of 120kg N/ha resulted in an increase in forage yield of pearl millet [30]. This indicates that nitrogen fertilizer can have a significant impact on the yield of pearl millet, which is a crucial crop in many agricultural systems. Researchers conducted a field trial to investigate the impact of integrated nutrient management on soil fertility under pearl millet and they recorded the maximum and minimum values of nitrogen, phosphorus, potassium and C which are important nutrients for plant growth [34].

7. EFFECT OF ORGANIC MANURE AND BIO- FERTILIZERS IN COMBINATION WITH CHEMICAL FERTILIZERS ON COWPEA (*Vigna sinensis* L.)

Cowpeas, also referred to as 'lobia,' are a versatile crop that can be used for multiple purposes such as fodder, pulse and green manure. Due to its high protein content and other essential nutrients, cowpeas are often referred to as "vegetable meat." It is a rich source of calcium and iron containing approximately 23.4% protein, 1.8% fat and 60.3% carbohydrates. This crop's nutritional value highlights its potential as a valuable food source and its significance in crop production systems. Cow pea is used as a consumption for both human and animals. Cowpea have a good forage quality for cattle than lucerne. Cowpea is most promising green

manure crop as it has a substantial vegetative growth and inspects soil erosion by operating as a cover crop. Using microbial inoculants and organic fertilizers like vermicompost and biofertilizers to improve the growth and yield of cowpea plants. This can help to reduce the reliance on synthetic fertilizers, which can have negative environmental impacts and be costly for farmers. Additionally, the use of these organic inputs can help to promote sustainable agricultural practices and support the health of the soil and surrounding ecosystems. The use of microbial inoculants such as Rhizobium, Phosphobacteria, and Azospirillum can have a positive impact on the yield and growth of cowpea plants. Combination of these three microbial inoculants led to a higher number of pods in cowpea [62]. Similarly, the study by Mundra and Bahti observed that rhizobium inoculation increased the number of nodules per plant, which is a positive indicator of improved plant growth and development [38]. There is increased in the yield of cowpea where vermicompost is applied comparatively to no vermicompost applied treatment and there is increase in dry matter production where biofertilizer applied comparatively to where no biofertilizer is applied [2]. The implementation of vermicompost is beneficial and it generally increase the fresh and dry weight and also it increases the yield of cowpea [36].

Use of a combination of organic inputs and microbial inoculants can help to improve the growth and yield of cowpea plants while reducing the use of synthetic fertilizers. This approach can be a more sustainable and cost-effective method for farmers and agricultural practitioners, leading to greater profitability and environmental benefits. The application of 75% recommended dose of fertilizers in combination with Rhizobium, vermicompost and PSB led to higher numbers of branches and leaves per plant, increased plant height and greater numbers and sizes of pods [19]. Moreover, this approach was found to be more effective compared to the application of recommended dose of fertilizers alone, and it also helped to save 25% of inorganic compounds. Similarly, the study by (Thomas and Lal 2002) found that the use of farm compost and vermicompost in combination with inorganic fertilizers led to the highest forage yield of cowpea plants. They also found that the application of phosphorus through PSB and Rhizobium or a combination of PSB with cow urine foliar sprays was effective. The application of 20kg N/ha through inorganic nutrient along with rhizobium inoculation led to the highest pod weight, shell fresh weight, number of leaves, branches and yield of green pods in cowpea plants [37].

8. EFFECT OF NANO-UREA IN COMBINATION WITH ORGANIC AND INORGANIC NUTRIENT SOURCES ON BARLEY (*Hordeum vulgare* L.)

Barley is the important cereal crop belongs to Gramineae family. Barley is a good source of food for people living in the cold semi-arid tropics. As a food, barley flour is used as a making ‘chapatis’. Barley grain carry 11.5 % albuminoids, 74% carbohydrates, 1.3% fat and 12.5 % moisture. Barley grain is roasted and used for making ‘Satu’. In India, most importantly barley grain is used as a feed to poultry and livestock. Barley is also used for the manufacture of beer and other liquors like whisky, brandy etc.

Study revealed that the application of 100% RDN significantly increases the plant height, nitrogen, phosphorus and potassium content in straw and grains of pearl - millet, dry matter accumulation and chlorophyll content. Study also observed the increased in the plant height, nitrogen, phosphorus and potassium content in straw and grains of pearl millet, dry matter accumulation and chlorophyll content when application of nano-urea as foliar spray (4ml/l of water) at 30th and 45th days over control and application of same dose of nano-urea at only 30th days [63]. The application of a combination of organic and inorganic fertilizers along with biofertilizers can lead to higher crop yields and better plant growth. Specifically, the application of 75% NPK in combination with 5t FYM/ha and biofertilizer resulted in higher grain and straw yield as well as improved spike length, number of spikelets/spikes, and weight of grain/spike in barley [68]. This highlights the importance of utilizing a combination of different fertilizers and biofertilizers to achieve optimal crop production. The application of 75% recommended dose of fertilizer (RDF) in combination with FYM showed the highest field productivity in barley, and this productivity was similar to the application of 75% RDF + FYM + biofertilizer together [55].

Application of farmyard manure (FYM) at the rate of 10 tons per hectare can significantly improve the productivity of crops, as evidenced by the increased effective tillers/meter of row length, number of grains/spikes, spike length, straw yield and biological yield [21]. The results suggest that

the use of organic fertilizers like FYM can be a viable alternative to synthetic fertilizers, especially for sustainable agriculture practices. Additionally, this study highlights the importance of proper nutrient management in crop production and the potential benefits of using organic fertilizers for improving soil fertility and productivity. Farmers and agricultural practitioners who wish to optimize the green fodder yield in dual-purpose barley may consider using the two-split nitrogen application method with 2/3 at basal and 1/3 immediately after cutting. However, the application of nitrogen in three splits with 1/2 at basal, 1/4 immediately after cutting and 1/4 at the next irrigation may also be considered as an alternative method [67].

9. EFFECT OF ORGANIC MANURE AND BIO- FERTILIZERS IN COMBINATION WITH CHEMICAL FERTILIZERS ON MAIZE (*Zea mays* L.)

Maize is a significant crop worldwide, following only wheat and rice in importance. It has earned the nickname "miracle crop" due to its exceptional yield in comparison to other cereal crops, making it the "Queen of cereals." Maize serves as both a food source for humans and animal feed. Its grain flour is utilized in the production of chapatis, while hard corn is a popular choice for popcorn. As for livestock, maize is an excellent source of feed for poultry and other animals. Maize grain carry out 2.3% crude fibre, 10% protein, 70% carbohydrates and 4% oil. Maize crop supply high amount of green fodder for cattle.

The application of organic fertilizers such as FYM along with appropriate doses of chemical fertilizers like nitrogen, phosphorus, and potassium can improve the growth and yield of crops like maize. Combining organic and inorganic fertilizers has been found to be more effective in increasing dry matter production, plant height and leaf area than using only chemical fertilizers. Additionally, the use of FYM has been shown to produce nutritious fodder for animals. Therefore, it is suggested that farmers should use a combination of organic and inorganic fertilizers to improve the growth and yield of crops and provide nutritious fodder for their livestock. It is also important to use the recommended doses of fertilizers and apply them at the right time and in the right manner to ensure maximum benefits. This recommendation was supported by researcher in an experiment at IARI observed that compared to other treatments application of 120 kg N +10 t FYM/ha gave higher dry matter production and plant height on maize [35]. Later, researchers observed that combination of 25t/ha FYM with 100kg N/ha produced nutritious fodder for animals [53]. Compared to chemical fertilizers application of 10t/ha FYM with 120 kg nitrogen + 26.2 kg phosphorus +33.2 kg potassium/ha gave higher plant height and leaf area [43]. The combination of organic and inorganic fertilizers can result in higher yields and yield components of crops such as maize. The use of poultry waste as an organic source of nitrogen can also be an effective alternative to chemical fertilizers. A combination of farmyard manure, poultry waste and urea can lead to increased yields and yield components in maize. It is also worth noting that applying nitrogen from poultry manure, along with a portion from urea, can lead to improved harvest index and grain yield in maize. In comparison to unfertilized treatment implementation of 60kg N/ha from poultry as an organic source and 60kg N, 40Kg P and 40Kg K kg/ha from inorganic compounds gave maximum grain and stover yield (8 and 8.9 ton per hectare) [54]. Later researcher noted that the application of an equal proportion of farmyard manure (FYM), poultry waste and urea at the same amount resulted in higher yields and yield components of maize in comparison to the application of either organic or mineral nitrogen alone [4] and the application of 50% nitrogen through poultry manure and the remaining amount through urea resulted in the maximum harvest index (24.91%), grain weight per cob (68.98 g), and grain yield of maize (5.6 t/ha) [15]. This finding was in comparison to the unfertilized treatment. The use of foliar nutrition can be an effective strategy for improving crop quality and yield and researcher found that the application of a recommended dose of fertilizer along with a single foliar spray of a multi-nutrient solution can improve the quality parameter of maize (oil content) [25].

10. EFFECT OF ORGANIC AND INORGANIC NUTRIENT SOURCES ON NUTRIENT UPTAKE

The application of both PSB and vermicompost together resulted in an increased amount of nutrient uptake compared to using either alone. The maximum uptake of nitrogen, phosphorus, and potassium was observed with the combination of 75% recommended dose of fertilizer (RDF), vermicompost at 1 ton/ha and PSB [20]. Total uptake of nutrients was highest when boron, sulphur, and farmyard manure were used in combination with 75% NPK (N-150, P-60, K-60) [56,57]. Organic manure is known to

facilitate high nutrient uptake due to the solubilization of complex nutrients during its decomposition. The decomposition of farmyard manure (FYM) leads to the release of organic acids, increasing the availability of phosphorous and promoting microbial growth, which helps to enhance the growth of the root system and ultimately leads to increased phosphorous uptake by the plant. Additionally, the combined application of FYM and vermicompost has been found to increase the availability of phosphorus in soil. Furthermore, the application of potassium-bearing minerals in soil released by organic acid from the decomposition of organic manure has been shown to increase the availability of potassium in soil [71].

11. EFFECT OF ORGANIC AND INORGANIC NUTRIENT SOURCES ON REDUCING THE ENVIRONMENTAL POLLUTION AND IMPROVING THE YIELD ATTRIBUTE CHARACTER

The intensive use of inorganic fertilizers is used by the farmer to get maximum return, but the use of inorganic fertilizer has a severe impact on soil and the environment. The use of inorganic fertilizer with the combination of organic sources raised the crop yield (8 to150%) and raised the economic return to the farmer. As sustainable agriculture production is the theme of INM, so it combines all the possible inputs to improve soil health. Any degradation in the soil leads to depletion in the yield as the soil is the primary source of the nutrients. INM improves the plant's water use efficiency (WUE), increases nutrient use efficiency (NUE) while reducing environmental pollution and increases yield [77].

Nitrogen is a crucial nutrient that is required to increase crop yield, and it is needed in higher amounts than any other nutrient. Combining organic and inorganic nutrients led to an increase in both biomass yield and grain yield [41]. The conversion of carbohydrates into proteins is facilitated by a high amount of nitrogen, which in turn supports the formation of protoplasm [12]. High nitrogen uptake has been shown to increase the yield attribute character, resulting in greater dry matter production [18]. The integration of both organic and inorganic sources of nutrients has been found to increase yield attributing characters such as grains per spike, test weight and dry matter accumulation [49].

12. EFFECT OF ORGANIC AND INORGANIC NUTRIENT SOURCES ON SOIL PRODUCTIVITY

Integrated Nutrient Management (INM) is a strategy that combines the use of inorganic and organic sources of nutrients, along with input

Table 1. Role of chemical nutrients on controlling diseases

Application of these essential nutrients impact on disease resistance:

Nutrient	Plant diseases	Presence of nutrient	References
Nitrogen	Facultative parasites, e.g., *Alternaria, Fusar-ium* and Xanthomonas spp.	Infection decreases with increase in Nitrogen supply	Chase [14]; Blachinski et al.[10] Woltz and Engelhar (1973)
Potassium	*Alternaria solani, Fusarium oxysporium*	Application of Potassium reduce the infestation of disease	Blachinski et al.[10] Srihuttanum and Sivasithamparam (1991)
Phosphorus	Bacterial leaf blight in rice, smut on corn	Phosphorus decreases the incidence of diseases	Huber and Graham [29].
Chlorine	Stalk rot in corn, stripe rust in wheat Downy mildew of millet	Application of chlorine reduce the infestation of diseases.	Graham and Webb [26]; Mann et al. [48].
Silicon	Blast of rice (*Magnaporthe grisea*) Brown spot (*Cochliobolus miyabeanus*	Silicon reduces the infestation of diseases	Savant et al. [61]

through biological processes, to increase crop yield [33]. Organic matter plays an important role in this strategy by increasing nutrient supply, water holding capacity and providing a suitable environment for plant growth and development. Additionally, organic matter improves soil physical conditions by enhancing soil bulk density, porosity and water storage capacity [8]. The application of manure not only enhances the current season's yield but also improves the availability of nutrients for the next season. Research shows that the integration of various sources of nutrients such as chemical fertilizer, farmyard manure, compost, organic manure and biofertilizer leads to a higher infiltration rate of the soil and reduces bulk density. This combination also improves soil organic matter content, aggregate stability, and moisture holding capacity [59]. The content of organic matter in the soil can increase from 28.6% to 35.7% and the efficiency of inorganic fertilizer is improved through suitable soil microbial activity and enhancement of the soil colloid, which possesses a large nutrient-holding surface area [47]. Additionally, the combination of chemical fertilizer with organic fertilizer can reduce the deficiency of secondary and micronutrients [13].

13. CONCLUSION

In conclusion, utilizing integrated nutrient management can provide benefits for both soil and plants. The use of chemical fertilizers for fodder crop production can lead to soil deterioration through increased acidity and chemical residue build-up. Integrated Nutrient Management represents the most effective approach to address this issue, offering advantages such as improved crop yields, enhanced nutrient uptake, environmental sustainability, cost-effectiveness and soil fertility and quality improvement, while also mitigating the negative environmental impacts of chemical fertilizers. Studies have demonstrated that the combined use of organic and inorganic nutrients can lead to better growth parameters, yield, disease control, and microbial activity in the soil. Furthermore, continuous cropping of crops with the combination of both inorganic and organic nutrients can result in increased grain yield and soil productivity and health. Therefore, it can be concluded that Integrated Nutrient Management is the most effective approach to promote crop yield and soil health while avoiding harm to the environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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