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# Farm-yard manure as a resource for integrated nutrient management

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**Abstract**
Intensively cultivated rice-wheat chemical fertilizers dependent system led to many sustainability issues *viz*. declining soil health, emerging insect-pest attacks, declining underground water tables, higher footprints of fertilizers etc. Out of all of them declining soil health is the main one that needs to be attended to at the earliest for which we need to improve the soil organic matter through the application of organic manures. Out of all of them, farm yard manure (FYM) is mainly used. In this article, we examine why farmyard manure is an ideal food source for plants and soil microbes. It's one of the most productive organic fertilizers available. Soil bacteria can use the organic stuff it provides as a carbon source. Pesticides and heavy metals are broken down by microbes in greater numbers into less toxic molecules. In addition, detrimental ions become stationary in soil when they adsorb on organic colloids. Farmyard manure has several beneficial effects on soil physical, chemical, and biological properties which further reduces the chemical fertilizers' footprints in a need-based, sustainable, and climate-smart way which further helps in mitigating the adverse effects of global warming and also improves the overall land productivities of different crops in the region.

**Keywords:** Declining soil health, organic manures, chemical manures, sustainability, INM

## 1. Introduction

Over the past three decades, inorganic fertilizers have been widely used to meet rising food demands. Pollution of land, water, and air is caused by the overuse of chemical fertilizers. Soil organic matter, microbial population, and soil response are all negatively affected by fertilizer overuse (Erisman *et al*. 2008) [33]. However, as fertilizers are washed away by leaching and surface runoff from crop fields, they degrade both surface water reservoirs and groundwater. Nitrogen oxides (NO, $N_2O$, and $NO_2$) are gaseous byproducts of the breakdown of nitrogen in chemical fertilizers (Byrnes 1990) [20]. The accumulation of inorganic fertilizers in plants can potentially have negative effects on human health (Savci 2012) [88]. While it is true that chemical fertilizers will always have a place in agriculture, it is hoped that more careful use of them can help alleviate environmental concerns while still allowing for a robust food supply to be produced (Wu and Ma 2015) [112]. While farming that relies only on organic fertilizer sources is preferable for preserving soil health, it is less productive and may not be able to produce sufficient food for the ever-escalating population.

Therefore, an integrated nutrient management (INM) appears to be a suitable approach for improving rather preserving soil inherent productiveness and ensuring potential land productivity in the region. Manure is a type of organic material that may be utilized as an organic source of nutrients in soil; it is often produced from animal excreta, while green manure is of plant origin (Wu and Ma 2015) [112]. These are inexpensive and sustainable resources. As a result, farmers may be able to use fewer chemical fertilizers if these are implemented. Manure from farms has been used as a fertilizer for a long time. Soil structure and biomass are both enhanced by the addition of FYM (Dauda *et al*. 2008) [26]. Soil physical qualities can also be enhanced with the use of FYM. Soil organic carbon, nitrogen, phosphorus, and potassium levels all improve as a result of this, as do the soil's chemical characteristics (Bayu *et al*. 2006) [16]. As a result, adopting a nutrient delivery system that combines integrated utilization of nutrient sources is crucial if we are to reduce our reliance on synthetic fertilizers and protect natural resources while yet maintaining agricultural productivity (Merentola *et al*. 2012) [69]. To maximize output and soil productivity, organic manures should be used in conjunction with chemical fertilizers (Wu and Ma 2015) [112].

## 2. Nutrient profile of farmyard manure
To absorb urine, dry litter must be scattered under the cow shed, and this must be done before FYM can be prepared. Gather the components from dung and urine-soaked litter piles, ditches, and pits. Farmers in India utilize dung cake made from animal dung for cooking and heating. Urine seeps through the clay floor of the cow shed, wasting a significant amount of the manure and urine produced by the animals. FYM loses nutrients in the form of ammonia when it is constantly exposed to the scorching sun and heavy rain (Webb *et al*. 2004) [110]. High temperatures accelerate the decomposition of cattle dung, converting the complex organic form of nutrients contained therein to available forms which might be lost easily (Reddy *et al*. 2010) [86]. Even then a well-prepared FYM has the following nutrient composition pertaining to both macro as well micro-nutrients (Fig. 1).

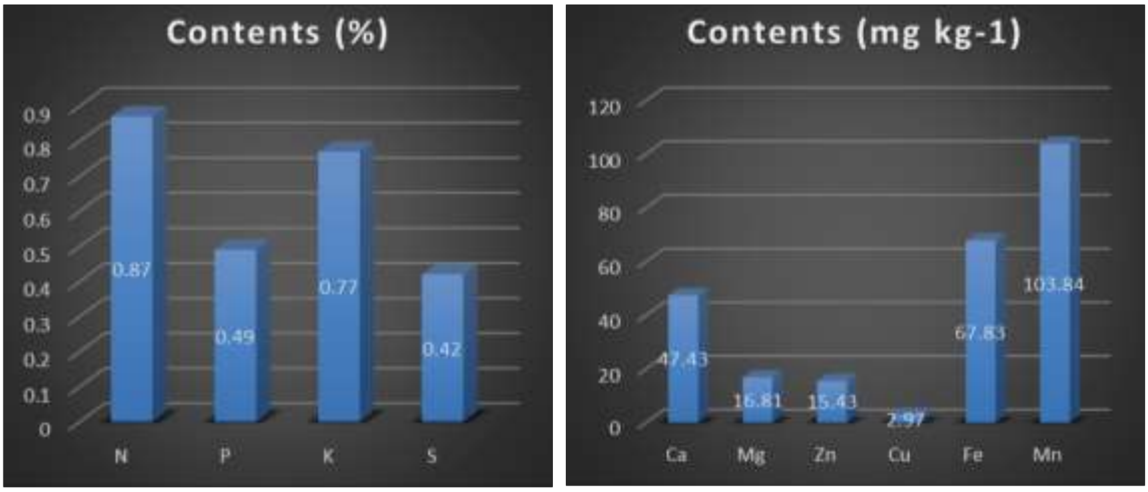


**Fig 1:** Nutrient composition of macro and micro-nutrients in Farm Yard Manure (Drafted Bhatt, 2023)

## 3. Farmyard Manure-Treated Soil Microorganisms
Farmyard waste contains isolates from Pseudomonas, Bacillus, Azotobacter, Flavobacterium, and Corynebacterium. Other FYM fungal isolates include Rhizopus, Aspergillus, Penicillium, Trichoderma, and Mucor (Adebusoye *et al*. 2007; Akinde and Obire 2008; Umanu *et al*. 2013) [1, 5, 104].

## 4. Role of farm yard manure in agriculture
1. Addition of farm yard manure in agricultural lands helps in build-up of the soil organic carbon and hence matter
2. Soil organic carbon is increased when FYM is applied. The high cation exchange capacity of soil is due to the great number of exchange sites found in soil organic matter (SOM) (Laxminarayana 2001; Verma *et al*. 2010; Scotti *et al*. 2015) [59, 107, 90].
3. FYM organic anions decrease soil phosphorus fixation by complexing with organic ligands and chelating with cations such Ca, Mg, Fe, Al, Zn, Mn, and Cu. (Singh *et al*. 2015) [19]. Decomposition of organic manures also results in the production of nutritional agents like humic and fulvic acids, which improve the nutrients' mobility, solubility, and availability (Kaushal and Kaushal 2013) [52].
4. Ca is released from exchangeable sites in the body due to organic acids created by FYM (Ano and Ubochi 2007) [7].
5. Organic acids such as citrate, oxalate, malate, malonate, and succinate have been shown to serve as chelators of micronutrients (Madrid 1999; Cline *et al*. 1982) [61, 25], which enhances their concentration in soil solution and makes them more readily available to plants.
6. When applied alongside fertilizers, FYM boosts plant metabolism by increasing nutrient uptake and, in turn, cell division and elongation (Torrey 1950) [102]. Further, following table no. 1 identifed different roles played by soil, micro-organisms *viz*. by Fungi and Bacteria

**Table 1:** Roles played by bacteria and fungi associated with organic soils

| Sl. No. | Microorganisms | Benefits | References |
|---|---|---|---|
| | | ***Fungi*** | |
| 1 | *Acaulospora elegans* | Arbuscular mycorrhizal relationships | Kamble *et al*. 2018 [50] |
| 2 | *Aspergillus niger* | The decomposition of plant lignocelluloses | Gautam *et al*. 2011 [39] |
| 3 | *A. nidulans* | Remediation of arsenic in soil | Maheswari and Murugesan 2009 [62] |
| 4 | *A. terreus* | A repository of many anticancer bioactive chemicals | Nadumane *et al*. 2016 [75] |
| 5 | *F. moniliforme* | Mycotoxins source | Bacon and Hinton 1996 [12] |
| 6 | *Penicillium rubrum* | Cellulose deprivation | Swer *et al*. 2011 [100] |
| 7 | *Trichoderma lignorum* | Perform the role of a parasite on harmful fungus. | Schuster and Schmoll 2010 [89] |
| | | ***Bacteria*** | |
| 8 | *Pseudomonas fluorescens* | Rhizobacteria that promote plant development and biopesticide | Ganeshan and Kumar 2005 [37] |
| 9 | *Pseudomonas putida* | Bio-control or Bioremediation | Zhou *et al*. 2019 [116] |
| 10 | *Bacillus megaterium* | Enhances plant development and resilience to salt stress | Trivedi and Pandey 2008 [103] |
| 11 | *Bacillus pumilus* | Enhances soil nutrient availability | Masood *et al*. 2019 [66] |
| 12 | *Bacillus coagulans* | Utilized as a biophosphorus fertilizer | Yadav *et al*. 2012 [114] |
| 13 | *Azotobacter vinelandii* | Oxidized N fascination | Van Dommelen and Avnderlevden 2007 [105] |

**5. Role of FYM in heavy metal reduction**

Toxic heavy metals are a widespread source of contamination in our water supply, and industrial wastewater is a major contributor (Mohan and Gupta 2014) [70]. Environmentally hazardous metals include chromium (Cr), cadmium (Cd), mercury (Hg), copper (Cu), lead (Pb), and others (Meena *et al*. 2008) [67]. Heavy metals can be cleaned up in a variety of techniques, including electrolytic deposition, reverse osmosis, filtering, adsorption, electrodialysis, chemical precipitation, etc (Mohapatra *et al*. 2007; Mohan and Gupta 2014) [72, 70]. Except for bioremediation, none of these approaches are cost-effective or environmentally friendly. Bioremediation is the removal of pollutants by the use of living organisms (Ogden and Adams 1989) [76]. Microbes may degrade molecules by altering their chemical structure in a way that cannot be done by any other creature. When compared to traditional physicochemical approaches, bioremediation is both more cost-effective and less harmful to the environment. Different soil pollutants which need to be controlled, all have different bioremediation needs (Lushchak *et al*. 2018) [60].

Now-a-days, the use of dung of cows as a remediation tool has been more widely recognized (Bachofen *et al*. 1995) [11]. Cow dung ash is both inexpensive and environmentally benign because of its adsorption properties. It includes trace levels of calcium oxide, magnesium oxide, calcium sulphate, aluminium oxide, iron oxide, and silica, respectively (Vasanthakumar and Bhagavanalu 2003) [106]. In addition to being an effective and efficient method, using cow dung as activated carbon may be used to regulate other environmental problems (Qian *et al*. 2008) [82]. Bacterial growth during arsenic volatilization was supported, in large part, by cow manure. The methylation process is effective for arsenic detoxification (Bachofen *et al*. 1995) [11]. Methanogenic bacteria convert inorganic and organic arsenic into dimethylarginine and trimethylarsine, two volatile chemical compounds (Mohapatra *et al*. 2007) [72]. Hard chromium exists mostly in multivalent states. Toxic levels of chromium can impact your respiratory system, liver, and kidneys (Teklay 2016) [101]. The adsorption of chromium ions from an aqueous solution by cow dung is highly promising; the level of contamination was significantly reduced (Mohan and Gupta 2014) [70]. Radiotoxic strontium with a very long physical half-life of 29 years, making it extremely poisonous in soil (Anon. 2006) [8]. Human actions, including the testing of nuclear weapons and the disposal of spent reprocessed fuel in liquid form, are a major contributor to this type of pollution. The poison it brings about makes illnesses like blood cancer more likely to be lethal (Barot and Bagla 2012) [15]. Biosorption of 90Sr from any aqueous media is facilitated by the presence of positive charge on the cow dung powder, which attracts enzymes (Barot and Bagla 2012) [15]. Because of its strong affinity to soil organic matter, mercury in polluted soils often exhibits high retention, poor mobility, and low bioavailability. Organic matter in the soil has been shown to increase mercury absorption by soil components (Alamgir *et al*. 2011) [6].

**6. FYM decomposes pesticides**

Sixty-four percent, or more, of Indians work in some capacity in the agricultural sector. Large quantities of pesticides are applied to fields every year in an effort to boost yields. As of now, India is Asia's second-biggest manufacturer of pesticides (Boricha and Fulekar 2009) [18]. Use efficiency for pesticides is typically about 2%, and the harmful residues that persist in topsoil for years after application (Randhawa and Kullar 2011) [84]. However, different researchers identified harmful effects of used different chemicals *viz*. insecticide and pesticides in agriculture (Table 2)

**Table 2:** Harmful effects of major herbicides and insecticides in agriculture

| Sl. No. | Chemical | Effects | References |
|---|---|---|---|
| | | **Herbicides** | |
| 1 | Butachlor | Harms other metabolic processes and redox homeostasis. | Agrawal *et al.* 2014 [93] |
| | | Cell growth | Xu *et al.* 2007b [113] |
| 2 | Bispyribac | Liver, lung, kidney, and spleen histopathology | Elalfy *et al.* 2017 [31] |
| 3 | Anilofos | Result in malfunctioning neurons and cells | Hazarika and Sarkar 2001 [43] |
| 4 | Oxadiargyl | Reduced production of leafy vegetables | Mahmoudi *et al.* 2011 [63] |
| 5 | Pendimethalin | Thyroid follicular cell adenomas in rats | Hou *et al.* 2006 [45] |
| | | The presence of residue inhibits root and shoot development. | El-Nady and Belal 2013 [32] |
| 6 | Diuron | Oysters and lizards have a reproductive mechanism that is sensitive to toxicity. | Huovinen *et al.* 2015 [46] |
| 7 | Atrazine | Liver and kidney injury in rats | Jestadi *et al.* 2014 [49] |
| 8 | Isoproturon | Reduced soil microbial population | Widenfalk *et al.* 2004 [111] |
| | | **Insecticides** | |
| 9 | Profenophos | Somatic and germ cell chromosomal abnormality suggests mutagenicity. | Fahmy and Abdalla 1998 [] |
| 10 | Cypermethrin | Neuronal DNA damage and oxidative stress | Singh *et al.* 2012 [97] |
| 11 | Fenvalerate | Endocrine disrupting chemical | Gao *et al.* 2010 [38] |
| 12 | Spinosad | Rats also had thyroid vacuolation and inflammation | Yano *et al.* 2002 [115] |

Pesticide waste is currently being treated using a variety of physico-chemical approaches, all of which are inefficient and ineffective. Pseudomonas plecoglossicida bactreia belongs to the genus Pseudomonas and. Bioremediation of the herbicide cypermethrin is aided by Pseudomonas plecoglossicida (Boricha and Fulekar 2009) [18]. Chlorpyrifos is effective against cutworms, corn root worms, leaf folders, leaf hoppers, and many other pests (Silambarasan and Abraham 2013) [96]. Granules, wet table powder, and other forms of chlorpyrifos are available for usage (Swati and Singh 2002) [99]. Bioremediation of chlorpyrifos-contaminated soils is possible because Pseudomonas resinovarans may utilise chlorpyrifos as a carbon and energy source (Fulekar and Geetha 2008) [36]. Synthetic pyrethroid fenvalerate is efficient against a wide variety of pests that can be found in agricultural settings. Soil bacteria are responsible for the degradation of fenvalerate, which results in the production of 4-chloroalpha benzene acetic acid and 3-phenoxy- benzoic acidovera. Both of these byproducts are far safer than the parent molecule (Geetha and Fulekar 2010) [40]. Atrazine, a common herbicide, impedes the process of photosynthesis in a wide variety of broad-leaved plant species. The toxic residue it leaves behind is carried by runoff into rivers, where it endangers the lives of aquatic organisms. According to the results of incubation experiments, the atrazine was broken down the quickest in treatments that included farmyard manure (Mukherjee 2009) [74]. Pseudomonas has excellent potential for chlorpyrifos degradation (Horne *et al*. 2002) [44]. In a similar vein, cyanobacteria played a significant part in the breakdown of malathion (Ibrahim *et al*. 2014) [47]. Chlorothalonil is a fungicide that does not need to be sprayed on the entire crop (April *et al*. 2014) [10]. Degradation of chlorothalonil has been attributed to a wide variety of bacteria, which could help in reducing the amounts of these pesticides in soils (Mori *et al*. 1996) [73].

## 7. Farm Yard manure effects on

### 7.1 Physicochemical possessions of soils

Bandyopadhyay *et al*. (2010) [14] conducted research at the Indian Institute of Soil Science in Bhopal, Madhya Pradesh. Their findings demonstrated how FYM and chemical fertilizers influenced the soil health when soybeans were grown in the area. They discovered that employing synthetic fertilizers in conjunction with organic manure considerably shifted the soil's organic carbon by 29.8 percent and 45 percent, respectively, in comparison to the complete NPK treatment and the control treatment. According to Shirale *et al*. (2014) [94], the greatest decline in pH (-0.17) was observed with FYM @ 10 Mg ha-1, and the maximum EC was observed in plots that received a higher amount of inorganic fertilizers. The greatest negative change in organic carbon was found under the treatment of 150 percent NPK. This resulted in a +1.10 percent increase in the amount of carbon dioxide in the soil. Soil pH was shown to range from 7.58 to 7.65 after receiving different organic manures in studies conducted by aur *et al*. (2005). Wheat treated with FYM at 15 t $ha^{-1}$ + N 120 kg P 30 kg and pearl millet treated with N 120 kg P 60 kg had the greatest decrease in pH (7.58). The highest levels of organic carbon (0.99%) were achieved with 15 t $ha^{-1}$ of FYM. Researchers Sepehya *et al*. (2012) [91] looked at the correlation between that factor and CEC [14.1 cmol (p+) $kg^{-1}$]. Long-term treatment of FYM raised the soil pH (6.95) over its starting condition, as discovered by Gopinath *et al*. (2009) [41]. (6.90). Similarly, the soil organic carbon content increased from 1.02 to 1.10 percent after FYM treatment. Comparing CEC under treatment of 50% N + 25% N via Green leaf manure + 25% N via FYM + Azospirillium to CEC under control conditions (7.92 cmol (p+) $kg^{-1}$) reveals a significant improvement. Maximum organic carbon was produced by a combination of FYM and Azospirillium (6.90 g $kg^{-1}$). Following table no. 3 delineates the increase in soil-accessible nutrients as a result of integrated nutrient management against fertilizers in various agricultural systems.

**Table 3:** Percentage hike in soil accessible nutrients under integrated nutrient management over fertilizers in different agricultural systems.

| Sl. No. | Cropping system | Availability (%) | | | Organic carbon (%) | References |
|---|---|---|---|---|---|---|
| | | Nitrogen | Phosphorus | Potassium | | |
| 1 | Maize–mustard crop sequence | 58.0 | 68.1 | 39.7 | 27.1 | Saha *et al.* 2010 [87] |
| 2 | Direct seeded upland rainfed rice | 13.9 | 40.5 | 20.7 | 13.7 | Choudhary and Suri, 2014 [24] |
| 3 | French Basil | 17.5 | 12.8 | 3.2 | 11.5 | Anwar *et al.* 2005 [9] |
| 4 | Rice-wheat crop sequence | 78.6 | 40.2 | 13.6 | 24.3 | Ram *et al.* 2016 [83] |
| 5 | Baby corn-rice cropping system | 24.4 | 27.8 | 8.90 | 10.1 | Sharma and Banik 2016 [93] |
| 6 | Cotton | 11.6 | 9.5 | 15.9 | 17.7 | Reddy *et al.* 2017 [85] |
| 7 | Sugarcane | 8.8 | 20.9 | 21.9 | 12.1 | Bokhtiar and Sakurai, 2005 [17] |
| 8 | Cauliflower | 11.9 | 22.1 | 9.14 | 22.6 | Chahal *et al.* 2019 [21] |
| 9 | Rice-wheat cropping system | 15.2 | 57.9 | 23.0 | 50.1 | Walia *et al.* 2010 [109] |
| | | 10.1 | 15.4 | 8.1 | 12.2 | Bahadur *et al.* 2012 [117] |

The impact of INM on onion soil parameters was investigated by Sharma *et al*. (2017) [92]. They showed that the pH of the soil did not significantly shift in response to the treatments. The soil's pH was between 6 and 6.4. Both 20 t ha-1 FYM + NPK (150-100-75 kg ha-1) and 10 t ha-1 FYM + mustard oil cakes (1 t ha-1) + NPK produced the greatest SOC values (125-100-100 kg ha-1). The effects of organic manures and chemical fertilizers on soil characteristics of a maize crop were compared in a field research conducted by Desta (2015) [28] in Chilga's Antra watershed. He claimed that increasing the soil's pH, organic carbon, and cation exchange capacity with a combination of organic and inorganic fertilizers was more effective than either alone.

Adeniyan *et al*. (2011) [2] conducted a pot experiment to determine the efficacy of combining various organic manures with NPK fertilizers on soil chemical characteristics. They found that by applying cow dung, the pH level went increased from 5.08 (an acidic level) to 6.30 (a basic level). Cane rat feces treatment also increased organic carbon (1.96%) and cation exchange capacity (3.10 cmol (p+) $kg^{-1}$) compared to NPK alone. Brar *et al* in 2007 showed an improvement in the soil organic carbon build-up with integrated use of nutrients as shown in Fig. 2. Soil nutrient status was studied by Parvathi *et al*. (2013) [77] at Regional Agricultural Research Station, Andhra Pradesh, between 1981 and 2011 while groundnuts were grown in large quantities. Soil pH was greatest (5.57), and organic carbon content was highest (when FYM was applied at 5 t $ha^{-1}$ once every 3 years) (0.40 percent). NPK + Gypsum + ZnSO4 also produced the highest EC (0.07 dS $m^{-1}$) of any treatment. In Kharif 2007, Sunitha *et al*. conducted a field test at the Agricultural Research Station in Honnavile, Shivmoga. The pH of the soil was observed to decrease after being treated with 100% N. The highest cation exchange capacity ever measured was 8.99 cmol (p+) $kg^{-1}$. The impact of INM on soil was studied by Jat and Singh (2017) [48] at the Agricultural Research Farm at Banaras Hindu University in Varanasi. In the range of 7.93 and 8.32, soil pH was measured. (70 percent RDF + 30 percent N by pressmud) (control). Organic carbon content at 0.48 percent and CEC at 10.17 cmol (p+) $kg^{-1}$ were significantly higher after treatment with 70% RDF + 15% N through FYM + 15% N via pressmud.

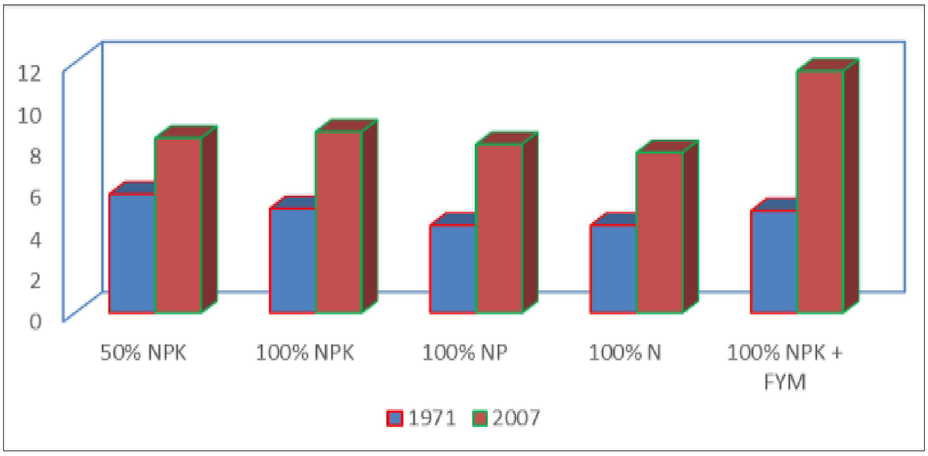


**Fig 2:** Integrated nutrient management effect on soil organic carbon Build-up (Mg ha$^{-1}$) (Brar *et al.* 2007)

### 7.2 Biological possessions of Soils

Bahadur *et al.* (2012) [117] investigated the effect of INM on the microbiome of a rice-wheat cropping system. After being treated with 100% NPK + FYM @ 5t ha-1 + Azotobacter, the populations of total bacteria (79*105 cfu g-1 soil), azotobacter (45*105 cfu g-1 soil), PSB (35*102 cfu g-1 soil), and actinomycetes (18*105 cfu g-1 soil) were found to have increased, whereas they were lower in the control group. The impact of using organic manures in addition to chemical fertilizers on soil microorganisms was investigated in an experiment done by Kumar *et al.* (2017) [56]. The use of organic manures was said to have a major impact on the microbial population. An integrated application of nitrogen sources was associated with a bacterial abundance (8.24 log cfu g$^{-1}$ soil) and a fungal abundance (3.89 log cfu g$^{-1}$ soil). Kour *et al.* (2019) [54] detailed how integrated nutrient management affected the microbial community in aonla planting. Bacterial counts ranged from 11105 cfu (with 100% N from fertilizers) to 13105 cfu (with 100% N from FYM), while fungal counts ranged from 9.7105 cfu (with 100% N from fertilizers) to 24.9105 cfu (with 100% N from FYM) (100 percent N through FYM). According to Kuttimani *et al.* (2017) [58], integrated nutrient management greatly impacted the fungal, bacterial, and actinomycetes population under the irrigated banana. The microbial population was observed to expand as the banana crop matured, as evidenced by data collected 3 and 5 months after planting. A greater number of bacteria (37.01*105 g$^{-1}$), fungi (20.86*103 g$^{-1}$), and actinomycetes (24.82*102 g$^{-1}$) were found in soil treated with the full RDF + FYM.

The impact of INM on soil parameters in a cotton-chickpea crop rotation was studied by Gudadhe *et al.* (2015) [42] found that the highest numbers of cfu g$^{-1}$ soil for bacteria, fungus, and actinomycetes, respectively, fell in the ranges of 20.20–36.30. The treatment consisting of 10t of both FYM and RDF yielded the highest microbial abundance in the soil. The impact of fertilizer management on soil biological characteristics was studied by Khan *et al.* (2017) [53] and they reported that when organic manures were spread across a field, the microbial population exploded. The greatest concentrations of bacteria (68.66*105 cfu g$^{-1}$ soil), fungi (71.33*105 cfu g$^{-1}$ soil), and actinomycetes (57.33*105 cfu g$^{-1}$ soil) were found in the soil that was treated with 75% NPK + 25% N via FYM. The impact of INM on sapota soil characteristics was recently shown by Meena *et al.* (2019) [68]. They discovered that the treatment consisting of two thirds of the recommended NPK plus 10 kg vermicompost plus 250g azospirillium plus 250g azotobacter plant$^{-1}$ was equivalent to the treatment consisting of half of the recommended RDF plus 250g azospirillium plus 250g azotobacter plant$^{-1}$ in terms of the increase in microbial population (fungi and bacteria) from 2013 to 2014. In a long-term experiment, Vineela *et al.* (2008) [108] showed how different crops and fertilizer management strategies affected soil microbes. They reported that under the treatment consisting of fertilizers administration on the basis of soil inherent fertility via chemical fertilizers and FYM at 5 t ha$^{-1}$, bacterial population was 85.2% higher than in the control, while the fungal and actinomycetes populations were 6.9% and 13.9% higher, respectively.

### 7.3 Growth of agricultural crops

Ahmad *et al.* (2014) [4] tested how farmyard, leaf, poultry, and chemical fertilizers influenced carrot growth and yield. Plant height (39.98 cm) and root length (21 cm) were maximum when chicken and farmyard manure supplied nitrogen need (22.42 cm and 11.25 cm). Shree *et al.* (2014) [95] examined cauliflower's response to organic and synthetic fertilizers. 1/2 NPK + FYM @ 5 t ha-1 + vermicompost @ 2 t ha-1 + Azospirillum yielded the most (252.48 q ha-1). 235.71 q ha-1 from RDF plots. Organic ingredients help cauliflower, according to Prabhakar *et al.* (2015). Fertilizers made the most curd (21.23 t ha-1). Manohar *et al.* (2013) [65] discovered FYM @ 20 t ha-1 produced the most (359.24 q ha-1). 20 t ha-1 FYM produced the tallest plant (60.98 cm) and most main branches (6.79). Malik *et al.* (2011) [64] evaluated sweet pepper development using inorganic fertilizers and organic manures (*Capsicum annuum* L.). Inorganic fertilizers and FYM @ 40 t ha-1 produced a maximum number of fruits per plant (20.45 and 19.00), fruit length (8.40 and 8.20 cm), fruit diameter (8.09 and 7.70 cm), average fruit weight (94.85 and 93 g), and average fruit yield/plot (38.79 kg and 35.34 kg).

Chaudhary *et al.* (2018) [23] evaluated cabbage growth and yield under INM. 100% RDF generated the longest head (17.5 cm) and diameter (14.7 cm). However, 50 percent N as mineral fertilizers + 50 percent FYM-treated plots had the maximum head weight (1176.7 g) and yield (470.7 q ha-1). Mohanta *et al.* (2018) [71] discovered that 50% NPK fertilizers + FYM @ 10 t ha-1 improved broccoli plant height (54.68 cm) and head diameter (13.83 cm). 50% NPK + vermicompost @ 2.5 t ha-1 had the maximum gross yield (233.56 q ha-1). Prativa and Bhattarai (2011) [80] reported the greatest plant height (116.16 cm), fruit weight (52.80 g), and yield (16.66 Mt ha-1 FYM + 8.33 Mt vermicompost + NPK) (25.74 Mt ha-1). Kumar (2016) [118] observed that 50% RDF and vermicompost at 5 t ha-1 provided the maximum plant height (1.66 m), dry weight (0.10 kg), and yield/plant (6.10 kg).

Kumar and Biradar (2017) [55] tested how integrated nutrition management affects broccoli productivity at Main Agriculture Research Station, University of Agricultural Sciences, Dharwad. Maximum plant height (35.4 cm), plant spread (83.4 cm2), stalk length (23.4 cm), cotton and green gram intercropped to integrated nutrient approach. They reported maximum available nutrients *viz*. N, P and K with 50% N from inorganic fertilizers, 50% from FYM, and 100% $P_2O_5$ fertilizer. Deshmukh *et al*. (2005) [27] found the maximum absorption of N, P, and K and accessible N, P, and K with FYM and recommended fertilizers. Devi *et al*. (2018) [29] studied the effects of integrated nutrient management on soil nutrient status and cauliflower growth and production in a field experiment. They found that applying 130 percent NPK (50:50 FYM and VC as per N content) greatly improved the available N (406.55 kg $ha^{-1}$), P (69.20 kg $ha^{-1}$), K (309.35 kg $ha^{-1}$) and S. (59.20 kg $ha^{-1}$). Devi *et al*. (2017) [30] examined cauliflower's characteristics and nutrition absorption using integrated nutrient management. Under the 130 percent NPK treatment, N, P, and K uptake were greater (64.57, 9.91, and 50.77 kg $ha^{-1}$). Kumari *et al*. (2017) [57] investigated rice-wheat soil fertility and integrated nutrient management with 50 percent recommended fertilizers + 50 percent N through FYM gave the maximum organic carbon and available nutrients. Priyanka *et al*. (2013) [81] examined rice's response to integrated nutrition management at CSKHPKV's Research Farm in Palampur, Himachal Pradesh. The experiment used 75 percent RDF + FYM + Vermicompost (1:1) to produce potential growth and yield parameters of rice.

### 7.4 Nutrient approval

Chandel *et al*. (2017) [22] tested three fertilization levels of RDF doses *viz*. 0, 50, and 100% where chief FYM treatment to the tune of (200 qt $ha^{-1}$) increased rice grain N and straw K, but not P, possibly because FYM slowly releases phosphorus. Phullan *et al*. (2017) [78] discovered that FYM boosted wheat crop N absorption by 14%, whereas full-dosage inorganic fertilizers increased N uptake by 81%. Inorganic fertilizers increased P and K uptake by 66% and 56%, respectively, compared to controls.

## 8. Conclusion

Farmyard manure improves soil health and plant development, as seen above. Organic amendments boost soil carbon. Organic colloids from FYM-incorporated soil organic matter provide several nutrient exchange sites. Organic matter helps soil nutrients chelate. Farmyard manure in fields bioremediates heavy metals, insecticides, and herbicides cost-effectively. Organic manure has several benefits in a world where chemical fertilizers dominate agriculture and threatens the ecological equilibrium. Farmyard manure's cost-effectiveness and efficiency must be communicated to farmers.

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