The Pharma Innovation Journal 2022; 11(3): 685-691

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(3): 685-691

www.thepharmajournal.com
Received: 02-12-2021
Accepted: 07-01-2022

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# A review on integrated nutrient management and its effect on mungbean (*Vigna radiata* L. Wilczek)

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**Abstract**

**Background:** Through this review article focusing on the various parameters towards the nutritive management along with integrated cropping system in agricultural sciences in mung beans. There are several beneficial aspects of conventional along with modern methods of nutritive management towards the support of farming system in agricultural sciences.

**Methodology:** all these review were done by different database like Google scholar by selecting a different journals with some keywords like integrated system in mung beans, nutritional approach towards the mung beans.

**Conclusion:** Through this review it concluded that integrated cropping system along with some nutritive management develop the farming system in aspects of high yielding, growth parameter of whole plants by several new techniques and methods.

**Keywords:** Integrated cropping, nutritive management, high yielding

## Introduction

The consumption of a protein deficit diet among the growing population is a serious threat in developing countries like India. The protein deficiency leads to several disorders such as malnutrition, kwashiorkor that are frequently observed in present days within the populations particularly among children. In addition, continuously decreasing soil fertility around the globe raises serious concerns about sustainable food production. According to nutritionists, pulses are an exceptional source of dietary proteins and thus, can play an important role in satisfying the needs of an exponentially increasing population.

Mungbean (*Vigna radiata* L. Wilczek) is one of the widely cultivated, protein-rich crops belonging to the leguminous family. Mungbean is a rich source of protein (21-24 g), carbohydrates (56.72 g), fiber (4.11 g), fat (1.31 g), minerals (3.48 g) such as calcium (124 mg), phosphorous (326 mg), iron (4.42 mg) and supplies a good amount of energy (334 kcal) (Gopalan *et al*., 2002; Dhakal *et al*., 2015) [1]. The crop is increasingly adopted by farmers due to its short duration nature which makes it suitable for intensive crop rotation. Despite nutritional benefits, it helps in reducing soil erosion; enhance soil fertility status through atmospheric nitrogen fixation (Bansal, 2009) [2]. Thus, it considerably helps in improving the yield of subsequently grown crops (Jat *et al*., 2012) [3]. The green portions of the plant are also used as fodder due to their easy digestibility, palatability, and taste (Kumawat *et al*., 2009) [4].

Mungbean is widely cultivated on large scale in South Asian nations such as India, Pakistan, Bangladesh, Sri Lanka, Thailand, Laos, Taiwan South China, and Malaysia. In India, during last year (2019-20) crop was cultivated over an area of 4580.54 million hectares with a production of 2508.87 million tonnes and productivity 547.72 kg/ha (Anonymous, 2019-20) [5]. However, the productivity of crops in the USA and Canada (1900Kg/hectare) is far ahead of the country's productivity (GOI, 2015) [6]. The crop is ranked third among the pulse crop in terms of production and opted in all three seasons i.e., *kharif*, *rabi*, and *zaid* by farmers. The leading states in mungbean production are Rajasthan (more than 50% production) followed by Madhya Pradesh, Karnataka, Bihar, Gujarat, and Maharashtra.

Micronutrients are highly essential for the proper growth and development of any crop and both quantitative (seed yield) as well as qualitative (nutritional quality) characters are highly influenced by soil's micronutrient status (Babaeian *et al*. 2011, Meena *et al*. 2013) [7]. In India, most legume crops including mungbean are cultivated in less fertile, poor, and marginal soils, and in addition low supply of organic and inorganic frequently affects the final yield (Kumawat *et al*., 2010) [8]. In addition, the cultivation of crops on problematic soils such as acidic and alkaline soils is estimated to affect more than 50% of the world's yield potential.

On the other hand, excess and improper use of inorganic fertilizers without knowledge of integrated nutrient management further aggravates the lower production and also drastically affects the healthy soil environment (Bradl 2004) [9]. In recent years, different approaches have been practiced to sustain agriculture production and among them, integrated use of available nutrient resources is the most promising approach. The balanced use of nutrients along with efficient crop, water, soil, and land management will be crucial for agriculture in the coming days. By keeping in view the changing climate scenario, an integrated approach of nutrient application along with biofertilizers and manures not only ensures improved soil health and but also sustains crop productivity (Babulkar, 2000) [10]. However, reports on integrated nutrient management are lacking in many crops including summer mungbean. Therefore, through this review chapter, an attempt has been made to present an overview of work carried out to study the effect of integrated nutrient management practices on the growth and yield of summer mungbean.

**The theory of INM**

Firstly, The INM refers to a broach approach where the benefits from all the conventional (organic, inorganic and biological originated components) along with modern methods of nutrient management collectively directed to supports the optimal farming system in a highly integrated, effective and judicious manner (Janssen, 1993) [11]. The INM enhance the utilization of the all features of nutrient cycling (macro and micro nutrients) and aims to synchronize nutrient requirement by the growing crop. INM also aims to highly efficient nutrient use by minimizing the nutrient losses through leaching, volatilization, surface runoff, immobilization and emission (Zhang *et al*., 2012) [12]. Furthermore, INM also targeted to minimize the land deteoration and improved yield potential by optimizing the soil factors (physical, chemical, and biological) in a well manner (Janssen, 1993; Esilaba *et al*., 2004) [13]. In a broad sense, INM includes the use of crop residues, natural and inorganic fertilizers, farmyard manure, biological agents, soil amendments, green manures, crop rotations, cover crops, intercropping, conservation tillage, irrigation and drainage to conserve available water and enhance nutrient availability to crops (Janssen, 1993) [14]. So, these kinds of practices are help farmers to aim on long term planning in place of only focusing on large yield benefits.

**Components of INM**

Integrated nutrient management (INM) involves the use of manures, chemical fertilizers and biological agent achieve sustainable crop production and improved soil health. Various components (organic and inorganic) are considered as major components of integrated nutrient management and all these components ultimately restore the soil fertility and enhance the crop production. The components such as (i) use of organic manures of different nature *viz*., vermicompost, compost, FYM, poultry manure, slurry, Phospho-compost, Press mud cakes, biogas, Biological composts, (ii) balanced application of fertilizers according to the crop requirement and targeted yields (iii) use of biological agents (iv) inclusion of green manure and legume crops to restore the soil fertility (iv) crop residues recycling (v) use of highly efficient genotypes.

**Effect of INM on morpho-physiological characters of mungbean**

Several literatures highlight the promotive role of different INM components on growth and developmental parameters. The findings of various researchers who have been work previously on mungbean suggested that the supply of nutrients (macro and micro) through various components significantly enhances the growth and developmental traits. In this regards, Soodi *et al.* (1994) found that the application of 25 kg N/ha alone and/or along with 50 kg $P_2O_5$/ha increases the number of nodules and dry weight of nodules per plant. Similarly, Mathur *et al*. (2007) [15] also suggested that the treatment with N and P alone or in combination significantly enhanced plant height and number of branches per plant. The reports of Sharma *et al*. (2003) [16] suggested that physiological parameters *viz*., crop growth rate, relative growth rate, photosynthetic efficiency were enhanced with the increasing rates of N and P.

Combined application of organic, inorganic fertilizers with biofertilizers was found synergistic and has an additative effect in enhancing the growth parameters of mungbean (Prajapati *et al*., 2016; Singh *et al*. 2017) [17]. The application of vermicompost at 2.5 t/ha along with Recommended fertilizers dosage (RDF) increased the growth parameters *viz*., plant height, dry matter and root weight (Rajkhowa *et al*., 2002) [18]. Tarafder *et al*., (2020) [18] found that plant height, branches/plant was highest when treated with 3 t $ha^{-1}$ poultry manure (PM) and 70% soil test based (STB) inorganic fertilizers. In similar direction, reports of Singh *et al*., (2017) [19] clearly indicated that the application of RDF and VC at 5.0 t/ha rate increases plant height, number of branches/plant, plant dry weight, number of nodules and dry weight of nodule when compare to RDF application alone. Identitical results also presented by Prajapati *et al* (2016) [20] who suggested that integration of 100% RDF with Vermicompost (1.0 t/ha) with Rhizobium improves the morphological traits such as plant height, number of primary branches/plant, total dry matter accumulation, and maximum leaf area index. Another finding from Dhakal *et al*., (2015) [21] suggested that the treatment with 75% RDF with vermicompost (VC) and bio-fertilizers (Rhizobium and phosphorus solubilizing bacteria) caused a significant increase in leaf area index, number of trifoliate, SPAD value of chlorophyll, and enhance the dry matter accumulation. The results from study conducted by Verma *et al*., (2017) [22] indicated that the application of Rhizobium along with phosphorus solubilizing bacteria (PSB) and 20 kg N/ha was ensures significantly higher number of nodules and dry weight of nodules/plant. The findings of Choudhary *et al* (2011) [23] and Tiwari *et al* (2011) were also leads to identical conclusions [24].

The application of biofertilizers (organic manure) with inorganic fertilizers and micronutrients is increased the availability of nutrients over a long period. The collective application of organic and inorganic fertilizers ensures balanced supply of nutrients to the growing crop and exerts a positive effect on growth of the plant (Afzal and Bano, 2008) [25]. Alongside, addition of Mo attributed to better availability and absorption of nutrients; whereas Co application improved the nodulation and maximizes the population of Rhizobia in the rhizosphere (Jena *et al*, 1994) [26].

Not only the soil application but seed inoculation with biofertilizers (Rhizobium and PSB) + micronutrient (Mo and Co) along with maintenance of fertility levels were also proven to be promotive in enhancing the growth and development of mungbean. As per Singh and Pareek (2003) [27] in a field experiment found that combined seed inoculation with PSB + Rhizobium significantly increased the plant height, branches per plant, dry matter, number and dry weight of nodules per plant in mungbean over control and inoculation with either PSB or Rhizobium. In addition, finding of Kumar *et al*., (2003) [28] revealed that vermicompost at the rate of 5 t/ha along with RDF maximizes the plant height and dry matter accumulation. The combined application of N, P, and biofertilizers played a crucial role in plant processes such as starch cell division, increased sugar utilization, and rate of photosynthesis. Furthermore at root levels, the growth of root system enhanced, thus a larger root surface area allow severe rhizobium infection and proliferation. Increased colonies of rhizobium with the root leads to formation of higher number of nodules that further contributed to increased N fixation and plant growth (Kumawat *et al*., 2009; Singh *et al*., 2013; Verma *et al*. 2017). [29]

**Yield attributes and yield**

Grain yield of mung bean crop is a function of cumulative effect of various yield components, which are influenced by genetic make-up of variety, various agronomic practices and environmental conditions. The various findings suggested that the management of nutrients in an integrated manner improved both yield attributing traits and final yield of mung bean. In this regard, study carried out by Sheoran *et al.*, (2008) [30] under rainfed condition indicated that the supply of 12.5 kg N + 40 kg P2O5/ha to mungbean leads to an increased in seed yield by 4.3 per cent over no fertilizer application. Similar to this, Kumar *et al*., (2003) [31] reported that vermicompost at 5 t/ha gave almost 16-17% higher seed yield in mungbean compared to control. In another study, Malik *et al*. (2003) [32] tested different levels of N (0, 25 and 50 kg/ha) and phosphorus (0, 50, 75 and 100 kg/ha) and concluded that the combined application of 25 kg N + 75 kg $P_2O_5$/ha results in the higher seed yield. The experiment conducted by Sharma *et al*. (2003) [33] revealed that the increasing rates of N and P up to 20 and 60 kg/ha respectively, increased the seed yield in mungbean. Nadeem *et al*., (2004) [34] opined that application of 30 kg N/ha with combination of 60 kg $P_2O_5$/ha significantly recorded higher seed yield. Mathur *et al*. (2007) [35] tested two fertility combinations (10+20 and 20+40 kg N + P2O5 /ha) and found that with the increasing fertility levels from 10 + 20 to 20 +40 kg N + $P_2O_5$/ha the yield contributing traits such as pods per plant, number of seeds per pod, 100-seed weight, and biomass per plant improved by around 25.6%, 21.3%, 7.3%, and 15.5% respectively. Furthermore, Sheoran *et al*., (2008) [36] carried out an experiment under rainfed conditions and revealed that the mungbean seed yield increased by almost 4.3% when supplied with 12.5 kg N + 40 kg P2O5/ha in compared to control.

The cumulative effect might be due to supply of nitrogen and phosphorus to the crop and also increased solubilization of mineral phosphates and other nutrients (Tanwar, 1997; Kumar *et al*., 2010; Kumar and Kumawat 2014; Verma *et al*., 2017) [37]. The enhanced nodulation and improved nitrogen fixation by plant might have also increased the seed yield due to the better nutritional environment during crop period. Due to the phosphorus supplying might have stimulated at the rate of various physiological process favoring increased growth and yield attributes and finally the yield. Thus, it appears that the increase in seed yield owing to application of phosphorus was resulted of cumulative effect of improved growth and yield attributes. This results obtained are in close conformity with those of Moolani *et al*., (2006) [38], Kumawat *et al*., (2009a) [39], Panwar *et al*., (2012) [40] and Bhanwariya *et al*., (2013) [41].

Seed inoculation with biofertilizers and micronutrient are also equally effective as soil application and known to improve the seed yield in mungbean. In this direction, Singh *et al*., (2017) [42] inoculated mungbean seeds with RDF+VC (5 t/ha) and recorded significantly improvements not only yield attributing traits such as number of pods/plant, pod length, number of grains/pod and but also final seed yield. Singh and Pareek (2003) [43] reported that the maximum number of pods per plant, pod length, test weight and number of seeds per pod in mungbean were recorded due to seed inoculation with PSB + Rhizobium over their individual inoculation. In a field experiment conducted by Mian *et al*., (2005) [44] compare the effects of different nitrogenous fertilizer and bio-fertilizers on the yield of mungbean (*Vigna radiata* L.), the seed inoculation with bio-fertilizers significantly increased grain, stover and biological yield.

The combination of organic and inorganic nutrition provides better soil environment for root growth, nodule formation, nitrogen fixation, increased solublization of native P, availability and absorption of nutrient from soil that collectively attributed to higher seed yields in mungbean (Singh *et al*., 2017) [45]. Tarafder *et al*., (2020) [46] reported that yield contributing traits such as pods/plant, number of seeds/pod, 100-seed weight, final seed yield of mungbean were improved upon application of 3 t $ha^{-1}$ poultry manure (PM) and 70% soil test based (STB) inorganic fertilizers. More conclusive evidences came from study conducted by Dhakal *et al*., (2015) [47] who applied 75% RDF + 2.5 t/ha VC + biofertilizers (Rh + PSB at rate of 12.34 q /ha) and reported an improved seed, straw, biological yield and harvest index. In another experiment Singh *et al*., (2015) [48] also reported parallel results. Further, Verma *et al*., (2017) [49] in his study showed that yield attributes such as number of pods/plant, pod length, number of seeds/pod, seed yield/plant and test weight could be enhanced with the application of Rhizobium + PSB + 60 kg P2O5/ha. In another study carried out by Prajapati *et al* (2016) [50] it was observed that the application of 100% RDF + Vermicompost @ 1.0 t/ha + Rhizobium enhances the number of pods/plant, number of seeds/pod, 1000-seed weight, and final seed yield.

The combined application of NPK along with VC and biofertilizers improved the nutrient absorption from deeper layer of soils that ultimately contributed towards increased rate of photosynthesis, translocation and accumulation of photosynthate in the economic sinks. These enhanced physiological activities finally results in increased grain, straw and biological yields (Dhakal *et al*., 2015) [51]. Besides this, the synergistic effect of Rhizobium and PSB also contributed to increased growth, yield attributes which might be due to increased nitrogenous activity, in turn supplied more nitrogen by fixation and more access to available phosphorus of soil (Dhakal *et al*., 2015) [52]. On the other hand, micronutrients also played a crucial role in enhancing the final seed yield of mungbean. For example, molybdenum is an important constituent of nitrogenase enzyme; hence, additional supply of Mo results in increased activity of nitrogenase enzyme that in turn enhance N fixation through bacteria. Higher N fixation is directly correlated with better plant growth and improved seed yield at final growth stages (Biswas *et al* 2009; Biyan *et al*, 2014; Singh *et al*., 2015) [53]. Similarly, cobalt application has been attributed to promotion of many developmental processes such as stem and coleoptiles elongation, opening of hypostyle hooks, leaf disc expansion and bud development (Ibrahim *et al*, 1989; Singh *et al*., 2015) [54]. Some other reports explained that inoculation with dual (Rhizobium + PSB) leads to higher production of growth hormones such as auxins, gibberellins and cytokinin which attributed to improve plant growth and stimulate the microbial development (Verma *et al*., 2017).

**Nutrient content, uptake and quality**

The nutritional aspects like protein content, increased uptake of nutrients can also be improved with the optimal management of nutrients. In this regards, the findings of Singh *et al*. (2017) [55] revealed that different fertility levels along with biofertilizers positively influence the protein content, protein yield and uptake of nutrients. The application of RDF, along with VC (5 t/ha) gave highest protein content (25.2%) and protein yield (107.6 kg/ha). In addition, Malik *et al*., studied the different dosage of nitrogen (0, 25 and 50 kg/ha) and phosphorus (0, 50, 75 and 100 kg/ha) and found that the highest protein content (25.6%) was obtained when crop supplied with 50 kg N + 75 kg $P_2O_5$/ha.

The results presented by Singh *et al*., (2017) [56] showed that treatment with RDF+ VC at 5 t/ha rate is highly effective in enhancing the nutrient uptake (Nitrogen, phosphorus, and potassium) uptake by crop. The N, P and K uptake by mungbean was also significantly higher when supplied with micronutrients *viz*., Mo and Co. Similar to this, another study carried out by Rajkhowa *et al*. (2003) [57] on mungbean suggested that the application of vermicompost at 2.5 t/ha + 100% RDF was significantly improved the organic carbon, available N, P and K status of soil. The application of micronutrients such as Mo and Co were also found promotive in increasing the protein content and protein yield (Khan *et al* 2002; Jain *et al* 2007; Singh *et al*., 2017) [58]. Alongside, Tarafder *et al*., (2020) [59] found that the soil total N, available P, exchangeable K, Ca, Mg, and available S, Zn, Fe, Cu and B were increased with the increased levels of organic manures. The highest values of these parameters were obtained with the application of 3 t $ha^{-1}$ poultry manure + 70% soil test base (STB) inorganic fertilizer, and 3 t $ha^{-1}$ vermicompost + 70% STB. Singh and Pareek (2003) [60] inoculated mungbean seeds and reported that application with PSB and Rhizobium not only increased the N and P content in seed but also enhance the protein content in compared to sole inoculation.

The increased uptake with the application of biofertilizers and micronutrients might be due to enhanced effect of Rhizobium in nitrogen supply (Bhattacharyya and Pal, 2001) [61]. The increased uptake of P by phosphobacteria (Bacillus) could be attributed to its greater P-solubilization potentiality in the presence of organic matter. Organic fertilizer provides significant cation exchange capacity to hold cations such as K+. The change in cation exchange capacity of organics by acidification might have enhanced K availability (Kumar *et al*, 2009 and Jat *et al*, 2011) [62]. Besides this, addition of different organic manures imparts in decreasing the soil acidity Organic residues (either plant or animal based) especially poultry manure and vermicompost when applied to soil releases organic anions which in turn neutralizes the hydrogen ion of acid soil (Wang *et al*., 2013) [63]; Tarafder *et al*., 2020) [64].

**Strategies for further development of INM**

The number of advantages that INM practices can bring to farmers and the environmental benefits are remarkable. By reviewing numerous research reports, here we have synthesized some strategies and recent opportunities that can be accessed and further enhanced by modification and adjustments in the adoption of site-specific INM practices. Future strategic development of INM under following points (i) combination of soil and plant analysis (ii) fine-tuned to the local environmental conditions (iii) mechanization due to serious labor shortage (iv) conservation tillage and rainwater-harvesting technologies (v) recycling of organic nutrient flows (vi) new technological innovations, and (vii) appropriate policy interventions.

**Conclusion**

Integrated use of organic, inorganic and biological sources of nutrients may be suggested for higher yield along with overall betterment of summer mungbean crop. Based on the findings of the present study, it was observed that different treatments influenced significantly in respect to yield, yield contributing and quality characters. The above studies show that bioinorganic combinations have their own roles play to higher productivity, not only solely supply all the nutrients to the soils but also create favorable conditions for betters growth to producing crop. Increased growth, yield and nutrient parameters of mung bean in this study, this may be associated with the supply of essential nutrients by continuous mineralization of organic manures, enhanced inherent nutrient supplying capacity of the soil and its favorable effect on soil physical and biological properties to better yield.

**Way forward**

The practice of INM includes all possible sources of plant nutrients to optimize nutrient inputs, spatial and temporal matching of the soil nutrient supply with crop demand and reducing N losses while improving crop yield. Interaction of agricultural inputs leads to increases in crop productivity while substantially reducing nitrogen losses and green house gas emissions, judicious application of mineral and organic fertilization with higher resource-use efficiency, enhance the soil-plant-microbes-environmental sustainability. Balanced use of organic manures will be of fundamental importance for crop productivity and environmental concerns, which should be a priority for INM practices, provides a "win–win" opportunity to simultaneously increase crop productivity and agricultural sustainability.

**Acknowledgement**

I thankful to My Research guide G.S Bhatnagar sir Professor in Department of Agronomy, Agriculture University and also Research advisor, CPU (Career Point University), Kota for given this platform for completing this review research paper.

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