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A review: Effect of some macronutrient fertilizers application on the growth and yield of moong bean

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Abstract
Among the pulse crop, moong bean [*Vigna radiata*] is one of the important edible beans in the human diet. Limitation in the production of moong bean in India indicates a lot of factor like lack of proper irrigation, soil texture, suitable climate and soil fertility status. According to criteria of essentiality of nutrient, all the plant nutrients are equally important for the proper growth and development of crop. Among all the factors, fertilizer application also plays important role the adequate production. This review paper focuses on the importance of some macronutrient fertilizer applications and its response to moong bean crop in terms of grain yield and other growth parameters. Nitrogen, phosphorus, potassium and Sulphur fertilization in insufficient or unbalanced levels can impede or restrict a plant's ability to grow, develop, and produce. Legume crops can meet 80–90% of their nitrogen requirements from biological nitrogen fixation process. The most important way to increasing moong bean production and quality is nutrient management and it is one of the substantial pulse crops that require little input. It provides food and fodder and is crucial for preserving the fertility of the soil.

Keywords: Fertilizers, nitrogen, phosphorus, sulphur, grain yield

Introduction
Moong bean is a legume and a short-duration crop grown across Asia for its edible seeds and sprouts. Pulses are essential to many international culinary traditions and, in many nations, they are a pillar of food and nutritional security. In the semi-arid and waterless portions of the country, it is largely farmed for food and fodder by marginal farmers with minimal resources. (Bilal *et al.,* 2021) [21]. In Asia, one of the conventional food is soy which is generally eaten by Japanese and Chinese people, is moong beans, also known as Lu Dou (Shahrajabian 2019) [88]. Moong bean contains very low oligosaccharides (sugars influence flatulence) (Ihsan *et al.,* 2013) [40] and it is high in proteins (24.8 percent), carbohydrates (0.6 percent), and minerals (3.48 grams). It also accommodates 75 milligrams of calcium, 8.5 milligrams of Fe, and 49 milligrams of β-carotene (Afzal *et al.,* 2004) [3]. These are easily digestible food that can be given to nursing babies or people suffering from malnutrition (Suneja *et al.,* 2011) [100]. Nutritionists claim that legumes are an exceptional source of enriched protein and it can be very helpful in meeting the demands of a rapidly expanding population (Tomar *et al.,* 2022) [105]. It is consumed as cooking, flour, and sprouts, and thus serves as a dominant protein source in the diet. There has been an increase in nutritional awareness among consumers, as well as a need for health-beneficial value-added products (Arnoldi *et al.,* 2015) [11]. The sustainability of dryland systems may be improved by moong-bean integration in cropping systems, particularly in South Asia (Pataczek *et al.,* 2018) [78]. The integration of moong in various cropping systems could improve the nutritional value by supplying requisite nutrients so that aiding in the alleviation of nutritional-related health disorders (Tomar *et al.,* 2022) [105]. Moong bean can be used for improving planting patterns due to its early maturity and quick growth. It can be fixed as an intercrop, catch crop, and also in rotation with cereals (Baza *et al.,* 2022) [88]. Recently in China, moong bean has been intercropped with many crops like pearl millet, cotton, and oats (Liang *et al.,* 2011) for better production (Gong *et al.,* 2022) [113]. Moong bean is known as "green pearls" in China (Wang *et al.,* 2021) [108]. Due to its high biomass production, moong can be used for both grain and forage purposes. It thrives in rain-fed areas because it is resistant to drought and withstands harsh environmental conditions (Anjum *et al.,* 2006). Due to the high nutritive value of moong bean, easy digestibility, and palatability, the plant's green parts are also used as fodder (Tomar *et al.,* 2022) [105]. Moong bean sprouts are abundant in vitamin C and folate and are widely used in Asian cooking.

Dotaniya (2019) asserts that the issue of food security is made worse by the rapid population growth and low output, notably for pulses. Studies indicate that rice is the main crop in India, and as a result of the land, pulses production has decreased. (Singh *et al.*, 2013; Mohbe *et al.*, 2015) [96, 65].
Mahmood and Athar, (2008) [58] and thus minimizing the need for chemical fertilizers on farms (Mohan *et al.*, 2020) [64]. According to Shahrajabian (2019) [8], the factors that intent the symbiotic process are plants, environment, bacteria and processes like pesticide and fertilizer. Modern inorganic fertilizers comprise more than one element that are most important in plant nutrition i.e. NPK along with secondary elements like sulphur, calcium and magnesium. Fertilizers are adjunct in the soil to enhance the growth of plant and production. Nitrogen, phosphorus, and potassium are essential elements that play leading roles in its vegetative growth, development, and yield, as potassium is crucial for photosynthesis, enzyme activity, protein synthesis, pest attack, and disease (Hussain *et al.*, 2011) [39].
Nutrient management has a remarkable impact on moong bean production (Muhammad *et al.*, 2014) [1]. According to Sadeghipour *et al.*, (2010) [86] and Yin *et al.*, (2018) [111], the proper application of fertilizers are of massive significance in crop growth parameters and productivity. Excessive use of fertilizer application has affected the agricultural product quality by releasing greenhouse gases and eutrophication, further affecting soil microecology, and enhancing soil-borne diseases by increasing salt concentration which can kill beneficial soil microorganisms (Jain *et al.*, 2007) [41]. According to Veresoglou *et al.*, (2013) [107], by applying nitrogen is higher than the recommended dose, the disease incidence and severity increase due to the crop canopy effect. Similarly, in case of phosphorous, application above the recommended dose, the pest and disease problems increased up to 28%. However, as a result of poor and imbalanced macronutrients, the growth and development of moong bean have been severely hampered and causing results in declined yield and deteriorated quality (Asaduzzaman *et al.*, 2008) [112]. Due to the various roles of nitrogen in plant physiology, biosynthesis of metabolites, and soil dynamics, it is a vital mineral whose nutritional management considers for special attention (Baza *et al.*, 2022) [88]. Phosphorus fertilizer incentivizes disease resistance, and drought tolerance, and improves seedlings' ability to absorb nutrients and water. Sulphur improves grain quality, and nutritional value and increases crop yields (Vaishali *et al.*, 2020) [106]. It also encourages nodulation in legumes through N- fixation in the atmosphere (Singh *et al.*, 2017) [95]. The reason for depletion of Sulphur from Indian soils are extensive use of high-analysis of macronutrient, heavy mining of sulphur through the removal of crops and fertilizers which are free of sulphur and are associated with leaching losses. Sulphur deficits have been reported across the nation, mostly as a result of intensive farming practices, increased crop yields, and a sudden switch from low to high-analysis fertilizers that contain low elemental S.
In India, moong beans are typically produced in poor, marginal soils that are less fertile, and as a result, the ultimate yield is typically affected by a lack of both organic and inorganic nutrient resources. Every crop needs micronutrients for optimal growth and development, and the availability of these minerals in the soil has a big impact on both qualitative and quantitative traits. (Tomar *et al.*, 2022) [105].

Green gram is grown in almost every Indian state, making India the world's largest producer. It is grown on an approximately 4.5-million-hectare area, producing 2.5 million tonnes and yielding 548 kg per hectare, accounting for 10% of total pulse production. According to the government of India, green gram production in the Marketing year 2020-2021 was found to be 2.64 million tonnes (Anonymous, 2021) [9].

Table 1: State-wise area under Green-gram in India

State	2019-2020			2020-2021		
	Area (Lakh ha)	Area (lakh acres)	% to total area	Area (Lakh ha)	Area (Lakh acres)	% to total area
Rajasthan	18.89	46.68	61.43	20.89	51.62	58.37
Karnataka	2.68	6.62	8.72	4.4	10.87	12.29
Maharashtra	3.24	8.01	10.54	3.94	9.74	11.01
Madhya Pradesh	1.8	4.45	5.85	1.57	3.88	4.39
Telangana	0.6	1.48	1.95	0.76	1.88	1.73
Others	4.14	10.23	13.46	4.99	12.33	13.94
All India	30.75	75.98	100	35.79	88.44	100

["Source: www.agricoop.gov.in"]

Nitrogen, phosphorus, and trace elements like sulphur a substantial impact on the growth and yield characteristics of moong bean. In agreement with this, low moong bean productivity has been shown to be caused by a lack of nutrients in the nation's agricultural regions. Maintaining soil fertility through a balanced fertilizer dose, which includes chemical, organic, and biological fertilizers are crucial for the improvement of agricultural crops' yield and quality (Baza *et al.*, 2022) [88]. Various approaches have been used in the last few years for sustainable agricultural, with integrated use of nutrients being the most auspicious. Agriculture will be dependent on the efficient use of fertilizers as well as soil, water, crop, and land management in the coming years. An integrated approach to nutrients, such as manures and biofertilizers, not only assures increased soil health but also maintains crop productivity in the current unpredictable climatic scenario (Tomar *et al.*, 2022) [105].

Effect of Potassium on growth and yield of moong bean

Potassium is another chief nutrient of plant growth (shoot growth under water stress conditions) and better production of crop (Baligar *et al.*, 2001) [16]. Due to high maneverability of potassium in soils and significantly higher cytoplasmic accumulation. Potassium encourage meristematic tissues's growth, stimulate some enzymatic reactions, subsidize metabolism of nitrogen, and protein synthesis (Liang *et al.*, 2011; Bhandal *et al.*, 1988) [56, 19], and is resistant to pests and diseases. It assembles the mineral elements activities, which alleviate metabolism of carbohydrate and translocation (Bhandal *et al.*, 1988) [19]. It also improves sugar metabolism, increases the osmotic cell concentration and thus aids in the regulation of stomatal opening and improving drought resistance and also increases productivity. Kabir *et al.*, (2004) [44] and it also preserves the cell turgor pressure which is essential for cell expansion (Yang *et al.*, 2004) [109]. For photosynthesis and protein synthesis, plants need the most potassium and over-all it also helps in increasing.
Mazed *et al.*, (2015) [57] stated that "an experiment in Bangladesh to look at how potassium and sulphur affect the

growth and yield of moong. Three levels of S and four levels of K were used in the study. According to the research, raising potassium and sulphur levels were found to boost moong bean grain and stover output. The treatment containing potassium and sulphate (25 kg K per hectare and 6 kg S per hectare) produced the highest grain and stover yield as well as the maximum plant height, number of branches per plant, and yield attributes like the number of pods per plant and the number of grains per pod."

Pranav *et al.*, 2014 [76], advised that 80 kg of potassium per hectare is sufficient for moong bean in an Agri-horticultural system based on custard apples as there was a significant response in yield and growth of moong bean. Quddus *et al*., (2019) [79] experimented on the calcareous and silty loam (sand content: 16.43; silt content: 63.21; clay content: 20.36).

According to Chaudhari *et al.*, (2018) [24] potassium application increased black gram grain yield significantly in all treatments when compared to the control. This suggests that potassium application involved in starch synthesis, and respiration, as well as sugar deportation from leaves to other parts of the plant and stomatal opening regulation. It may also help in plant disease resistance. This study showed that applying potassium @ 60 kg per hectare resulted in the highest moong bean seed yield.

With the introduction of high-yielding crops and increasing crop production on Indian soils, various potassium levels are being used. Kumar *et al.*, 2018 [54], observed that applying 90 kg of potash per hectare gave the highest yield up to 763 kg per hectare.

Effect of Nitrogen and Phosphorus Application on Growth and Yield Parameters

Higher levels of nitrogen and phosphorus plays a crucial part in its growth, development, yield and quality, as well as also having a significant impact on many other green gram traits.

Effect of Phosphorus

Phosphorus availability in Indian soils ranges from poor to medium. Plants only utilise about 30% of the phosphorus, with the remainder being converted into insoluble phosphorus. (Sharma *et al.*, 1997) [89]. Adding phosphorus to other micronutrient applications can increase output and productivity, claim Kumar *et al.*, (2012) [52]. The most significant reason for the poor production of moong beans in all types of soil is its insufficiency. Proteins, phospholipids, coenzymes, and nucleic acids all require phosphorus as an essential component. The "energy unit" of a plant is also referred to as ATP, which also requires ADP, NADP, and phosphorus as important components. Involved in a variety of physiological and metabolic requirements of plants from seedling to grain formation to maturity stages, ATP is created during photosynthesis. It has been determined that adding phosphorus to moong beans will boost yield and yield characteristics. Hossain *et al.*, (2011) [38] also declared that raising phosphorus up to 50 kg per hectare boosted the grain production of legumes. A phosphorus treatment of approximately 45 kg per hectare, according to Kumar *et al.*, (2012) [52], considerably increased plant height, nodules dry weight, grains per pod, grain production, and stover yield, etc. Basu *et al.*, (2003) [17]. He claimed that applying 60 kg of phosphorus per hectare improved growth metrics and increased grain output (426 kg per hectare) when compared to applying a different dose of phosphorus.

Soodi *et al.*, (1994) [99] studied that dry weight of nodules per plant increases when 25 kg of nitrogen or 50 kg of phosphorus per hectare are applied alone or both. Similar to this, (Mathur *et al*., 2007) [60] observed that treatments with nitrogen and phosphorus, either separately or in combination, greatly boosted height of plant and the number of branches. According to Sharma *et al.*, (2003) [91], moong bean seed output rose when nitrogen and phosphorus rates were increased.

Kumar *et al.*, (2017) [55] during an experiment observed that 60 kg per hectare is the best dose for obtaining the optimum yield of 1214.6 kg per hectare. However, with application @ phosphorus at 49.7 kg per hectare resulted in higher grain yield, and it will be highly input responsive. Furthermore, increased nutrient dose leads to increased yield at a decreasing rate.

Table 2: Yield increased in different locations due to the application of different sources of N, P & K despite of seasonal changes in mungbean

Location	Crop season	Nutrient source	Increase in yield	References
Bangladesh	kharif	Phosphorus 40 kg per hectare and molybdenum 1kg per hectare.	Grain yield (14.61 g per plant). Highest stover (26.67g per plant).	According to Rahman *et al.*, (2008)
Allahabad	kharif	NPK (20:40:40) + FYM @10 ton per hectare.	A seed yield of 12.10 q per hectare was obtained from the rest of other treatments.	According to *Meena et al.*, (2016).
Gujrat	summer	NPK (10:20:0 kg per hectare) + biocompost 2.5t per hectare.	Seed yield 1592 kg per hectare.	According to Joshi *et al.*, (2020).
Junagarh (Gujarat)	Summar	Phosphorus 60 kg per hectare+ rhizobium	Highest seed yield of 1140 kg per hectare at par with 40 kg P per hectare, seed yield of 1100 kg per hectare.	According to Gajera *et al.*, (2014).
Allahabad (UP)	Zaid	NPK (20:60:20) + 0.2% foliar spray of borax at 35 days.	The maximum grain yield obtained 1.62 tons per hectare and the straw yield (was 2.85 tons per hectare. The highest gross return (78795.00 per hectare, net return (57222.00 per hectare and benefit-cost ratio (2.65) were obtained.	According to Choudhary *et al.*, (2017)

Effect of Nitrogen

Nearly all of the biochemical compounds necessary for plant life include both nitrogen and phosphorus as essential ingredients. There is no plausible alternative to the biochemical system of plants combining these two components. There is no question that N and P both play important morphological, biochemical, and physiological functions in crop growth (Sinclair and Vadez, 2002) [94]. Actually, the first nitrogen requirements of new plants are met by soil mineral nitrogen. N fixation succeeds to assimilation once nodules have taken root, peaks during pod growth, and then starts to fall. The majority of filling seed is thus achieved by transferring N from vegetative plant to the growing seeds (Sushant *et al.*, 1999) [101].

Chattha *et al.*, (2017) [23] Research on various nitrogen and phosphorus levels was done in Pakistan on clay loam soil with a pH of 7.6, and it was found that applying nitrogen and phosphorus at rates of 20 and 50 kg per hectare boosted moong bean growth and production. Moong bean yield is determined by the sum of numerous yield components by a different genetic makeup, environmental factors, and farming methods.

Razzaque *et al.*, (2017) [83] stated that experiment at Gazipur in low-nutrient soil. The soil had a sandy loam texture and a pH of 6.9. The findings showed that across all the treatments, the IPSA 12 genotype produced considerably more dry matter, leaf area, and grain yield (14.12 g per plant). The findings also demonstrated that nitrogen fertiliser application had an impact on crop growth rate, as crop growth rate rose up to 60 kg per hectare as nitrogen fertiliser application increased. Due to the immobilisation of nitrogen fertiliser (Steenberg effect), every additional increase in the application of nitrogen fertiliser above 60 kg per hectare significantly affected the rate of growth and subsequently the yield.

Soodi *et al.*, (1994) [99] discovered that applying 25kg of nitrogen alone increased. Malik *et al.*, (2003) [13] observed that combining nitrogen fertilizers with phosphorus gave the maximum protein content in moong bean (~25.6%) as well as higher maximum seed yield and higher net income. Ahmad *et al.*, (2001) [4] performed Cereal-legume crop rotation with Rice, wheat, Moong bean, and black gram, and found that the nitrogen-fixing range was about 26-36 kg per hectare in Rice-legume rotation, whereas about 30-36 kg per hectare in wheat-legume intercropping along with higher yields of cereal crops in cereal-legume intercropping than cereal-cereal intercropping.

Effect of Sulphur

According to Patel (2020) [34], Nutritional factors have been found to be the Sulphur largest limiting factor in the growth of green gram, after phosphorus. Sulphur deficiency is a severe problem that is getting worse every year which persuade chlorosis in younger leaves, decrease seed yield (Khairul *et al.*, 2015) [57], decrease quality and nutrient efficiency (Patel *et al.*, 2020) [34]. Sulphur, like other essential nutrients, serves a specific purpose for the plant. So, the only method for treating a sulphur deficiency is to apply sulphur fertilizer (Tandon and Messick, 2007) [102]. Plants require as many phosphorus sulphides, one of the elements commonly regarded as essential for plant nutrition. According to Ashraf (2021) [14], cysteine is a crucial component of proteins, and apart from this also necessary to establish the structural conformation of binding between proteins and metals, which aids in the catalysis of enzymatic reactions. In addition, sulphur is required for the creation of coenzyme A, which is necessary for the oxidation of citric acid cycle intermediates, fatty acid biosynthesis, and ferredoxin oxidation (Ashraf 2021) [14]. When sulphur-containing fertilizers are applied, the soil may become more acidic, which may ultimately affect nutrient uptake (Havlin *et al.*, 2016) [35].

Mondal *et al.*, (2003) [66] found that applying sulphur increased moong bean grain yield. According to Singh *et al.*, (2017) [95], by applying 40 kg sulphur per hectare gives a significant maximum grain yield. According to Kumar *et al.*, (2012) [52], sulphur is directly related to cell division, elongation, and enlargement and therefore it is linked, whereas they also observed that increasing the dose of sulphur application (30 kg per hectare) also increased the parameters like the higher dry weight of nodules, maximum number of grains per pod, higher grain yield and straw yield, etc. Sulphur boost crop yields and improves product qualities such as proteins, fats, starch, etc. (Bharvi *et al.*, 2020) [20]. Similar findings were made by Khairul in 2016, who experimented with different sulphur levels (0, 3 and 6 kg per hectare) and saw an increase in grain and stover yield as the sulphur level rose. It is crucial since it not only enhances nutritional quality but also boosts grain production.

The application of sulphur strongly contributed and also significantly increased dry matter, pods per plant, and test weight. A fake positive association between pods and grains per plant was observed. According to Asaduzzaman, numerous specialists assert that adequate nutrient supply significantly enhance growth. Fertilizer applications considerably boost the accumulation of dry matter compared to the control after 30 days of planting and beyond. According to Krishna *et al.*, (2020) [50], the moong bean crop can yield its best results and maintain soil fertility if fertilized with sulphur at a rate of 20 kg per hectare, along with nitrogen at 20 kg, phosphorus at 30 kg, and potassium at 20 kg per hectare. Additionally, because legumes are so environmentally friendly, they are valuable in sustainable agriculture.

Sachan *et al.*, (2020) [84], conducted study at UP revealed that the full prescribed quantity of nitrogen, phosphate, potassium, and sulphur was superior to other treatments and recorded the highest grain production. In an experiment done in Meerut in 2019 by Krishna *et al.*, (2020) [50] Potential of moong bean production when it was fertilized with sulphur and the recommended amount of NPK. Three copies of each of the 17 treatments were made. The highest grain yield (1524 kg per hectare) was discovered to be produced by the treatment using the full 150% recommended dose of NPKS.

Table 3: Effect of different source and doses of sulphur on grain and stover yield of mungbean

Location	Crop season	Nutrient Sources	Increase in yield	References
UP	Zaid season	60 kg phosphorus in the form of DAP with 20 kg sulphur in the form of gypsum. And 20 kg sulphur with NPK (20:30:20) kg per hectare.	Increase seed yield (970.33 kg per hectare), stover yield (1597.67 kg per hectare) gross return (₹ 106736.3 per hectare), net return (₹ 63592.3 per hectare).	According to Dey *et al.*, (2021) [28] and Krishna *et al.*, (2020) [50]
UP (Banaras hindu university)	Kharif season	30 kg S (Zypsum) per hectare	Grain yield comes out 9 quital per hectare than the rest of other treatments.	According to Kumar *et al.*, (2012) [52].
Maharashtra	Kharif season	40 kg sulphur per hectare in form of elemental sulphur. Seed treatment with Bavistin 4g per kg.	Increased grain yield 1412.65 kg per hectare and stover yield 4619.46 kg per hectare.	According to Patil *et al.*, (2011) [73]; Patil *et al.*, (1992) [74]; Sharma *et al.*, (1993) [92].

Problems

Poor crop management techniques, abiotic and biotic restrictions, a shortage of high-quality seeds of improved varieties available to farmers, and low yield of moong beans are all contributing factors (Pratap *et al.*, 2019) [77]. For rapid stand establishment and maximum yields, adequate levels of them. Crop yield increased as a result of proper management, which also reduced fertilizer costs. Farmers consistently use large amounts of chemical fertilizers without consideration of environmentally friendly methods like using organic manures and do not adhere to the recommended dose of fertilizer, and the amount of fertilizer is often inappropriate due to a lack of proper knowledge. Due to nutrient imbalances caused by this, ecosystem services, biodiversity, the environment, and human health are all negatively impacted (Kumar *et al.*, 2022) [53].

Diseases such as yellow mosaic virus, anthracnose, powdery mildew, leaf spot, and blight, are among the major biotic factors are all abiotic stress factor that affects moong bean production (Singh *et al.*, 2011) [97]. An important viral disease of the moong bean is called the Moong bean Yellow Mosaic Disease (Noble *et al.*, 2019) [70].

The expense of fertilizers is continuously increasing in the current environment of intensive and chemical-driven agriculture production. The cost of growing green gram has increased due to the regular rise in fertilizer prices. Therefore, research is needed to determine the ideal or recommended fertilizer requirements for summer moongbean cultivation, which will not only be economically viable but also increase factor productivity in pulses/legumes, farmer income, and subsistence. The farming community will benefit from financial and nutritional security as a result.

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Conflict of Interest

The authors affirm that their publishing of this paper does not include any conflicts of interest.

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