

## **A Brief Insight into Nutritional Deficiencies in Pulses and their Possible Management Strategies A Review**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author ANH designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors FAB, SSM, MAB, AH and RHK wrote the protocol. Authors TS, RA, OAW, HMN, SF, AA and SI managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

One of the main abiotic constraints that limits pulse production is nutrient imbalance. Pulses play very important role in human diet providing all nutritional and physiological beneficial effects on human health. Pulses are rich in protein, carbohydrates, and dietary fibre, and a rich source of other bioactive components, and their consumption extends worldwide. Pulses are dried legumes that consist of various varieties of beans, lentils, peas, green gram, black gram, horse gram, and chickpeas. Protein-rich pulses are considered a primary food for a large portion of the Indian population, which satisfies everyone's protein and energy demands. Phosphorus and Fe have significantly enhanced pulse crop productivity in many pockets in response to potassium application. The production of both applied and native P is increased by phosphatic fertilisers and the use of bio-fertilizers. Some micro-nutrient foliar nutrition proved to be very successful, the amount and mode of application is determined by indigenous nutrient supply. Balanced nutrition is vital for achieving higher productivity. At the same time, in order to 'increasing nutrients demand, there is immense need to exploit the alternate source of nutrients viz Organic materials and bio- fertilisers for

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sustainable productivity with more environmentally friendly systems for the management of nutrients. Environmental issues and other hazards arising from the imbalanced use of nutrients should also be addressed properly. Several investigators reported that integrated use of chemical fertilizers with organic manure is becoming a quite promising practice not only for maintaining higher productivity but also for greater stability to crop production as well as make the pulses become healthy to feed the population.

**Keywords:** Pulses; nutrient; environment and deficiencies; management.

## 1. INTRODUCTION

Pulses in India have long been considered the only source of protein for the poor man. They are the main source of dietary protein in vegetarian countries like India. The major pulse crops of the country are red gram or pigeon pea (tur, arhar), chickpea or gram, black gram (urad bean), green gram (moong bean) and lentil (masur). Minor pulses include rajmash and other beans, cowpea, horse gram, moth, khesari-dal, etc. If we consider some of the major sources of proteins, pulses turn out to be one of the most economical sources of protein for human consumption. Pulses contain 18-25% of protein. Increasing their production and keeping their prices within the reach of the poor therefore assumes chief importance. India leading producer of Pulses with (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Despite various efforts of the Government of India, the pulse production from an area of 23.0 (million ha) has stabilized at around 18–20 million tonnes against the consumption of 22–24 million tonnes [1]. Even with this level of production and import, availability of pulses (47 g/capita/day) is far lower than the recommended minimum requirement of 70 g/capita/day. Legumes are one of the predominant crops of mixed crop-livestock systems providing highly nutritious fodder as well as contributing soil fertility through biological nitrogen fixation. Estimates indicate that India needs an annual growth rate of 4.2% in pulse production to ensure projected demand of 30 million tonnes by 2030 [2]. To meet this standard, constraints to production must be analysed and effective steps must be undertaken. In India, pulses are generally cultivated on marginal and submarginal lands, which are categorised as poor soil fertility and moisture stress, and therefore their yield potentials have not been realised. In addition, more than 90% of the area under pulses is rainfed. Pulses has its important role in contribution to food and nutritional security and restocking soil nutrients having an enormous potential in addressing needs like future global

food security, nutrition and environmental sustainability needs. For the both small and large farmers, pulses signify important economic opportunities to boost income and reduce risk by diversifying their crop and income stream range. Besides the environmental benefits of adding pulses to crop rotations, there is an also social and economic benefit of pulse production as it helps needs for protein, minimize soil degradation, and support diversification in food production and consumption. Therefore, there is a great scope of increasing the production in rainfed as well as irrigated areas through nutrient management [3]. Out of 16 essential elements, pulses specially need adequate amount of P, Ca, Mg, S and Mo [4] Calcium and magnesium are required to stimulate growth and to increase size of nodules, pod formation and grain setting. Sulphur is required for nodulation and protein synthesis. Mo for nitrogen fixation and assimilation and boron for reproduction, are required. Phosphorus is required for proper root growth and growth of rhizobia. Phosphorus is vigorous to agriculture as it is required by all plants, being involved in seed germination, root growth, structure development, and several metabolic processes such as photosynthesis and nutrient formation [5]. The pulses have great potential to bear the vagaries of the changing climate, provided other crop management practices are strictly followed to harness achievable yields. Pulses can adapt to a wide range of edaphic and climatic conditions and can therefore be an important component of climate change mitigation and adaptation strategies.

### 1.1 Status of Pulses in India

India is the world's leading producer of pulse, accounting for 24 per cent of global production. The major pulse crops, viz. chickpea (*Cicer arietinum* L.), pigeonpea [*Cajanus cajan* (L.) Millsp.], mungbean [*Vigna mungo* (L.) Hepper.], urdbean [*Vigna radiata* (L.) R, Wilczek], lentil (*Lens culinaris* Medikus) and field pea (*Pisum sativum* L.) of India, in order of importance, are chickpea (48%), pigeonpea (15%), mungbe

**Table 1. Contribution of 100 g of cooked pulses to the Dietary intakes**

Nutrient	RDA and AI <sup>a</sup> (adults > 18 y) <sup>86</sup>		Amount of nutrient in 100 g of pulses <sup>b</sup>	RDA/AI
	Males	Females		
Protein (g/d)	56	46	8.62	15–19%
Fiber (g/d)	30–38 <sup>c</sup>	21–25 <sup>c</sup>	7.4	19–35%
Folate (lg/d)	400		127	32%
Iron (mg/d)	8	8–18	2.27	13–28%
Magnesium (mg/d)	400–420	310–320	52	12–17%
Phosphorous (mg/d)	700		142	20%
Potassium (mg/d)	4700 <sup>c</sup>		401	9%

Abbreviations: AI, Adequate Intake; RDA, Recommended Daily Allowance [6]

<sup>a</sup>From Dietary Reference Intakes Tables and Application: DRI Values

<sup>c</sup>An RDA for this nutrient is not available. This value is represented as an AI

(7%), urdbean or blackgram (7%), lentil (5%), and field pea (5%) [7]. The major pulse-growing states are Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka and Andhra Pradesh, which together account for about 80% of the total production [8]. Despite the increases, average pulse yields in India are much lower than the world average. The pulse requirement is projected to reach 32 million tonnes by 2050, taking into account the estimated population growth of 1,69 billion by 2050.

## 2. NUTRIENT DEFICIENCIES

### 2.1 Nitrogen Deficiency in Pulses

Pulses Nitrogen deficiency is mainly found during the early stages of crop growth when root symbiotic nitrogen fixation nodules have yet to develop. Deficiency may also occur during later stages of crop growth when the symbiotic nitrogen supply mechanism is disrupted for some reason, such as nodule infestation, nodule pathogenic disease or physiological causes. The symptoms of deficiency appear on the old leaves first and more severely. The younger leaves are usually green and apparently healthy. In a mild deficiency, the whole plant appears uniformly

light green.

### 2.2 Likely to Occur in

1. Soils with low organic matter.
2. Light-textured sandy soils that have been bleached by heavy rainfall or excessive irrigation.
3. Acid soils with a pH lower than 6.0.
4. Alkaline soils with a pH above 8.0.
5. Crops with poor Rhizobium nodules or damaged Rhizobium nodules.

### 2.3 N- Nutrient Management

Get the soil tested before sowing to measure the amount of 'available' nitrogen in the soil. Inoculate the crop with the appropriate strain of Rhizobium by seed treatment. During the initial stage of growth, the crop needs nitrogen when symbiotic nitrogen fixation by the plant has yet to begin. The basal starting application of nitrogen at 20–25 kg/ha is therefore important in soils with nitrogen deficiency. Nitrogen deficiency in existing crops may be managed by applying urea with irrigation water or as a foliar spray [9].



**Fig. 1. Interveinal chlorosis on an older leaf (Pigeon Pea) [9], Severely deficient white-yellow leaf (Black gram) [9]**

### 3. P DEFICIENCY

Phosphorus deficiency in black gram reduces biomass, photosynthetic activity and the ability to fix nitrogen. Phosphorus deficiency leads to reduced plant growth. Plants are bluish green and stunted. Root development is limited and flowering is reduced. Crop maturity has been delayed. The number and size of the pods are reduced, leading to poor yields. Phosphorus is mobile within plants and can be easily transferred from older to younger plant tissues under restricted supply conditions. Therefore, older leaves show symptoms of deficiency first. Deficient plants appear dark green and the lower stems turn purplish. If the deficiency persists for a long time, the dark green.

#### 3.1 Likely to Occur in

1. Soils with low organic matter.
2. Calcareous and alkaline soils.
3. Soils exhausted by intensive cultivation.
4. Acid soils and highly wet soils.
5. The soils where the soil has been removed by erosion.
6. Acid soils with a pH lower than 6.0.
7. Alkaline soils with pH between 7.5 and 8.5.

#### 3.2 Nutrient Management

Get the soil tested before sowing to measure the amount of 'available' phosphate in the soil. Apply the recommended amount of phosphorus as a baseline based on analysis by using. Organic manure. Phosphate-solubilizing microbial cultures. Phosphate fertilisers. Soluble phosphate fertilisers such as ammonium phosphate with irrigation water are used in deficient standing crops [9].



**Fig. 2. Purple coloration of older leaves (Lentil) [9]**



**Fig. 3. Purpling appearing on the edges of Leaflets (Chickpea) [9]**

### 4. K-DEFICIENCY

#### 4.1 Symptoms

Potassium deficiency causes putrescine accumulation in the leaves and may be detected before symptoms of deficiency appear. Potassium-deficient plants become small and thick. Short, young internships. Plant growth is slowed down and the pods are poorly filled. Potassium is considered to be highly mobile within plants and has a tendency to move quickly from older to younger tissues when supplies are reduced. As a result, symptoms first become evident on older leaves, and then the plant progresses to younger leaves. Leaves become dark green with yellowing at the tips. And the edges of the old leaves. The margins of the old leaves are scorched and show inward cutting.

#### 4.2 Likely to Occur in

1. Soils formed from a low potassium parent material.
2. Light-textured soils where potassium has been leaked due to heavy rainfall or excessive watering.
3. The soils are low in organic matter.
4. Soils with a wide Na:K, Mg:K or Ca:K ratio.
5. Acid soils with a pH lower than 6.0.

#### 4.3 Nutrient Management

Analyze the soil before sowing to measure the amount of potassium available in the plant. Problematic acid/alkaline/saline soils should be recovered. Add organic manure well

before planting. Apply soluble potassium salts such as potassium chloride, potassium sulphate or potassium nitrate to soil at or before planting. Apply soluble potassium salts with irrigation water to standing crops [9].



**Fig. 4. Chlorosis advancing inward (Green gram) [9]**



**Fig. 5. Chlorotic areas around the edges of leaves (Lentil) [9]**

## 5. MAGNESIUM (Mg) DEFICIENCY

### 5.1 Symptoms

Deficient plants are stunted with short and thin stems. Magnesium is mobile in the plant and is transferred from older to younger leaves under short supply conditions. The symptoms of deficiency appear first and more severely on older leaves. The youngest leaves are green and apparently healthy. Symptoms begin with the fading of the interveinal tissues of the older leaf. As symptoms develop, greenish-yellow to pale-yellow interveinal chlorosis develops on older leaves. All the veins of the leaf (primary and secondary) remain green. If the deficiency persists and becomes more serious, these symptoms move up the plant to the upper leaves. Under severe deficiency conditions, the affected interveinal regions turn necrotic.

### 5.2 Likely to Occur in

1. Mostly occur in acid sandy soils from which magnesium has been leached through severe rainfall.
2. Peat and muck soils which are low in total magnesium.
3. Soils derived from parent material which is inherently low in magnesium.
4. Soils with heavy and excessive use of potassium fertilisers.
5. Soils with heavy and excessive application of lime (calcium carbonate) or other calcium fertilisers.
6. Acid soils with a pH lower than 6.5.
7. Alkaline soils with a pH above 8.5.

### 5.3 Nutrient Management

Get the soil analysed before sowing to estimate the amount of soil. Soluble and exchangeable magnesium in the soil. Apply the recommended amount of magnesium based on analysis. Before sowing with soluble salts such as magnesium sulphate or Chloride of magnesium. Application of soluble salts such as magnesium to deficient standing crops Sulfate, chloride or nitrate with irrigation water. A leaflet Sprays of these salts are usually not recommended as many sprays at frequent intervals. Intervals are required to meet the crop needs.

Magnesium deficiency in acid soils can be corrected by applying dolomite (a mixture of calcium carbonate and magnesium carbonate,  $\text{CaCO}_3 \cdot \text{MgCO}_3$ ) through broadcasting and mixing in the soil a few months before the sowing. Reclamation of problematic acid soils or alkaline soils should be done to regulate the proper supply of magnesium [9].



**Fig. 6. Chlorosis intensified into interveinal areas (Pea) [9]**



**Fig. 7. leaf showing interveinal chlorosis (Kidney Bean) [9]**

## 6. SULPHUR (S) DEFICIENCY

### 6.1 Symptoms

Sulphur deficiency symptoms are often seen in the early stages of Pulses. The deficient plant lacks vigour, appears pale green to pale yellow, produces few branches, bears few pods and yields poorly. Sulfur is immobile in plants and does not mobilise in short supply conditions from older to younger leaves. As a result, symptoms of deficiency appear first on younger leaves, while older leaves remain green and healthy. Sulfur deficiency, even if severe, does not produce any type of necrosis or burning of leaves. A change in the colour of the leaf is the only indicative symptom of a deficiency in sulphur. At the initial stage, the symptoms of sulphur deficiency are often confused with those caused by nitro A close observation is needed to see whether the older leaves are darker green and the younger ones are paler (sulphur deficiency) or whether the younger leaves are darker green and the older ones are paler (case of nitrogen deficiency). The symptoms of deficiency appear as uniform, pale green to pale yellow chlorosis across the laminate of the young leaves. Midrib and other veins are very similar in colour to the interveinal areas of the leaf If deficiency persists and is present.

### 6.2 Likely to Occur in

1. Having Soils with low organic matter.
2. Light-textured sandy soils that have been leached by heavy rainfall or excessive irrigation.
3. Soils which is exhausted by intensive cropping.

4. Soils derived from parent material that is inherently low in sulphur (for example, soils formed from volcanic rocks).
5. Acid soils with a pH lower than 6.0.

### 6.3 Nutrient Management

Get the soil tested before sowing to measure the amount of 'available' sulphate in the soil and predict the amount of fertiliser required. Apply the recommended amount of sulphur, based on analysis, by mixing in the soil well before sowing, either:

- a. Elemental sulphur; or
- b. Titanium (calcium sulphate).

Ammonium sulphate, magnesium sulphate or potassium sulphate with irrigation water are used in deficient standing crops. Problematic acid soils should be recovered [9].



**Fig. 8. Plant with small and pale yellow young leaves (Kidney Bean) [9]**



**Fig. 9. Affected leaf (left) in comparison to a normal leaf (right) (Pigeon Pea) [9]**

## 7. IRON (Fe) DEFICIENCY

### 7.1 Symptoms

The frequent use of foliar application of iron in Legume crops has considerable effect on chlorophyll synthesis, enzymatic activity and active iron content in green leaves. Pulses are very greatly in their resistance to iron deficiency in view of chlorosis symptoms, plant growth and seed yield. Some cultivars are highly susceptible to iron deficiency, whereas some are very tolerant to iron deficiency. Deficient plants become thin-stemmed and have smaller leaves. The number and size of pods are reduced. Decreased number and size of seeds per pod resulting in low yields. Crop maturity gets delayed. Iron is immobile within plants and hence it is not readily redistributed from older to younger plant tissues under reduced supply conditions. Therefore, the deficiency symptoms become evident first on younger leaves. Young leaves become yellow (chlorotic) with contrasting narrow, dark green main veins, while older leaves remain green. Chlorotic young leaves then turn yellow to white and symptoms spread down the plant to lower leaves.

### 7.2 Likely to Occur in

1. Sandy soils with low overall iron content.
2. Alkaline and calcareous soils where Fe solubility is very low.
3. Peat and muck soils where organic matter binds iron and reduces the availability of soil solution.
4. Acid soils with excessive levels of soluble zinc, manganese, copper or nickel that despite being high, can hinder the uptake of iron in spite of high iron availability.
5. Alkaline soils with a pH above 7.5.

### 7.3 Nutrient Management

Analyse the soil before sowing to measure the 'available' iron in the soil. Reclaim problematic alkaline soils. Add organic manure well before sowing. Apply basal dose of soluble iron fertilizers such as FeSO<sub>4</sub> (commonly at 25 kg/ha) or Fe chelates (10 kg/ha). Use of organic chelates proves to be more promising as they maintain iron in soil solution. In standing crops, apply FeSO<sub>4</sub> or Fe chelates (0.5% w/v solution) and 0.1% w/v citric acid as foliar sprays. Foliar sprays are required to be repeated every 10–15 days [9].

## 8. ZINC (Zn) DEFICIENCY

### 8.1 Symptoms

Pulses are very sensitive to zinc deficiency. Symptoms of deficiency appear more prominently during the early stages of crop growth, usually within 2-3 weeks of sowing. Zinc-deficient plants are stunted with short stems and small branches. The leaflets are small, faded with a sick appearance. Zinc is mobile in plants and is transferred from older to younger leaves under short supply conditions. As a result, symptoms of deficiency appear first and more severely on older leaves. Symptoms begin with faded, pale green interveinal chlorosis of older leaves. Interveinal chlorosis begins at the tip of the leaf and proceeds towards the base. The main veins are green and prominent.



**Fig. 10. Severely deficient trifoliate with white interveinal tissues and veins staying green(Pigeon Pea) [9]**



**Fig. 11. Plant showing interveinal chlorosis on top leaves (Cluster Bean) [9]**

### 8.3 Likely to Occur in

1. Mostly found in Leached sandy soils where total zinc is low.
2. Just-levelled soils where the subsoil is exposed for cultivation. zinc available on surface soil is often twice that of the subsoil.
3. predominantly in Cool, wet weather.
4. Soil having heavy and excessive use of phosphate fertilizers, which hinders the use of zinc by the crop.
5. Acid soils having pH below 5.0.
6. Alkaline soils having pH above 7.5.

### 8.4 Nutrient Management

Get the soil analysed before sowing to estimate the amount of 'available' zinc in the soil. Problematic alkaline soils should be recovered. Application of optimum organic manures before sowing. Apply 25–30 kg of zinc sulphate or 10 kg of zinc chelate per hectare every 2 years in zinc-deficient soils. Do not mix zinc fertilisers with phosphate fertiliser [9].



**Fig. 12. Chocolate brown necrotic lesions and holes in an affected leaf (Black gram) [9]**



**Fig. 13. Brown necrotic lesions on an affected leaf (Kidney Bean) [9]**

## 9. NUTRIENT MANAGEMENT

The nutrient requirement for legumes is much lower than for cereals, mainly due to organic nitrogen fixation. They do, however, respond favourably to higher doses of applied phosphorus (P), sulphur (S) and potassium (K). Efficient management of nutrients, especially nitrogen along with biofertilizers, can minimise the magnitude and duration of pulse moisture stress.

[10] The use of arbuscular mycorrhizal (AM) fungi also holds great promise in terms of tolerance to water stress in addition to phosphorus nutrition in rainfed peas [11]. The use of balanced fertilisers (NPK) with micronutrients increases the absorption of water as well as the relationship of water in plant tissues. Among the major nutrients, nitrogen (N), potassium (K) and magnesium (Mg) are found to be very deficient due to water-deficient conditions. [11] Increase of pigeon pea yield by 36% with application of 50 kg K<sub>2</sub>O/ha in pod-borer infested fields Lack of insufficient availability of gypsum or pyrites as a low-priced source of S leads to widespread S-deficiency in major pulse-growing regions [12] In addition, zinc (Zn) and boron (B) deficiency is quite common in cereal-and pulse-growing regions. Pulses also require a relatively higher amount of certain micronutrients, such as molybdenum (Mo) and iron (Fe), which are integral components of the enzyme nitrogenase, essential for N-fixation [13]. Sulfur application @ 20–40 kg/ha (through gypsum, single superphosphate) for sowing and Zn sulphate @ 25–50 kg/ha once every 2 years effectively solves the problem and maximises crop productivity [14]. Soil-Test Crop Response (STCR)-based targeted precision nutrient management practises in legumes and other field crops may also be a good alternative to maintaining nutrient and moisture stress for higher crop productivity with the economic use of chemical fertilisers under Indian conditions [15]. Evidence has shown that pulse crop diseases could be significantly reduced with the addition of organic manures/residues/modifications [16]. Reported that the incidence of chickpea wilt was significantly reduced by incorporating deoiled mustard cake, groundnut cake and FYM into the soil. This could be attributed to the increased activity of competing soil micro-organisms [17]. In addition to these benefits, organic manures have a package of micronutrients that could overcome micronutrient deficiency in pulse and reduce salinity in soils Nutrient deficiency and excess stress occur when the essential nutrient is either



not available to plants in the required quantity or when it is available in excess of plant needs. In contrast to symptoms of deficiency, symptoms of toxicity are less common. In some cases, the presence of one element in excess of the concentration may lead to a deficiency of another element. Nutrient stress is due to the lopsided use of NPK fertilisers, the growth of high-yielding varieties, intensive cultivation without the addition of secondary and micronutrients, no or less use of organic manure, the leaching of nutrients such as nitrogen (N), potassium (K), sulphur (S), calcium (Ca), boron (B) and manganese (Mn) under high rainfall and irrigation [18]. Foliar application of nutrients and anti-perspirants to pulse would be advisable due to low pulse productivity due to erratic and scarce rainfall; prolonged dry spell during flowering and pod-formation, resulting in a drastic reduction in yield [19]. In such environments, the foliar application of nutrients, together with in-situ moisture-preservation practises for the better establishment and production of crops, is

imperative [20]. Suggested foliar spray of 2 percent N at flower initiation along with chemical fertilisers and FYM coupled with opening of shallow furrows between 2 rows to reduce drought and nutrient stress in pigeon-pea crop. Foliar kaolin spray (6 per cent) with FYM + dust mulch produces desirable changes in the productivity of pigeon pea + mung bean intercropping in addition to reducing evapotranspiration losses, weed suppression and soil moisture retention [21].

Table 2. studied under the temperate condition of Kashmir and found that yield and soil quality are improved by the use of integrated inorganic and organic fertiliser and that the yield of seed in all treatments differs significantly from control. Maximum seed yield was recorded as (1386.67 kg/ha) with 125% RDF (T4) while minimum seed yield (535.00 kg/ha) was recorded with control (T1) where no fertiliser or biofertilizer was used.

**Table 2. Studies of French Bean (*Phaseolus vulgaris* L.) on Yield and Soil Quality as Influenced by Integrating various organic and inorganic fertilizers [22,20]**

Abbreviation used	Treatment details	
T1	Control	No organic, inorganic or Biofertilizer applied
T2	75% RDF	22.5 N: 37.5 P2O5:22.5 K2O kg/ha
T3	100%RDF	30 N: 50 P2O5: 30 K2O kg/ha
T4	125% RDF	37.5 N: 62.5 P2O5: 37.5 K2O kg/ha
T5	FYM	6 ton/ha
T6	Vermicompost	2.2 ton/ha
T7	Biofertilizers (Rhizobia+PSB)	20 g/kg seed
T8	50% FYM+ 50%VC + Biofertilizers)	3 ton/ha + 1.1 ton/ha + 20 g/kg seed
T9	50% RDF + 50% FYM	15 N: 25 P2O5: 15 K2O kg/ha + 3 ton/ha
T10	50% RDF + 50% VC	15 N: 25 P2O5 :15 K2O kg/ha + 1.1 kg/ha
T11	50%RDF+Biofertilizer	15 N: 25 P2O5:15 K2O kg/ha + 20 g/kg seed
T12	50%RDF + 25% FYM + 25%VC + biofertilizer	15 N: 25 P2O5: 15 K2O kg/ha +1.5 ton/ha + 0.55 ton ton/ha + 20 g/kg seed

  

Treatments	Germi nation (%)	Days to 50% flowering	Relative growth rate Days after sowing 20-40	40-60	60-harvest	Seed yield (Kg ha-1)	Strover yield (kg ha-1)
T1	81.00	34.5	0.295	0.184	0.050	535.00	680.33
T2	84.00	35.3	0.333	0.481	0.255	890.00	841.33
T3	82.67	36.4	0.400	0.587	0.326	1190.00	1249.00
T4	85.82	37.5	0.424	0.564	0.370	1386.67	1224.00
T5	85.55	32.6	0.355	0.546	0.171	977.00	928.00
T6	85.00	31.0	0.360	0.547	0.180	1002.00	949.00
T7	88.44	30.3	0.344	0.543	0.206	952.00	883.67
T8	87.50	33.0	0.334	0.510	0.222	912.00	920.00

Treatments	Germi nation (%)	Days to 50% flowering	Relative growth rate Days after sowing 20-40	40-60	60-harvest	Seed yield (Kg ha-1)	Strover yield (kg ha-1)
T9	86.00	35.3	0.387	0.529	0.210	1052.00	985.00
T10	86.44	35.0	0.399	0.522	0.165	1113.00	1035.33
T11	88.50	35.3	0.365	0.552	0.200	1045.00	973.00
T12	88.00	34.3	0.404	0.582	0.213	1272.00	1235.00
SEm±	1.88	1.4	0.009	0.028	0.036	51.49	32.23
CD (p=0.05)	NS	4.1	0.026	0.084	0.107	152.00	95.15

**Table 3. yield attributes and yield of Mung Bean (*Vigna radiate* L.) as Influenced by Integrated Nutrient supply [24]**

Treatment	No. of pods/plant	Grains/ pod	1000-Seed weight (g)	Seed yield q ha <sup>-1</sup>
T <sub>1</sub> Absolute control [No fertilizer/biofertilizer]	13.17	5.03	32.80	7.72
T <sub>2</sub> Recommended dose of fertilizers [NPK=30:60:30]	14.11	6.47	35.16	9.17
T <sub>3</sub> 20 kg N/ha applied as basal with dual inoculation [source Urea]	14.87	6.80	37.54	9.97
T <sub>4</sub> 20 kg N/ha applied as basal without inoculation [source Urea]	14.02	6.57	36.62	9.12
T <sub>5</sub> 40 kg P <sub>2</sub> O <sub>5</sub> /ha applied as basal with dual inoculation [source DAP]	16.09	7.97	40.09	10.87
T <sub>6</sub> 40 kg P <sub>2</sub> O <sub>5</sub> /ha] applied as basal without inoculation [source DAP]	15.71	7.60	39.45	10.14
T <sub>7</sub> 20 kg N/ha + 40 kg P <sub>2</sub> O <sub>5</sub> /ha with inoculation [Rizobium]	17.39	8.60	42.60	11.12
T <sub>8</sub> 20 kg N/ha + 40 kg P <sub>2</sub> O <sub>5</sub> /ha with inoculation [PSB]	17.15	8.23	42.11	11.02
T <sub>9</sub> 20 kg N/ha + 40 kg P <sub>2</sub> O <sub>5</sub> /ha with inoculation [Rizobium + PSB]	19.03	9.55	44.39	13.23
T10 20 kg N/ha + 40 kg P <sub>2</sub> O <sub>5</sub> /ha without any inoculation	15.20	7.53	39.27	10.07
SE(m)±	0.78	0.43	0.72	0.84
CD (P=0.05)	2.03	1.16	1.71	2.17

However, no statistical difference was found between seed yield (1386.67 kg/ha) with 125% RDF (T4) and seed yield (1272.00 kg/ha) with 50 percent RDF + 25 percent FYM + 25 percent VC + biofertilizer (T12). Treatments 100 per cent RDF (T3), 50 per cent RDF + 50 per cent VC (T10), 50 per cent RDF + 50 per cent FYM (T9) and 50 per cent RDF + biofertilizers (T11) were on par with each other. Maximum stover yield (1249.00 kg/ha) was recorded with 100 per cent RDF (T3), showing an increase of 83.59 per cent over control, but remained statistically equal to stover yield (1235.00 kg/ha) with 50 per cent RDF + 25 per cent FYM 25 per cent VC + biofertilizer (T12) and stover yield (1224.00 kg/ha) with 125 per cent RDF + 25 per cent FYM

25 per cent VC + biofertilizer (T12) (T4). All treatments had significantly higher stover yields compared to higher seed yields and stover yields associated with higher inorganic fertilisation may be due to higher availability of NPK to the crop. Furthermore, higher seed and stover yields by the use of inorganic fertilisers in combination with organic manures may be due to increased availability and uptake of macro and micro nutrients resulting in higher photosynthesis, tissue differentiation, translocation of assimilates, etc., leading to higher seed and stover yields [23].

Table 3 study of the Yield and Yield attributes of Mung Bean (*Vigna radiate* L). Found that the

**Table 4. Effect of phosphorus levels and bio-fertilizers on yield attributes and seed yield of field pea [26]**

Treatments	Seed yield (q ha <sup>-1</sup> )	Stover yield (q ha <sup>-1</sup> )
Control	10.06	23.76
50% recommended dose of P	12.64	27.45
75% recommended dose of P	14.50	31.24
100% recommended dose of P	15.85	33.63
SEm ±	0.16	0.78
CD (p=0.05)	0.55	2.34
Control	10.81	27.01
Rhizobium	13.87	31.89
PSB	13.14	30.09
Rhizobium + PSB	15.01	33.90
SEm ±	0.29	0.66
CD (p=0.05)	0.87	1.98
Interaction	1.77	N.S.

highest number of pods per plant was achieved with treatment T9 with 20 kg N/ha-40 kg P2O5/ha with inoculation Rhizobium and PSB with 19.03, which is significantly higher than the other treatment indicated in Table 4. Whereas Grain per pod, 1000 seed weight and seed yield were recorded as 9.55, 44.39 and 13.23, respectively. From the study it is revealed that Integrated nutrient management play pivotal role in overall growth and production of Mung Bean [25].

Table 4 Dual Inoculation of Rhizobium + PSB was studied and the highest yield of seed (15.01 q ha<sup>-1</sup>) and stover yield (33.90 q ha<sup>-1</sup>) was recorded and the magnitude of increase was 38.85, 8.21 and 13.91 per cent compared to control, Rhizobium and PSB alone in the case of seed yield, whereas the magnitude of increase was 25.50, 6.30 and 12.66 per cent compared to control and this is demonstrated. The synergistic effect of Rhizobium and PSB may have increased growth, yield attributes and, ultimately, yields due to increased nitrogenase activity and available soil P status [27].

## 10. CONCLUSION

- Pulses are most sustainable crop utilizing less quantity of water as compare to others.
- Effective dose of sufficient and balanced quantities of organic and inorganic fertilizers in combination with specific microorganisms, called INM, has a bright solution in this area.
- Recently, several investigators reported

that integrated use of chemical fertilizers with organic manure is becoming a quite promising practice not only for maintaining higher productivity but also for greater stability to crop production.

- Decreasing the enormous use of chemical fertilizers and accreting a balance between fertilizer inputs and crop nutrient requirement, maintaining the soil fertility.
- Optimizing the level of yield, maximizing the profitability, and subsequently reducing the environmental pollution.
- The review clearly indicates that integrating inorganic that's (50%), organic and bio-fertilizers are crucial in realizing the higher growth, yield and yield attributes of Legume crops and reducing cost of cultivation by practicing integrated manner. This practices not only improve yield but also improves physic chemical properties of soil.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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