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Effects of Phosphorus Fertilizer on Agronomic, Grain Yield and Other Physiological Traits of Some Selected Legume Crops

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Abstract
Phosphorous is another nutrient that is critically important for legumes and the clover plants that are fixing nitrogen, but all plants need phosphorous as they do nitrogen. Legumes need a higher level of P fertility than the neighbouring grass plants. Phosphorus is vital for plant growth, and is a component of the nucleic acid structure of plants and bio-membranes. Therefore, it is important in cell division and tissue development. It is also involved in the energy metabolism of cells and is required for the biosynthesis of primary and secondary metabolites in plants. Legume crops requires less nitrogen but application of phosphorus and potassium plays a vital role in getting high yield per unit area. The application of phosphorus increases dry matter at harvest, number of pods plant^{-1}, seeds pod^{-1}, 1000 grain weight, seed yield and total biomass of mung bean. The experimental results of different authors stated that the highest number of pod plant^{-1} and grain yield of soyabean were obtained from maximum level of phosphorus as compared to other treatments. common bean crop dependent on nitrogen fixation needs more inorganic phosphorus than the same crop provided with mineral nitrogen. Common beans are therefore especially susceptible to low soil phosphorus when accompanied by low soil. Phosphorus also plays an important role in biological nitrogen fixation, for the symbiotic fixation of nitrogen to occur, the roots have to interact with compatible rhizobia in the soil and factors that affect root growth or the activity of the host plant would affect nodulation. however, the rate of phosphorus is varied from place to place, or it's governed by the amount of P status in the soil. Since, legume crops demanding more P than other nutrient, we have to apply it obtained best grain yield.
Keywords: Bacteria, Dry matter, Grain yield, Legume and Nodule
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INTRODUCTION

Adequate phosphorus nutrition enhances many aspects of plant physiology, including the fundamental processes of photosynthesis, root growth particularly development of lateral roots and fibrous rootlets (Brady and Weil, 2002) cited by Hagos and Hailemariam 2016.

The effects of land degradation and rapid population growth, addressing poor soil fertility in the farming land in the tropics including Ethiopia has become a major issue to achieve food security at household level (FAO, 2014). The root causes of the current low soil fertility problem in this part of the country are soils of inherent low fertility; continual nutrient mining due to continues cropping without replacement of nutrients taken together with the harvest and top soil removal through water erosion. The advanced production technology stresses on the use of appropriate level of fertilizers which is a key input contributing about 30-70% increase in crop yield. Being a legume crop it requires less nitrogen but application of phosphorus and potassium plays a vital role in getting high yield per unit area. They concluded that number of pods per plant, number of seeds per pod and seed weight were the highest with the application of phosphorus fertilizer. Sandhu (1993) also reported that application of phosphorus is essential to harvest good yield of mung bean on a sandy loam soil appeared to be the best level. There are many factors and conditions that impact plant nutrient needs. The use of fertilizer is considered to be one of the most important factors to increase crop yield on per unit basis. The application of phosphorus to mung bean has been reported to increase dry matter at harvest, number of pods plant^{-1}, seeds pod^{-1}, 1000 grain weight, seed yield and total biomass (Naeem *et al.* 2000; Wondimkun and Hailu, 2022). Legumes have a high phosphorus requirement for growth and also for nodulation and nitrogen fixation (Gill *et al*., 1985). Phosphorus deficiency, common in tropical soils, is therefore a major factor contributing to poor nitrogen fixation and yield of legumes, and P fertilization results in improved growth (Shoitsu *et al*., 1988). Being a legume crop it requires less nitrogen but application of phosphorus plays a vital role in getting high yield per unit area. Phosphorus is one of the essential mineral macronutrients, which is required for maximum yield of cultivated crops. Most of the essential plant nutrients, including phosphorus, remain in insoluble form in the soil (Abd-Alla, 1994; Yadav and Dadarwal, 1997). Phosphorus is vital for plant growth, and is a component of the nucleic acid structure of plants and bio-membranes. Therefore, it is important in cell division and tissue development. Phosphorus is also involved in the energy metabolism of cells and is required for the biosynthesis of primary and secondary metabolites in plants (Yagoob, 2015). He also stated that, consequently plants have evolved a range of strategies to increase phosphorus uptake and mobility. So, the main objective of this review paper is to assess the role of phosphorus fertilizer rate for better pulse crop production and its economic value.

LITRATURE REVIEW

Effect of Phosphorus Fertilizers on Growth and Physiological traits of Soy bean

Soybean (*Glycine max* (L.) Merrill) is one of the most cultivated crops across a wide range of the world even including Ethiopia (Giller and Dashiell, 2007) because of its nutritional, industrial and economic importance. Soy bean is relatively new crop in Africa according to (Mideksa, 2020). Till today, it was seen as being applicable only for large- scale commercial farming for production of seed that are used in making livestock feed. The major soybean producing countries in the world are the United States, Brazil, China, Nigeria, India, Argentina, South Africa and Uganda (IITA, 2009). The economic viability of soybean production is determined by the commercial utilization of both its sub-products, meal and oil, which, respectively, account for about two thirds and one third of the crop's economic value. Soya bean oil and meal is consumed worldwide as food and animal feedstuff respectively (UNDP, 2015). It is also the most important legume worldwide due to its versatile uses as a human food, animal feed and its role in soil amelioration (Mideksa, 2020). Soybean can grow in *Woina Dega* (middle highland) and *Kola* (low land) areas of the country. The potential areas for soybean are: Southern Nations Nationalities People region, Oromia region, Benshangul Gumuze region (Metekel, Kamashe and Asosa areas); Amahara and Tigray regions are expected to be more appropriate for soybean production (Miruts, 2016). The experimental results of Ojo *et al*. (2016) and Ferguson *et al.* (2006) which revealed that the highest number of pod plant^{-1} and grain yield of soyabean were obtained from maximum level of phosphorus as compared to other treatments.

The results of different founding's indicated that shoot dry matter, root dry matter and biological yield of soybean cultivars were significantly affected by the application of different source of phosphorus fertilizers, the highest values for shoot dry matter, root dry matter and biological yield were given by the application superphosphate fertilizers (Darwesh *et al*., 2013). They also revealed that the combination between cultivars and phosphorus fertilizers affected significantly the protein, nitrogen, potassium and phosphorus concentration. This result could be explained on the ground that the addition of convenient source of phosphorus fertilizer increase the nutrient content of soyabean plant, via enhancing the root growth and increasing the root hair length, beside increase the root surface area (Jabaji-Hare, 1987). Its plant height, straw and grain yield were significantly affected by different rates of phosphorus the important component of straw yield and may also affect the grain yield. As a result of this P accumulation, we expected soya bean fields to have higher concentrations of Phosphorus (Syers *et al*., 2008). The high P-binding capacity of soils would keep P surpluses in the upper soil, and that P transport deeper in the soil column is relatively small (Hansen *et al*., 2002). This experimental result was supported by the graph indicated below.

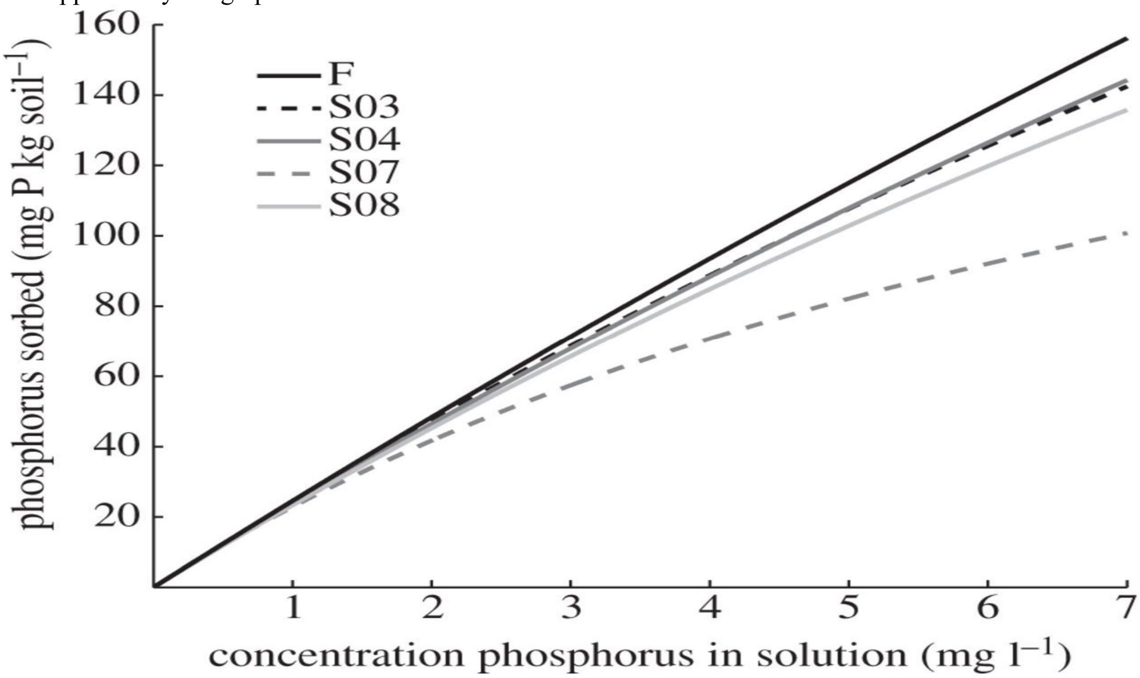

Figure 1. Phosphorus (P) sorption isotherms for each land use at 10 cm depth. Land uses are forest and soybean fields converted to soya bean (Scheffler *et al*., 2011).

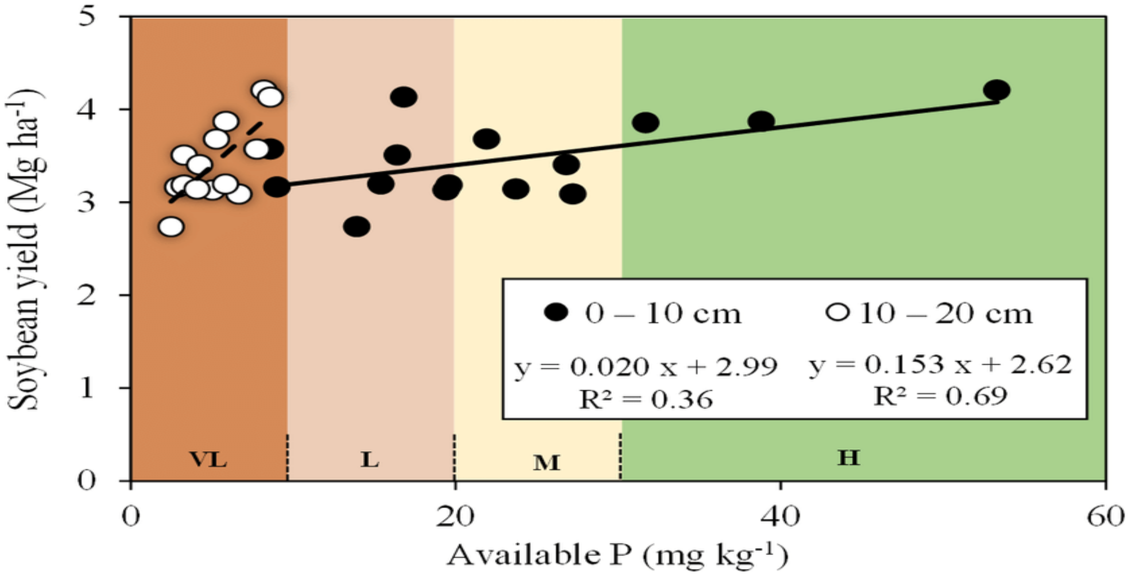

Figure 2. Relationship between soybean grain yield and available phosphorus (P) in 0–10 and 10–20 cm soil layers, in an integrated crop–livestock system in the Brazilian subtropical region (source Luiz *et al*.,2020).

Review on effects of phosphorus fertilizer rates on growth, yield components and yield of common bean (Phaseolus vulgaris L.)

Common bean has high nitrogen requirement for expressing their genetic potential. Even though, common bean has the ability to fix and use atmospheric nitrogen with regards to soil fertility and mineral nutrition requirement, phosphorus is considered as the first and nitrogen as the second limiting plant nutrient for bean yield in the tropical zone of cultivation (CIAT, 1997). Phosphorus plays an important role in biological nitrogen fixation, for the symbiotic fixation of nitrogen to occur, the roots have to interact with compatible rhizobia in the soil and factors that affect root growth or the activity of the host plant would affect nodulation (Graham, 1984 and Freire, 2006). The bacterial growth, nodule formation, and the biological nitrogen fixation activity itself are processes that are dependent on the energy supplied from the sugars that need to be transacted down ward from the host plant shoots. So, phosphorus is the basis for the formation of useful energy, which is essential for sugar formation and translocation (Graham, 1984; Israel, 1987) reported that common bean crop dependent on nitrogen fixation needs more inorganic phosphorus than the same crop provided with mineral nitrogen. Common beans are therefore especially susceptible to low soil phosphorus when accompanied by low soil. Phosphorus is a major constraint to common bean production in the tropics and east Africa like Ethiopia (Allen *et al*, 1997). In the tropics, the amount of available phosphorus in soils is largely in sufficient to meet the demand of legumes and thus phosphorus deficiency is widespread in pulse crops. However, in Ethiopia the highest rate of P_2O_5 ha^{-1} recommended for common bean production in semi-arid zones of Central Rift Valley of it (Girma, 2009). Phosphorus is the most important element for adequate grain production of common bean (Brady and Weil, 2002). The yield of common bean increases with P_2O_5 application (Gemechu,1990). The experimental results of Getachew (1990) reported that lack of optimum fertilizer rate is one of the several factors contributing to the low grain yield of the common bean in the production areas. The result of (Degife and Samuel, 2019; Shubhashree., 2007) they reported that number of seeds per pod increased significantly to levels of phosphorus added. The increment of seeds per pod of common bean is increased with application P fertilizer up to optimum level might be for nodule formation, protein synthesis, fruiting and seed formation. Phosphorus is an essential plant nutrient which involves in all physiological activities of the common bean production (Hagos and Hailemariam, 2016). Application of the correct level of fertilizer is necessary to achieve maximum yield of common bean crop (Legesse *et al*., 2006). The study of Meseret and Amin (2014) revealed that application of different levels of phosphorus has significantly increases dry matter yield, grain yield and other yield component of common bean.

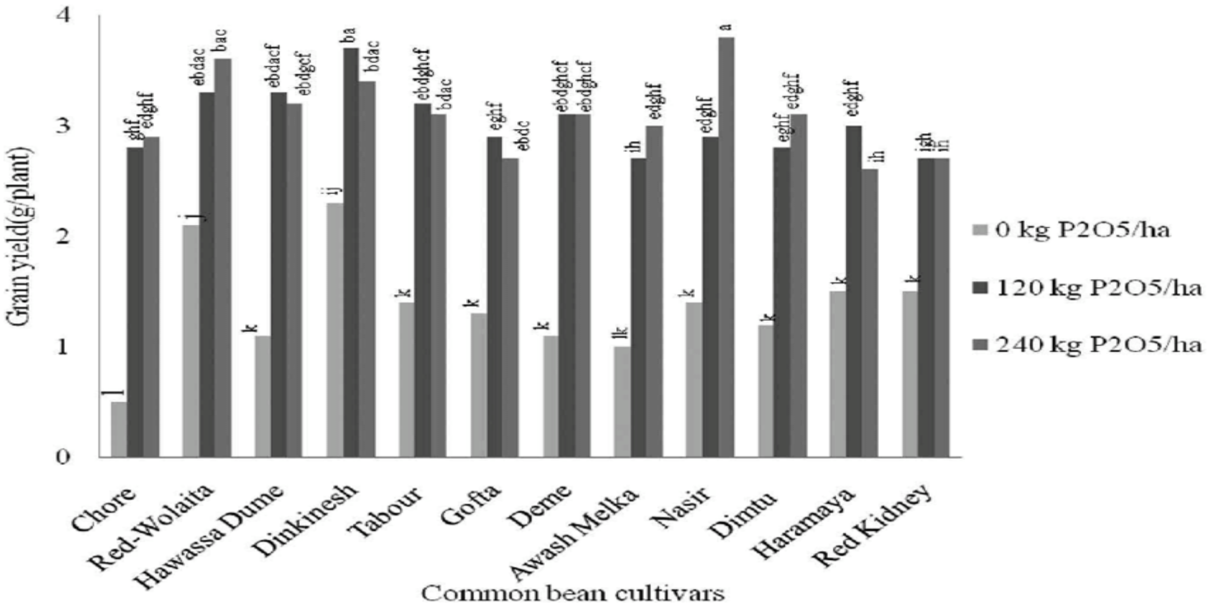

Figure 3. Grain yield of common bean cultivars with three phosphorus levels at Hawassa University, southern Ethiopia (Dereje et al., 2018).

Effects of phosphorus fertilizer rates on growth, yield components and yield of Mung bean

Mung bean (*Vigna radiata*) is one of the important annual pulse crops that belong to family *fabacaae*. It is originated from India and Expanded to East, South, Southeast Asia (China) and some countries in Africa (Mesele *et al*., 2015). It is a warm season annual grain legume the optimum temperature ranges from 27^{o}c to 30°C it is requiring 90 to120 days of frost-free for maturity (Degefa, 2016). Mung bean is an essential short duration, self-pollinated diploid legume crop with high nutritive values and nitrogen fixing ability. It is an eco-friendly food grain leguminous crop of dry land agriculture with rich source of proteins, vitamins, and minerals. The performance of leguminous plants is determined mainly by their pod and seed-bearing capacity. The findings of (Taminaw and Eman, 2021; Wondimkun and Hailu, 2022; Khan *et al*, 1999) they revealed that maximum number of seeds per pod, thousand seed weight, grain yield and other physiological traits were recorded from treatments receive the maximum phosphorus fertilizer. The experimental results of Gill *et al*. (1985) also observed that phosphorus fertilizer significantly increased seeds/pods, grain yield and harvest index compared with check plots. The experimental results of Ali *et al.* (1996); Bonepally *et al*. (2021); Thavaprakaash (2017); Siddaraju *et al*. (2010), they observed significant higher plant height in mung bean crop when fertilized at the rate of 100 kg ha^{-1} phosphorus.

The experimental results of Veeresh (2003), Shubha Shree (2007), Meseret and Amin (2014) they reported that applications of different rates of phosphorus fertilizer influence number of pod per plant. They also stated that a greater number of pods per plant of common bean at application rate of 75 kg P_2O_5 ha^{-1}. The experimental results of Singh and Singh (2000) was also supported who reported that significant increase in number of pods per plant, due to increased P fertilization. The increment of number of pods per plant may be due to application of P fertilizer confirms with P fertilizer promotes the formation of nodes and pods in legumes. These results agree with Wondimkun and Hailu (2022); Ahmad *et al*. (2015); Malik *et al*. (2004) who reported that P induced significant increase in pods plant^{-1}, they also reported that phosphorus up to maximum level, significantly increase number of pod plant^{-1}. The experimental results of Lake and Jemaludin, (2018); Arega and Zenebe 2019); Deresa *et al.* (2018), also stated that, the increase in number of pods per plant with the increased P rates might possibly be due to adequate availability of P nutrients which might have facilitated the production of more branches and canopy development, which might, in turn, have contributed for the production of higher number of total pods. The main reason of low productivity of mung bean agrology is due to improper use of fertilizer doses on marginal and sub marginal lands results in low fertility in soils (Khan *et al*. 2020). Phosphorus is an essential nutrient next to nitrogen for plant growth and best production of mung bean. Similar with other legume crops Phosphorus has been identified as one of the most limiting nutrient elements in tropical soils, which is responsible for the reduction of the total vegetative growth, secondary branches, leaf development and finally yields of mung bean on all types of soil (Khan *et al*. 2020). The experimental data reveal that the grain yield was significantly influenced by different levels of phosphorus. The Maximum grain yield of mung bean was recorded with 45 kg P_2O_5 ha^{-1} whereas, the minimum grain was recorded with control (Yadav and Luther 2005). Grain yield per hectare was commensurate with yield attributes like number, and length of pod, number of seed pod^{-1}

(45 kg P_2O_5 ha^{-1}) was most appropriate and suitable levels of phosphorus for grain yield per hectare (Muhammad *et al*., 2004). Grain yield gradually increased with the increase in the levels of phosphorus as compared to control (Johstan *et al*., 2001; Lal, 2004 and Jat *et al*., 2012).

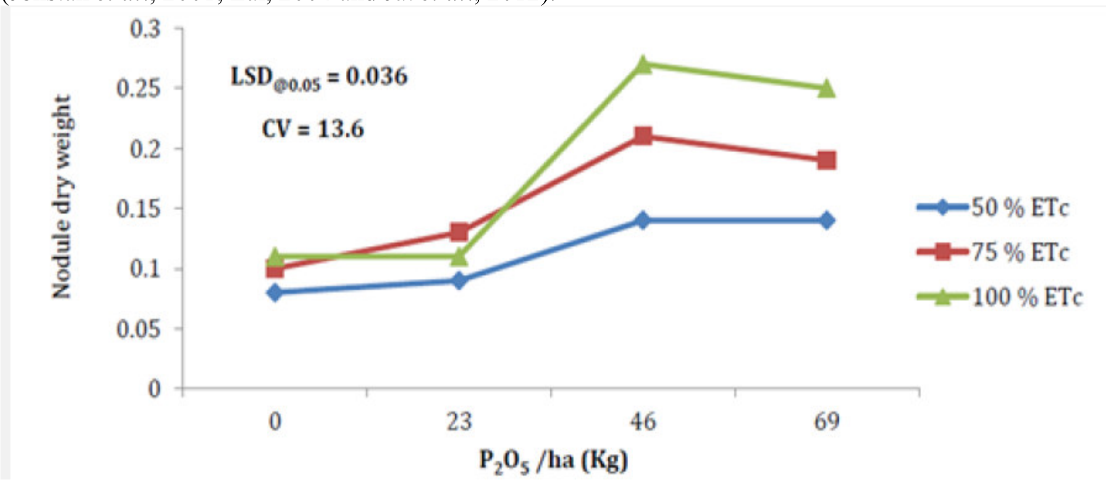

Figure 4. The interaction effects of irrigation levels and phosphorus rates on number nodule $plant^{-1}$ (Arebu *et al*., 2019)

Effects of phosphorus fertilizer on Agronomic and grain yield of chick pea

Chickpea (Cicer arietinum L.) crop performance is depended on cultivar performance and environmental area. The most important factors of limiting chickpea production and low yield in the Southeast Anatolia of Turkey are anthracnose, inadequate moisture, late sown and poor soil deficit nutrient (BICER, 2014). The author also stated that, plant nutrient has significant effects on yield and yield component, also suitable cultivars and correct consumption of fertilizers lead to optimum uses of soil and environmental factors that produce. The high yield and yield component (Khourgamy and Farnia, 2009). Phosphorus (P) is a key nutrient element required for high and sustained productivity of grain legumes such as chickpea. The low soil phosphorus and poor utilization efficiency of phosphorus is a major constraint limiting the productivity of most grain legumes (Aulakh *et al*., 2003; Sheikh and Siadat, 2003). Many studies found a positive yield response of chickpea to phosphorus fertilizer (Islam *et al*., 2011) but the rate of P required varies according to growth conditions (Chen *et al*., 2006) as cited by (BICER, 2014). In chickpea production inoculated plants with G. mosseae and G. intraradices showed more leaf phosphorus, root fresh and dry weight, root length and volume than control. Root related traits such as root fresh and dry weight, root length and root volume increased in more phosphorus application and consequently will lead to increase above-ground dry matter of chickpea. Relationships between traits showed that with increasing leaf phosphorus, root dry weight and root volume in inoculated mycorrhizal chickpea plants enhanced above-ground dry matter for chickpea production (Yagoob, 2015). The initial reduction ingrowth related to phosphorus deficiency has an ultimate effect on the final crop yield, which is experienced by the crop throughout the remaining of the growing period. Phosphorus is critical for plant growth and makes up about 0.2% of dry mass, but it is one of the most difficult nutrients for plants to acquire. In soil, it may be present in relatively large amounts, but much of it is poorly available because of the very low solubility of phosphates iron, aluminium, and calcium, leading to soil solution concentrations of 10 mM or less and very low mobility (Ryan *et al*. 2005). The balanced nutrient application for crop production is essential and their imbalance use reduces crop yields. The leaves are green factories where the complex chemical processes of photosynthesis produce the compounds, plants needed for growth. All sources of nutrients may be applied to crops and advocated that foliar fertilization is widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots (Frossard *et al*., 2000). Phosphorus (P) is an essential nutrient both as a part of several key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. Phosphorus is noted specially for its role in capturing and converting the sun's energy into useful plant compounds; thus, P is essential for the general health and vigor of chickpea. The chickpea growth factors that have been associated with Phosphorus are: stimulated root development, increased stalk and stem strength, improved flower formation and seed production. Application of phosphorus fertilizer leads for more uniform and earlier crop maturity, increased nitrogen N-fixing capacity of legumes, improvements in crop quality, and increased resistance to plant diseases (Shabeer *et al*., 2015). However, phosphorus transformations and mobility in the soil-plant system are controlled by a combination of biological, chemical and physical processes.

Effects of Phosphorus on Bacterial Root Nodulation

Nodule growth (and the proportion of nodule biomass) is more likely to be regulated by another feedback mechanism, related to the N content of the plant (Valverde *et al*., 2000; Wall, 2000). Seedlings that formed a normal number of nodules with low P supply could also regulate their distribution, whilst, seedlings that did not receive any external supply of P and that showed a clear P deficiency for growth, could develop some nodules (Claudio *et al*., 2002). They also stated that, differentiation of Frankia into vesicles was observed within these nodules, although carbohydrate metabolism was apparently impaired in noninfected cells of the symbiotic tissue. The response of early nodulation to P supply might be related to the content of P in the seeds. A high P content in the seeds could facilitate the establishment of the symbiosis though further growth would be more dependent on external P supply (Wall,2000, Claudio *et al*., 2002). In account with this possibility, we observed that nodule development was re-established in P deficient seedlings once P nutrition was resumed, suggesting that some infection events had occurred at the moment of inoculation but that their development was arrested by lack of P (Valverde and Wall, 1999). Hussain and Faridullah (2003) indicated that P is vital for healthy plant growth. Optimal level of phosphorus initiates root growth, increased flowering and fruit preparation that finally resulted in enhanced seed productivity. The availability of sufficient phosphorus increases the chances of uniform ripeness and early maturity, legumes increase nitrogen-binding capacity, harvest quality and increase resistance to plant diseases. The founding of Solis (2013) was stated that, application of phosphorous has a direct and significant effect on grain yield of legume crops. This accumulation of **P_2O_5** in seeds could be interpreted as an adaptive strategy to ensure initial growth of the seedling after germination and establishment of the symbiosis with filamentous bacteria (Claudio *et al*., 2013; Hellsten and Huss-Danell, 2001**)**. The requirement for external **P_2O_5** would arise later on and may be acquired directly by root exploration of soil or be complemented by the establishment of an additional symbiosis with mycorrhizal fungi (Almeida *et al*., 2000).

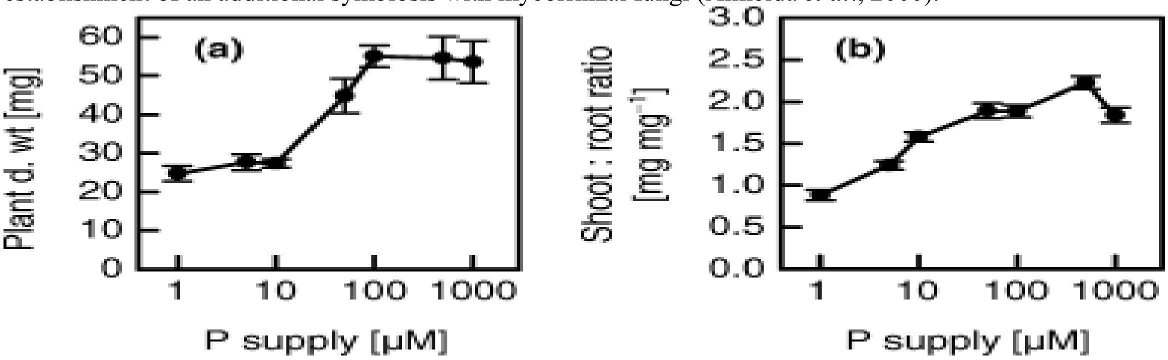

Figure 5. Effect of phosphate on the growth of symbiotic *Discaria trinervis*. Seedlings were grown and inoculated with *Frankia* with different supplies of phosphate in nitrogen-free nutrient solution. (a) Growth is shown as plant biomass and (b) relative allocation of shoot to root ratio (Sources Claudio *et al*., 2002)

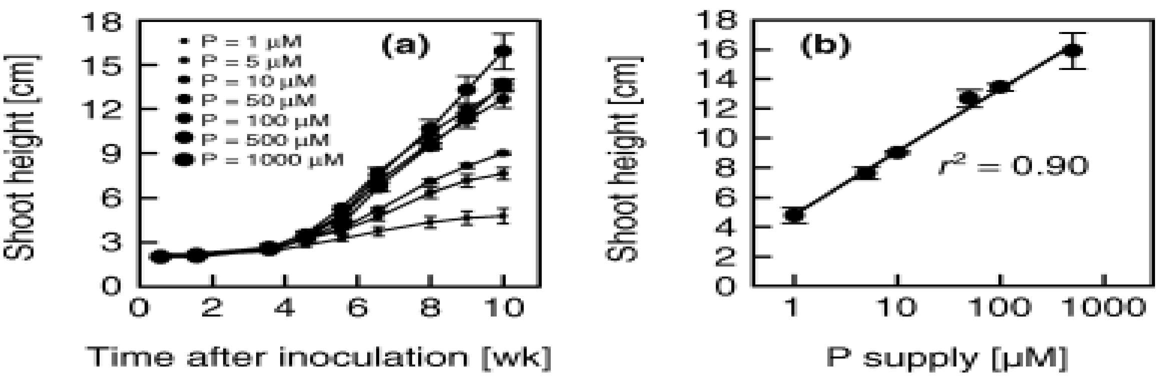

Figure 6. Stimulation by phosphate of shoot development in symbiotic *Discaria trinervis*. (a). Time course of shoot height for different phosphate supplies. (b) Correlation between shoot height and phosphate concentration in nutrient solutions (Claudio *et al*., 2002)

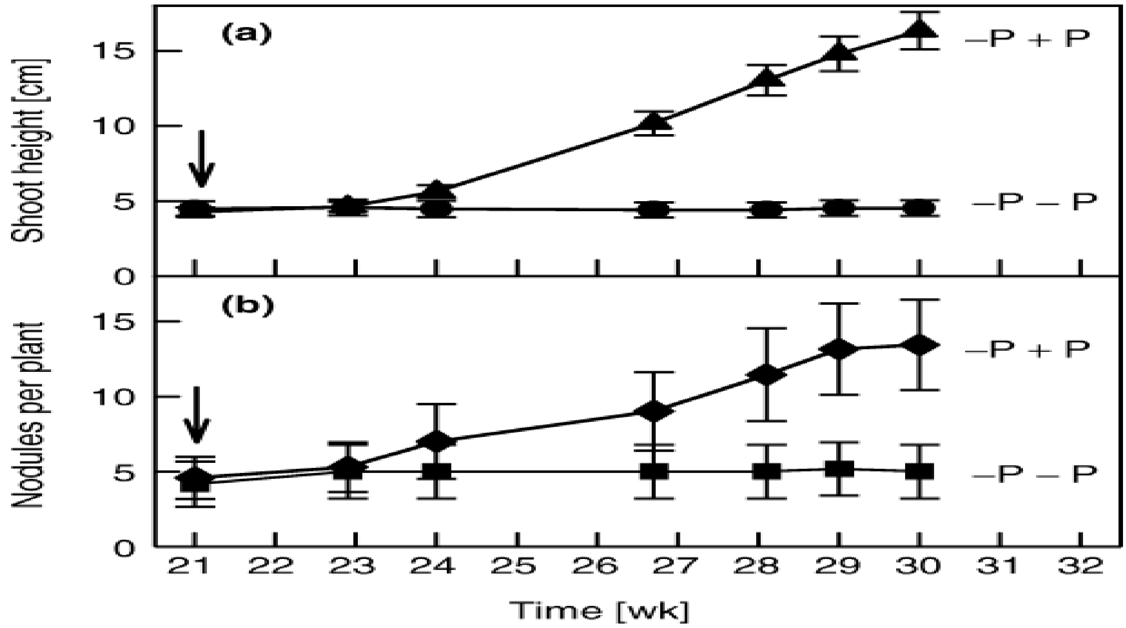

Figure 7. Recovery of *Discaria trinervis* seedlings from phosphate deficit. (a) Time course of shoot height of *D. trinervis* seedlings (b) Time course of number of nodules per plant in *D. trinervis* seedlings (Claudio *et al*., 2002)

Effects of Phosphorus on faba bean production

The lack or low rates of essential elements like, Phosphorus in the soil is one of the factors negatively affect growth and yields of faba bean (Negasa *et al*., 2019). They also stated that, phosphate can readily be rendered unavailable to plant roots as it is the most immobile of the major plant nutrients. The experimental results of Phosphorus fertilization have positive effect on faba bean yield and yield components (El-Gizawy *et al*., 2009). Majumdar *et al*. (1994) found that increasing of phosphorus caused the significant increase on seed yield, nitrogen concentration phosphorus in seeds, stem and leaves of faba bean. Phosphorus application caused to increase fresh weight of plants, number of pods plant^{-1}, number of seeds pod^{-1}, hundred grain weight and grain yield of faba bean (Davood, 2013). The above reported evidence on phosphorus supply being particularly important for high yielding faba bean crops grown under low soil. Phosphorus supply has important implications for production practice in the world (Alves *et al*., 2021). The use of phosphate solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and faba bean yield. The Strains from the genera *Pseudomonas, Bacillus* and *Rhizobium* are the most powerful phosphate solubilizers. The founding's of Rodríguez and Fraga (1999); Keneni *et al*. (2010) indicated best Faba bean production is depends on the presence available phosphorus nutrient. The experimental results of (Shakori and Sharifi 2016) indicated application of the maximum phosphorus fertilizers finally leads to obtained dry matter accumulation and grain yield. They also stated that biological phosphorus fertilizers efficiency increases if combined with 75% chemical phosphorus fertilizers. Adhami *et al*. (1999) reported that dry weight of faba bean increased by application of phosphorus. They had stated increased P uptake, plant nutrition development and possibly further rooted in the soil can be reason of increasing weight of dry air organs. The research results of Turk *et al*. (2002) who revealed that significant increase of seed yield, seed weight plant^{-1}, 100 seeds weight, seeds pod^{-1}, plant height, pod length, pods plant^{-1} and branches plant^{-1} of faba bean with Phosphorus application. Turk *et al*. (1997); Shakori and Sharifi (2016) indicated at low rates of applied Phosphorus, Faba bean expressed some P deficiency symptoms, such as dwarf growth and purpling of the leaves, while such effects were absent at high Phosphorus rates. The positive effect of phosphorus on production of faba bean pods might be attributed to the merit of the nutrient in promoting of both vegetative and reproductive, thereby improving the photosynthetic efficiency and partitioning of carbohydrate to pod yield. Phosphorus is, in fact, the most important growth limiting nutrient factor for pulses including faba bean (Ghizaw *et al*., 1999).

Phosphorus for Legumes, Legumes for soil

Legumes play a significant role in sustainable agriculture through their ability to improve soil fertility and health. Legumes, with a mutual symbiotic relationship with some bacteria in soil, can improve nitrogen (N) amount through biological N-fixation (Mitran *et al*., 2018). However, to maximize such functions, legumes need more phosphorus (P) as it is required for energy transformation in nodules. This nutrient also plays a significant role to root development, nutrient uptake, and growth of legume crops. The deficiency of P causes significant yield reduction in leguminous crops. Improving the PUE of applied fertilizer requires enhanced P acquisition from the soils by crops for growth and development (Wondimkun and Hailu 2022). It is necessary to better exploit soil P resources through increasing labile soil P using leguminous crops in a rotation cycle. Moreover, incorporation of legumes in cropping system with better P management under P-deficient conditions could be a promising tool for improving legume productivity. Root gravitropism may be an important element of plant response to phosphorus availability because it determines root foraging in fertile topsoil horizons, and thereby phosphorus acquisition (Liao *et al*., 2001). Phosphorus availability regulates root gravitropic growth in both paper and solid media, especially the more responses observed in young seedlings continue throughout vegetative growth (Ge *et al*., 2000). The response of root gravitropism to phosphorus availability varies among genotypes, and genotypic adaptation to low phosphorus availability is correlated with the ability to allocate roots to shallow soil horizons under phosphorus stress (Arebu *et al*, 2019; Liao *et al*., 2001).

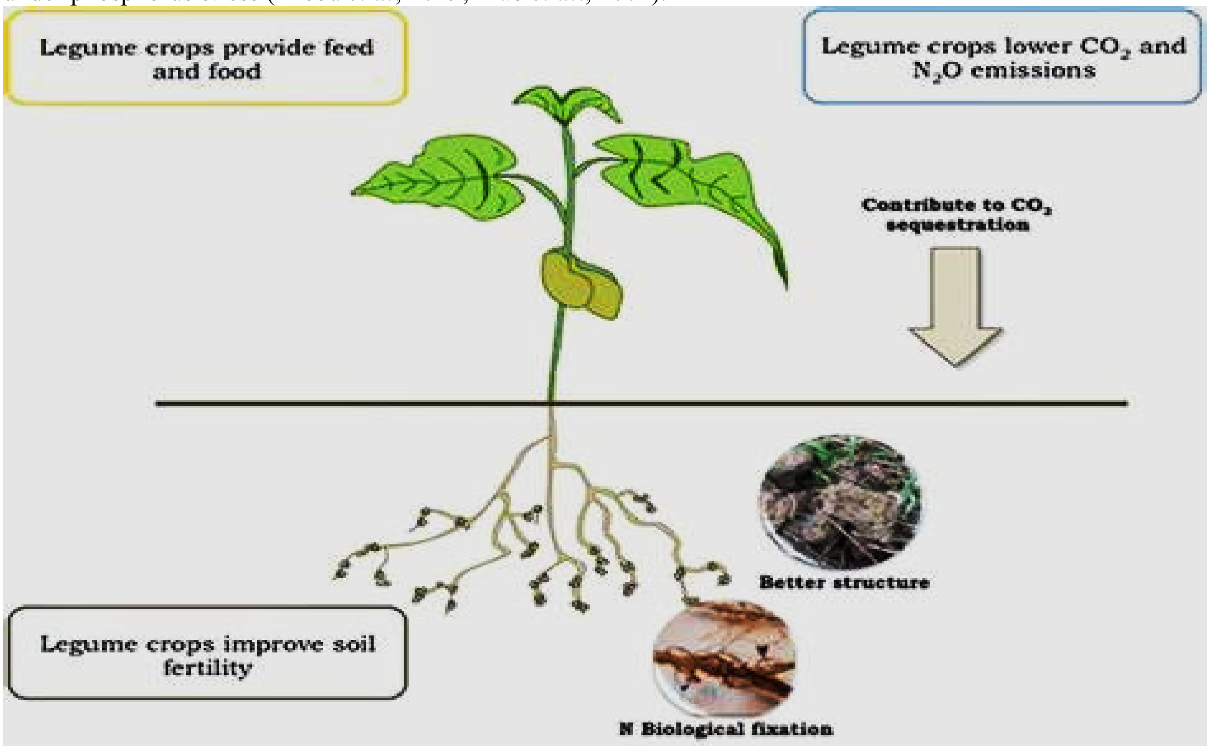

Figure 8. Showed the role of phosphorus on legume crop production (Mitran *et al.*, 2018)

Effects of phosphorus for physiological process legume crops

The rate of root growth, an extension of root hairs, and the plasticity of root architecture are very much important for effective exploration of soil and interception of nutrients (Richardson *et al.* 2009). The recent studies indicated that P enhanced root system which provides greater root-soil contact and eventually higher uptake of P and other important and low mobility nutrients and absorption of higher concentration of mineral nutrients (Zafar *et al*. 2011). Almost all the legumes required P in relatively large amounts for growth and have been reported to promote leaf area, biomass, yield, nodule number, and nodule mass (Kasturi krishna and Ahlawat 1999). P supplement in legumes has great potential for promoting growth and higher yield, increases nodule number, as well as enhances symbiotic establishment for increased N-fixation (Ndakidemi *et al*. 2006). Several studies have reported the important role of P ingrowth and production of legumes in many tropical soils (Buerkert *et al*. 2001; Ohyama, 2010; Kisinyo *et al*. 2012). The low availability of P in the bulk soil limits plant uptake. So, there is a need to study how beneficial bacteria and P application can affect the uptake of nutrients in leguminous crops (Ndakidemi *et al*. 2011; Olivera *et al*. 2004) reported that the application of P significantly increased root and shoot P concentration (six- and fourfold, respectively) and nodule biomass(fourfold) in common bean (Phaseolus vulgaris L). Makoi *et al*. (2013) reported that Rhizobium inoculation significantly increases the uptake of P, potassium (K), magnesium (Mg), zinc (Zn), Fe, and Ca in different plant organs. Weisany *et al*. (2013) reported that the leguminous crops take up small amounts of nutrients relatively in the early season, but as they grow, the nutrient uptake increases. The brady rhizobium inoculants have been developed and are primarily used for supplying N to plants, and inoculation enhances the uptake of P, K, S, Mn, Fe Ca, Mg, B, Cu, Mo, and Zn in leguminous plants. A number of researchers have reported that the application of P fertilizers and inoculation with Brady rhizobium significantly enhanced nodulation, shoot biomass, and grain yield and improve symbiotic nitro-gen fixation of mash bean crop (Zaman *et al.* 2008; Vance, 2001; Meena *et al*. 2017). The experimental results of Tessema and Alemayehu (2015) they reported that application of P_2O_5 forced the common bean to early flowering as compared to other control treatment. This could be because of increased cytokinin synthesis (Horgan and Wareing, 1980) and supply of photosynthates (Marschner, 2012) for flower formation. Perhaps, P deficiency has been related to the reduction in foliar expansion (Fredeen *et al*., 1989), decrease in the number of leaves (Lynch *etal*., 1991) and loss in photosynthetic efficiency (Lauer *etal*., 1989).

SUMMARY AND RECOMMONDATION

Phosphorus is one of the essential nutrients for legume growth and phosphorus in biological nitrogen fixation. Its deficiency can limit nodule number, leaf area, and biomass and grain development in legumes. The shoot dry matter, root dry matter and biological yield of soybean cultivars are significantly affecting by the application of different source of phosphorus fertilizers, the highest values for shoot dry matter, root dry matter and biological yield were given by the application superphosphate fertilizers. Phosphorus is the most important element for adequate grain production of common bean. It is the basis for the formation of useful energy, which is essential for sugar formation and translocation common bean crop dependent on nitrogen fixation needs more inorganic phosphorus than the same crop provided with mineral nitrogen. So, beans are therefore especially susceptible to low soil phosphorus when accompanied by low soil phosphorus nutrient. Phosphorus is a major constraint to common bean production in the tropics and east Africa like Ethiopia. Phosphorus (P) is a key nutrient element required for high and sustained productivity of grain legumes such as chickpea across the production areas. Similar with other legume crops Phosphorus has been identified as one of the most limiting nutrient elements in tropical soils, which is responsible for the reduction of the total vegetative growth, secondary branches, leaf development and finally yields of mung bean on all types of soil. In most of the experimental results of different researchers the maximum grain yield of mung was obtained from maximum levels of phosphorus. The response of early nodulation to P supply might be related to the content of P in the seeds. A high P content in the seeds could facilitate the establishment of the symbiosis though further growth would be more dependent on external P supply. The availability of sufficient phosphorus increases the chances of uniform ripeness and early maturity, legumes increase nitrogen-binding capacity, harvest quality and increase resistance to plant diseases. This accumulation of $\mathbf{P_2O_5}$ in seeds could be interpreted as an adaptive strategy to ensure initial growth of the seedling after germination and establishment of the symbiosis with filamentous bacteria. The rate of phosphorus is varying across the world and affected by agro-ecologies. Therefore, this review paper recommended that application optimum rate of phosphorus enables to obtained the best grain of legume crops.

REFFERENCES

Abd-Alla MH. 1994. Phosphatases and the utilization of organic phosphorus by Rhizobium leguminosarumbiovarviceae. Appl. Microbiol. 18: 294-296.

Adhami A, Ronaghi A. 1999. Effect P and Zn on growth and chemical content in corn, bean, soybean and faba bean. Proceeding of 6th Congress of Soil Science. University of Mashhad, Ferdowsi.

Arebu H, Walelign W, Moltot Z. 2019. Effects of Deficit Irrigation and Phosphorus Levels on Growth, Yield, Yield Components and Water use Efficiency of Mung Bean (Vigna radiata (l.) Wilczek) at Alage, Central Rift Valley of Ethiopia. *Agri Res and Tech: Open Access* J. 21(3): 556167.

Almeida JPF, Hartwig UA, Frehner M, Nösberger J, Lüscher A. 2000. Evidence that P deficiency induces feedback regulation of symbiotic N2fixation in white clover (Trifolium repens L.). Journal of Experimental Botany51: 1289 –1297.

Alves S., Murphy K., Carroll J., Deverell I., Plunkett M., Wall D. and Hennessy M. 2021. Phosphorus fertilisation of faba bean. *Legumes Translated Practice* Note 29. Teagasc.

Ahmad, S., Khan, A. A., Ali, S., Imran I. M. and Habibullah, M. 2015. Impact of Phosphorus Levels on Yield and Yield Attributes of Mung bean Cultivars under Peshawar Valley Conditions. *Journal of Environment and Earth Science*. Vol. 5, No. 1.

Allen D.J., Ampofo K.A. and Wortmann C.S. 1997. Field Problems of beans in Africa. CITA and Centre for Tropical Agriculture (CTA). International Livestock Research Institute (ILRI), Addis Ababa.

Ali A., Malik, M. A. Ahmed, R. and Atif, T.S. 1996. Response of Mung bean (Vigna rediata L) to Potassium fertilizer. Pakistan. J. Agric, Sci 33(1 - 4);44 – 45.

Arega, A., and Zenebe, M. 2019. Common Bean (Phaseolus vulgaris L.) varieties response to rates of blended NPKSB fertilizer at Arba Minch, Southern Ethiopia. Advances in Crop Science and Technology, 7(3), 429.

Aulakh M.S., Pasricha N.S., Bahl G.S. 2003. Phosphorus fertilizer response in an irrigated soybean-wheat production system on a sub-tropical, semiarid soil. Field Crops Res., 80:99-109.

Bonepally Rashmitha, Umesha C. and Meshram M. R. 2021. Influence of Spacing and Phosphorus Levels on Growth and Yield of Blackgram (*Vigna mungo* L.) *Biological Forum an International Journal* 13(1): 82-85.

BICER, B.T. 2014. THE EFFECT OF PHOSPHORUS DOSES ONCHICKPEA CULTIVARS UNDER RAINFALL CONDITIONS Cercetări Agronomice în Moldova 17; 2;158.

Buerkert A, Bationo A, Piepho HP. 2001. Efficient phosphorus application strategies for increasedcrop production in sub-Saharan West Africa. Field Crops Res 72(1):1–15.

Claudio Valverde, Alejandro Ferrari and Luis Gabriel Wall. 2002. Phosphorus and the regulation of nodulation in the actinorhizal symbiosis between *Discaria trinervis* (Rhamnaceae) and *Frankia* BCU110501, *New Phytologist,* 153: 43 – 51.

CIAT (Centro Internationale Agricultural Tropical), Bean project annual report 1997. CIAT Working Document No.177. CIAT. Cali, Colombia. 1998.

Darwesh Dalshad A., Maulood Pakhshan M. and Amin Shireen A. 2013. Effect of Phosphorus Fertilizers on Growth and Physiological Phosphorus Use Efficiency of Three Soy Bean Cultivars *IOSR Journal of Agriculture and Veterinary Science 3(6); 32-36.*

Davood Hashemabadi. 2013. Phosphorus fertilizers effect on the yield and yield components of faba bean (*Vicia faba* L.) *Annals of Biological Research*, 4 (2):181-184.

Degife Asefa Zebire1 and Samuel Gelgel. 2019. Effect of phosphorus fertilizer levels on growth and yield of haricot bean (Phaseolus vulgaris.L.) in South Ommo Zone, Ethiopia Agric. Sci. Digest., 39(1) 2019: 55-58.

Degefa Itefa. 2016. General Characteristics and Genetic improvement Status of Mung bean (Vigna radiata L.) in Ethiopia, *International Journal of Agriculture Innovations and Research*, 5(2); 232-237.

Dereje Shanka, Nigussie Dechassa, Setegn Gebeyehu and Eyasu Elias. 2018. Phosphorus Use Efficiency of Common Bean Cultivars in Ethiopia, *Communications in Soil Science and Plant Analysis,* 49:11, 1302-131.

Deresa, S., Demissie, A., Tekalign, A., and Belachew, D. 2018. Response of Common bean (Phaseolus vulgaris L.) Varieties to Rates of Blended NPS Fertilizer in Adola District, Southern Ethiopia. Journal of Plant Biology and Soil Health, 5(1), 1–10.

El-Gizawy N. Kh. B, Mehasen SAS. 2009. Response of faba bean to bio, mineral phosphorus fertilizers and foliar application with zinc. World Applied Sciences Journal, 6(10):1359-1365.

FAO (Food and Agriculture Organization). 2104. the State of Food Insecurity in the World: when people must live with fear, hunger and starvation. FAO. Rome., ISBN 92-5-104815-0.

Fredeen, A.L., I.M. Rao and N. Terry, 1989. Influence of phosphorus nutrition on growth and carbon partitioning in Glycine max. Plant Physiol., 89: 225-230.

Freire J.R. 2006. Important limiting factors in soil for the rhizobium-legume symbiosis. In; Alexander M (ed), BNF: Ecology, Technology and Physiology, Plenum Press, New York. PP. 75-98.

Frossard, E., L. M. Condron, A. Oberson, S. Sinaj, and J. C. Fardeau. 2000. Processes governing phosphorus availability in temperate soils. Journal of Environmental Quality. 29: 15-23.

Gemechu Gedeno. (1990). Haricot bean (Phaseolus vulgaris L.) Agronomic Research at Bako. Research on Haricot Bean in Ethiopia: An Assessment of Status, progress, priorities and strategies. Proceedings of a national workshop held in Addis Ababa, 1-3October, 1990, 114 p.

Getachew Kassaye. 1990. Research Recommendations and the adoption of improved Technology for Haricot Bean in the southern Zone of Ethiopia. Research on Haricot Bean in Ethiopia: An Assessment of Status, progress, priorities and strategies, Proceedings of a National Workshop held in Addis Ababa, 1-3 October 1990. 114p.

Ge Z, Rubio G and Lynch J P 2000 The importance of root gravitropism for inter-root competition and phosphorus acquisition efficiency: results from a geometric simulation model. Plant Soil. 218, 159–171.

Ghizaw A. , Mamo T. , Yilma Z. , Molla A. and Ashagre Y. 1999. Nitrogen and Phosphorus Effects on Faba Bean Yield and Some Yield Components, *Journal of Agronomy and crop sciences*, 167-174.

Graham P.H. 1984. Plant factors affecting nodulation and symbiotic fixation in Legumes. In; Alexander M., Plenum press, New York. PP. 75-98.

Giller, K.E. and Dashiell, K.E. 2007. *Glycine max* (L.) Merrill. In: van der Vossen HAM and Mkamilo GS (Eds.) Plant Resources of Tropical Africa 14. Vegetable Oils. PROTA Foundation, Wagenigen. Netherlands/Backhuys Publishers, Leiden, Netherlands/CTA, Wagenigen, Netherlands.74 – 78.

Gill, M.A., A. Naimat and M.M. Nayyer, 1985. Relative effect of phosphorus combined with potash and *Rhizobium phaseoli* on the yield of *Vigna radiata* (Mung). J. Agric. Res., 23: 279-282.

Girma A. 2009. "Effect of Np Fertilizer and Moisture Conservation on the Yield and Yield Components of Common bean (Phaseolus Vulgaris L.) In the Semi-Arid Zones of the Central Rift Valley in Ethiopia". Advances in Environmental Biology, 3(3): 302-307.

Gobena Negasa, Bobe Bedadi and Tolera Abera. 2019. Influence of Phosphorus Fertilizer Rates on Yieldand Yield Components of Faba Bean (Vicia faba L.) Varieties in Lemu Bilbilo District of Arsi Zone,Southeastern Ethiopia, 28(3): 1-11.

Hagos Brhane Gebreslassie and Hailemariam Abrha Demoz. 2016. A Review on: Effect of Phosphorus Fertilizer on Crop Production in Ethiopia, *Journal of Biology, Agriculture and Healthcare,* 6;7;117-120.

Hansen NC, Daniel TC, Sharpley AN, Lemunyon JL. 2002. The fate and transport of phosphorus in agricultural systems.J. Soil Water Conserv.57, 408–417.

Hellsten A, Huss-Danell K. 2001. Interaction effects of nitrogen and phosphorus on nodulation in red clover

(Trifolium pratense L.). Acta Agriculturae Scandinavica, 49: 00 – 00.
Horgan, J.M. and P.F. Wareing, 1980. Cytokinins and the growth responses of seedlings of
Betula pendula Roth. and Acer pseudoplatanus L. to nitrogen and phosphorus deficiency, J. Exp. Bot., 31: 525-532.
Hussain MA, Faridullah S. 2003. Effect of phosphorus on mustard and rapeseed in relation to grain filling period and yield potential. Journal of Agricultural Research. 34:59-369.
IITA. 2009. International Institute of Tropical Agriculture, International Institute of Tropical Agriculture (PTA) 2009.lbadan. Nigeria. ISBN 978-131-333-1 Ijere, M.O, (1992) Leading Issues in Rural Development. Enugu Acena Publishers, Pp.1-8.
Islam M.S., Mohsan S., Afzal S., Akmal M.A. and Khalid R. 2011. Phosphorus and sulfur application improves the chickpea productivity under rainfed conditions. Int. J. Agric. Biol., 13:713-718.
Israel D.W. 1987. Investigation of the role of Phosphorus in symbiotic nitrogen fixation. Plant Physiology. 84: 835-840.
Jabaji-Hare S.H. and Kendrick,W.B. 1987. Response of an endomycorrhizal fungus in *Allium porrum*L. To different concentrations of the systemstic fuingicides metalaxyln (Ridomil) and Fosetyl-Al (Aliette), *Soil Biological Biochemistry, 19*; 95-99.
Jat, R.A. Arvadia, M.K., Bhumika Tandel Patel, T.U. and Mehta, R.S. 2012. Response of saline water irrigated green gram (Vigna radiata) to land configuration, fertilizers and farm yard manure in Tapi command area of south Gujarat. Indian Journal of Agronomy, 57(3): 270-274.
Johnstan, Mstevenson. A.F.C. 2001. Field pea response to seeding depth and P fertilization. Canadian Journal of Plant Science; 81(3): 573-575.
Kasturikrishna S, Ahlawat IPS (1999) Growth and yield response of pea (Pisum sativum L.) to moisture stress, phosphorus, sulphur and zinc fertilizers. Indian J Agron 44:588–596.
Keneni A, Assefa F, Prabu PC. 2010. Isolation of phosphate solubilizing bacteria from the rhizosphere of faba bean of Ethiopia and their abilities on solubilizing insoluble phosphates. *J Agric Sci Technol.* 12: 79-89.
Khan Muhammad Amir, Baloch Muhammad Safdar, Taj Ishtiaq and Gandapur Inamullah. 1999. Effect of Phosphorous on the Growth and Yield of Mung bean *Pakistan Journal of Biological Sciences*, 2 (3): 667-669.
Khourgamy A., Farnia A. 2009. Effect of phosphorus and zinc fertilization on yield components of chickpea cultivars. African Crop Sci. Conference Proc., 9:205-208.
Kisinyo PO, Gudu SO, Othieno CO, Okalebo JR, Opala PA, Maghanga JK, Agalo DW, Ng'etichWK, Kisinyo JA, Osiyo RJ, Nekesa AO, Makatiani ET, Odee DW, Ogola BO. 2012. Effects oflime, phosphorus and rhizobia on Sesbania sesban performance in a Western Kenyan acid soil.Afric *J Agric Res* 7(18):2800–2809.
Lake, M., and Jemaludin, S. 2018. The response of common bean (Phaseoluse vulgaris L.) to various levels of blended fertilizer. *International Journal of Research in Agriculture and Forestry,* 5 (7), 15–20.
Lal, H. 2004. Effect of nitrogen and phosphorous on seed yield of pea (Pisum sativum L.) and French bean (Phaseolus vulgaris L.). Progressive Horticulture.36(1): 150-151.
Lauer, M.J., D.G. Blevins and Sierzputowska H., Gracz. 1989. Nuclear magnetic resonance determination of phosphate compartmentation in leaves of reproductive soybeans (Glycine max L.) as affected by phosphate nutrition. *Plant Physiol*., 89: 1331-1336.
Legesse D.G., Kumssa T., Assefa M., Taha J., Gobena T., Alemaw A., Abebe Y., Mohhamed and Terefe H. 2006. Production and Marketing of White Pea Beans in the Rift Valley, Ethiopia. A Sub-Sector Analysis. National Bean Research Program of the Ethiopian Institute of Agricultural Research.
Liao, H., Rubio, G., Yan, X. 2001. Effect of phosphorus availability on basal root shallowness in common bean. *Plant and Soil* 232, 69–79.
Luiz Gustavo de O. Denardin, Amanda P. Martins, Leonardo M. Bastos, Ignacio A. Ciampitti, Ibanor Anghinoni, Fernanda G. Moojen, Paulo César de F. Carvalho, Min Huang and Abad Chabbi. 2020. Soybean Yield Does Not Rely on Mineral Fertilizer in Rotation with Flooded Rice under a No-Till Integrated Crop-Livestock System *Agronomy* 10, 1-11.
Lynch, J., Lauchli, A. and Epstein, E. 1991. Vegetative growth of the common bean in response to phosphorus nutrition. *Crop Sci*., 31: 380-387.
Makoi JHJR, Bambara S, Ndakidemi PA. 2013. Rhizobium inoculation and the supply of molybdenum and lime affect the uptake of macro-elements in common bean (P. vulgaris L.) plants. Am J Crop Sci 7(6):784–793.
Majumdar, B., Nayak, G.S., Rathora, G., Dwivedi, A. K. 1994. *FABIS- Newsletter,* 34-35: 14-18.
Malik Asghar, M., Saleem Farrukh M., Ali Asghar and Mahmood Ijaz. 2004. Effect of Nitrogen and Phosphorus Application on Growth Yield and Quality of Mung bean (Vigna radiata L.) Pak. J. Agri. Sci., 40;3-4.
Marschner, P. 2012. Marschner's Mineral Nutrition of Higher Plants. *3rd Edn*., Academic Press,San Diego, ISBN: 9780123849052, Pages: 651.
Meena RS, Meena PD, Yadav GS, Yadav SS. 2017. Phosphate solubilizing microorganisms, principles and

application of microphos technology. *J Clean Prod* 145:157–158.

Melese Lema, Bililign Mekonnen and Getachewu Gudero. 2018. Performance and Growth Analysis of Three Mung bean (*Vigna Radiate (L.) Wilczek*) Genotypes at Hawassa, Ethiopia, *International Journal of Horticulture and Agriculture* 3(2): 1.

Meseret Turuko, and Amin Mohammed. 2014. "Effect of Different Phosphorus Fertilizer Rates on Growth, Dry Matter Yield and Yield Components of Common Bean (*Phaseolus vulgaris* L.)." *World Journal of Agricultural Research* 2.3; 88-92.

Mideksa Dabessa Iticha. 2020. Factors Affecting Adoption of Soybean Production Technologies in Ethiopia Food Science and Quality Management, 96; 11-20.

Miruts Fitsum. 2016. "Analysis of the Factors Affecting Adoption of Soybean Production Technology in Pawe District, Metekele Zone of BenshangulGumuz Regional State, Ethiopia." World Scientific News 53(3): 122-137.

Mitran, T., Meena, R.S., Lal, R., Layek, J., Kumar, S., Datta, R. 2018. Role of Soil Phosphorus on Legume Production. In: Meena, R., Das, A., Yadav, G., Lal, R. (*eds*) *Legumes for Soil Health and Sustainable Management*. Springer, Singapore. 978-981.

Muhammad, D., Gurmani, A.H. and Matiullah, K. 2004. Effect of phosphorus and Rhizobium inoculation on the yield and yield components of mung bean under the rain-fed conditions of D.I. Khan. Sarhad Journal of Agriculture. 20(4): 575-582.

Naeem M, Khan F, and Ahmad W. 2000. Effect of farmyard manure, mineral fertilizers and mung bean residues on some microbiological properties of eroded soil in district Swat, Soil and Environment, 28(2): 162-168.

Ndakidemi PA, Dakora FD, Nkonya EM, Ringo D, Mansoor H. 2006. Yield and economic benefits of common bean (Phaseolus vulgaris) and soybean (Glycine max) inoculation in northern, Tanzania. Aust J Exp Agric 46:571–577.

Ndakidemi PA, Bambara S, Makoi JHJR. 2011. Micronutrient uptake in common bean (Phaseolusvulgaris L) as affected by Rhizobium inoculation, and the supply of molybdenum and lime. Plant Omics J 4(1):40–52.

Ohyama T. 2010. Nitrogen as a major essential element of plants. In: Ohyama T, Sueyoshi K (*eds*)Nitrogen assimilation in plants. Research Signpost, Kerala, 1–17.

Oliveira ALM, Urquiaga S, Dobereiner J, Baldani J.I. 2002. The effect of inoculating endophyticN2-fixing bacteria on micro-propagated sugarcane plants. Plant Soil 242:205–215.

Richardson AE, Barea JM, McNeill AM, Prigent-Combaret C. 2009. Acquisition of phosphorus and nitrogen in the rhizosphere and plant growth promotion by microorganism. Plant Soil321:305–339.

Rodríguez H, Fraga R. 1999. Phosphate solubilizing bacteria and their role in plant growth promotion. *Biotech Adv.* 17: 319–339.

Ryan MH, van Herwaarden AF, Angus JF, Kirkegaard JA (2005). Reduced growth of autumn-sown wheat in a low-P soil is associated with high colonisation by arbuscular mycorrhizal fungi. Plant and Soil270: 275–286.

Sandhu Kulbir. 1993. Strategies for the utilization of the USDA mung bean germplasm collection for breeding outcomes Crop Breeding and Genetics 5(1); 10-16.

Scheffler R, Neill C, Krusche AV, Elsenbeer H. 2011 Soilhydraulic response to land-use change associated withthe recent soybean expansion at the Amazon agricultural frontier. Agriculture Ecosyst. Environ.144,281–289.

Shabeer Ahmed Badini, Mian Khan, Sana Ullah Baloch, Shahbaz Khan Baloch, Hafeez Noor Baloch, Waseem Bashir, Abdul Raziq Badini and Manzoor Ahmed Badini. 2015. Phosphorus Levels on Growth and Yield of Chickpea (Cicer aretinum l.) Varieties, Journal *of Natural Sciences Research.* 5;3, 169-176.

Shakori S. and Sharifi P. 2016. Effect of Phosphate Biofertilizer and Chemical Phosphorus on Growth and Yield of Vicia faba L. *Electronic J Biol*, S:1; 47-52.

Sheikh Hoseini M. and Siadat M. 2003. Effect of supplemental irrigation onyield of chickpea. Master Thesis.Azad Islamic University, Dezfol, Iran.

Shoitsu Ogata, Joseph Adu-Gyamfi and Kounosuke Fujita. 1988. Effect of phosphorus and pH on dry matter production, dinitrogen fixation and critical phosphorus concentration in pigeon pea (Cajanus cajan (L) millsp.), Soil Science and Plant Nutrition, 34:1,55-64.

Shubhashree K.S. 2007. "Response of Rajmash (Phaseolus Vulgaris L.) To The Levels of Nitrogen, Phosphorus and Potassium during Rabi in the Northern Transition Zone".

Siddaraju, R., Narayanaswamy, S., and Prasad, S. R. 2010. Studies on growth, seed yield and yield attributes as influenced by varieties and row spacings in cluster bean (*Cyamopsis tetragonoloba* L.). *Mysore Journal of Agricultural Sciences*, 44(1), 16-21.

Singh A.K. and Singh S.S. 2000. "Effect of planting dates, nitrogen and phosphorus levelson yield contributing characters in French.

Solis. 2013. Effect of the phosphorus on agronomic traits of canola (*Brassica napus* L.). *Asian Journal of Plant Science*. 1:634-635.

Syers JK, Johnston AE, Curtin D. 2008. Efficiency of soil and fertilizer phosphorus use: reconciling changing concepts of soil phosphorus behaviour with agronomic information. Rome, Italy: Food and Agriculture Organization of the United Nations.

Taminaw Zewdie and Eman Hassen. 2021. Review on effects of phosphorus fertilizer rates on growth, yield components and yield of common bean (Phaseolus vulgaris L) *Journal of Current Research in Food Science,* 2(1): 34-39.

Tarik Mitran, Ram Swaroop Meena, Rattan Lal, Jayanta Layek, Sandeep Kumar and Rahul Datta. 2018. Role of Soil Phosphorus on Legume Production, *Legumes for Soil Health and Sustainable Management*, 15-510.

Thavaprakaash, N. 2017. Effect of System of Crop Intensification Practices on Productivity in Greengram (Vigna radiata (L.) Wilczek). *International Journal of Agriculture, Environment and Biotechnology*, 10(5), 609- 613.

Turk MA, Tawaha AM. 2002. Impact of seeding rate, seeding date, rate and method of phosphorus application in faba bean (*Vicia faba* L. minor) in the absence of moisture stress. *Biotech Agron. Soc Environ.* 6: 171–178.

Turk MA. 1997. Comparison between common vetch and barley to phosphorus fertilizer application. *Legume Res.* 20: 141–147.

UNDP (United Nations Development Program). 2015. *Ethiopia: Key economic and social indicators*. Report No.2, 2015, UNDP Ethiopia, Addis Ababa, P.O.Box 55.

Valverde C, Wall LG, Huss-Danell K. 2000. Regulation of nodulation and nodule mass relative to nitrogenase activity and nitrogen demand in seedlings of Discaria trinervis (Rhamnaceae). Symbiosis28: 49 – 62.

Vance CP. 2001. Symbiotic nitrogen fixation and phosphorus acquisition. Plant nutrition in a world of declining renewable resources. *Plant Physiology* 127:390–397.

Veeresh N.K. 2003. “Response of French bean (Phaseolus vulgaris L.) to fertilizer levels in Northern Transitional Zone of Karnataka” M.Sc. (Agri.) Thesis, *Univ. Agric. Sci*., Dharwad. 37-79.

Yadav, V.S. and Luther, I.P. 2005. Effect of organic manures at different levels of phosphorous on yield and economics of vegetable pea. Journal of Horticultural Sciences. 5(11): 120-122.

Yadav KS, Dadarwal KR. 1997. Phosphate solubilization and mobilization through soil microorganisms. *In*: Biotechnological Approaches in Soil Microorganisms for Sustainable Crop Production. Dadarwal, R. K. ed., Scientific Publishers, Jodhpur, India. pp. 293-308.

Yagoob H. 2015. Effects of phosphorus levels on dry matter production and root traits of chickpea plants in presence or absence of Arbuscular mycorrhizal fungi, *Journal of Agricultural Science and Food Technology*. 1 (1); 1-6.

Wall LG. 2000. Actinorhizal symbioses. Journal of Plant Growth Regulation19: 167–182.

Weisany W, Raei Y, Allahverdipoor KH. 2013. Role of some of mineral nutrients in biological nitrogen fixation. *Bull Environ Pharmacology Life Sci* 2(4):77–84.

Wondimkun Dikr and Hailu Garkebo. 2022. Evaluation of the Agronomic Traits and Grain Yield of Mung bean (*Vigna radiata* L.) by Different Levels of Phosphorus Fertilizer with Row Spacings at Abine Germama Kebele in Adamitulu Jido kombolcha Wereda, *Journal of Biology, Agriculture and Healthcare*, 12;7,25-36.

Zafar M, Abbasi M, Rahim N, Khaliq A, Shaheen A, Jamil M, Shahid M. 2011. Influence of integrated phosphorus supply and plant growth promoting Rhizobacteria on growth, nodulation, yield and nutrient uptake in Phaseolus vulgaris. *African Journal of Biotechnology* 10(74):16793–16807.

Zaman M, Nguyen M, Blennerhassett J, Quin B. 2008. Reducing NH3, N2O and N losses from a pasture soil with urease or nitrification inhibitors and elemental S-amended nitrogenous fertilizers. *Biol Fert Soils* 44:693–705.