International Journal of Research in Agronomy 2021; 4(1): 32-40

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2021; 4(1): 32-40
Received: 06-11-2020
Accepted: 07-12-2020

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Review on effect of N and P fertilizer rates on yield and yield components of common bean [*Phaseolus vulgaris* (L.)] varieties

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Abstract
This paper reviews on effect of N and P fertilizer rates on yield and yield components of common bean [*Phaseolus vulgaris* (L)] varieties. Under this review recent literatures concerning on effect of nitrogen fertilizer rate, effect of phosphorus fertilizer rate and interaction effect of NP fertilizer rate relating with different varieties of common bean have been covered. From those N and P fertilizers have significance effect on production of common bean varieties. And it showed that the increased N rates linearly increased grain yields in both common bean cultivars IPR 139 and perola up to a rate of 180 kg n ha^{-1}, regardless of the plant density. The review also covered the effects of Phosphorus Fertilizer and different common bean varieties and it indicated that Hawassa Dume variety showed the best performance followed by Nasir where as Ibbado showed the least except in 1000 seed weight and harvest index. Under the interaction effect of NP fertilizer this review showed that no significant increase in growth and phonological characters as well as yield attribute with increased rates of NP fertilizers above 27 kg n: 69 kg p2o5 ha-1. Optimum grain yields were reviewed in response to combined application of 27 kg N and 69 kg P_2O_5 ha-1 for Awash 1, Awash Melka and Red Wolayita respectively. Generally, under this review it is triad to show the recommended fertilizer rate and its combination for the recommended types of varieties and its growth performance from different literatures with explanatory tables and figures.

Keywords: common bean, fertilizer rate, leaf area, pod, seed, productivity

Introduction

Common bean (*Phaseolus vulgaris* L.) is the most important food and export crop in Ethiopia and it is the source of protein and cash for poor farmers (Dereje Negatu *et al.*, 1995) [17] and it is high in starch, protein and dietary fiber and is an excellent source of potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid (Maiti, R.K., and Singh, V.P., 2007) [38].

Common bean is the best-known species of the genus Phaseolus in the family Fabaceae of about fifty plant species, all native to America. After the Asteraceae and Orchidaceae, the Fabaceae is the third largest family of flowering plants in the world and the first in Ethiopia (Arenas, O.R., *et al.*, 2013) [8]. It is a family of great economic importance and very unique in having members that can form associations with symbiotic bacteria to fix atmospheric nitrogen (Karagkiozi, P., *et al.*, 2012) [32].

Common bean originated from the New World; two centers of origin were identified Andean and Mesoamerican (Hornakova, O., *et al.*, 2003; Logozzo, G., *et al.*, 2007) [30, 36]. The domestication occurred independently in South America and Central America/Mexico, leading to two different domesticated gene pools, the Andean and Mesoamerican, respectively (Papa, R. and Gepts, P., 2003; Petry, N., *et al.*, 2015) [44, 45]. This crop is native to Mexico and Guatemala where the greater part of the diversity of varieties is found (Arenas, O.R., *et al.*, 2013) [8].

Common bean is the most widely distributed of the related species and has the broadest range of genetic resources (Gomez, O., 2004) [26] and is frequently used as food crop throughout the world, especially in Latin America and Africa. Different races have been described in both gene pools differentiated for morph-agronomical traits. Common bean was introduced to Europe probably from Cuba immediately after Columbus‟s voyage/ since the first half of the sixteenth century. It was distributed widely in all parts of Europe and the Mediterranean area where many landraces and varieties evolved that were grown to provide dry seed or fresh pods (Logozzo, G., *et al.*, 2007) [36]. The species was perhaps introduced to the eastern part of Africa by Portuguese traders in the sixteenth century (Wortmann, C.S., *et al.*, 2004) [61].

The wide range of growth habits of common bean varieties has enabled the crop to fit in the many growing situations. Among the different growth habits of common bean, the prostrate and the bushy types achieve rapid ground cover, compete with weeds and avoid competition (Zelalem Zewdu, 2014) [62]. Moreover, common bean is an important understory companion crop in various intercropping systems throughout the world (Rahmeto Negash, 2007) [46]. It is planted in pure stands of single landrace, as mixed plantings of several farmers‟ varieties, and intercropped with maize, sorghum, sweet potato, cotton, coffee and other crops. Under Ethiopian condition, the crop is normally grown twice a year, the first production is during the short rainy season (April to June) and the second is during the long rain season (July to October) (Kedir Oshone *et al.*, 2014) [33].

Common bean is the major staple food supplementing the protein source for the poor farmers who cannot afford to buy expensive meat. Common bean is high in starch 49%, protein 21.4% and dietary fiber 22.9% and is also a good source of minerals and vitamins including iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid (Ferris, S., Kaganzi, E., 2008).

Common beans are important for direct consumption because they grow all over the world and are consumed as dry and snap beans (Asrat Asfaw and Blair, M. W., 2014) [9]. The world major common beans producers are India, Brazil, Myanmar, China, Turkey and Ethiopia taking significant steps to encourage grain legume production.

Significance of the review

This review is significance for farmers, young researchers, extension workers, crop experts, students and policy makers

Statement of the problem

The low national mean yield observed for common bean could be attributed to various constraints related to low adoption of improved agricultural technologies, drought, and lack of improved varieties, poor cultural practices and disease, (Legesse *et al.*, 2006) [35]. Moreover, low soil nitrogen and phosphorus and acid soil conditions are important limitations for bean production in most of the bean grown areas (Graham *et al.*, 2003) [27]. Early maturity and moderate degree of drought tolerance led the crop's vital role in farmers' strategies for risk aversion in drought prone lowland areas of the country (Fikiru, 2007) [22]. In addition to other production constraints that limit the volume of production, lack of high yielding varieties with improved resistance to diseases and other biotic and abiotic constraints has been the major production constraint of common bean in Ethiopia in general (Mulugeta, 2011) [41]. Moreover, the response of common bean to application of fertilizer varies with varieties, soil moisture, soil types, agronomic practices etc. Thus, there is a need to develop recommendation on the fertilizer rates to increase the productivity of common bean varieties. Thus,

Objectives of the Review

- To review the effect of Nitrogen and Phosphorus fertilizer rates on yield and yield components of common bean
- To identify the best Nitrogen and phosphorus fertilizer rates for common bean
- To advise farmers about the recommended Nitrogen and phosphorus fertilizer rate in order to produce common bean

Literature Review

Production of common bean

World production of common bean

Brazil is the greatest common bean (*Phaseolus vulgaris* L.) producer in the world (FAOSTAT, 2009) [19]. This legume crop is an important source of protein and energy for the nutrition of Brazilian people. Although the association with *Rhizobium* bacteria supplies the bean crop with part of the nitrogen (N), the amount supplied is not sufficient for the crop. Bean plants that are deficient in N show lower development and grain yield (Oliveira, I.P., *et al.* 1996). Therefore, N supplied at the right time is fundamental for the bean plants to develop appropriately, because plants that are stronger, with more stems and that show more re productive structures result in higher grain yield.

Common beans are mostly consumed in countries where they are produced. Countries with the highest rates of consumption per capital (in Central America, Caribbean, East Africa and some Asian economies) produce beans and also import them at varying levels, depending on the harvest, for meeting the internal demand. Considering the global imports and exports of dry beans between 2008 and 2012, it seems that 15 to 20% of the world annual production (around 4 MT on average) is traded internationally. Myanmar, China and the United States are the main exporters, with India and the European Union being the largest importers (FAOSTAT, 2015) [20]. Globally, the annual production of green and dry beans is 17 Million tons (FAO, 2010) [21], which makes the crop the most widely utilized of legumes. It is produced for its green pod and dry seed which are both edible. In 2014/15, total common bean production in Ethiopia was about, 5,137,348.07 quintals (1.9% of the grain production) on approximately 323,327.27 hectares of land (2.58% of the grain crop area) and yield Quintal/Hectare is about 31.83 (CSA, 2015) [16].

According to Food and Agriculture Organization Statistic (Maiti, R.K., and Singh, V.P., 2007) [38], common bean *(Phaseolus vulgaris* L.) is globally grown in nearly 28 million ha and produced about 20 million ton. Its average yield in the world ranged from 493 kg in 1961 to 729 kg/ha in 2008. Although average yield of common bean has been gradually increased starting from 1999, it has been reviewed as irregular after the new millennium (Maiti, R.K., and Singh, V.P., 2007) [38]., The average yield is low and unstable due to abiotic stresses (Brucher H., *et al.*, 2011)., while common bean has high yield potential as 5 tonnes/ha (Negash Hailu, 2007). One of the reasons of these fluctuations in average yield is climate change.

Ethiopian production

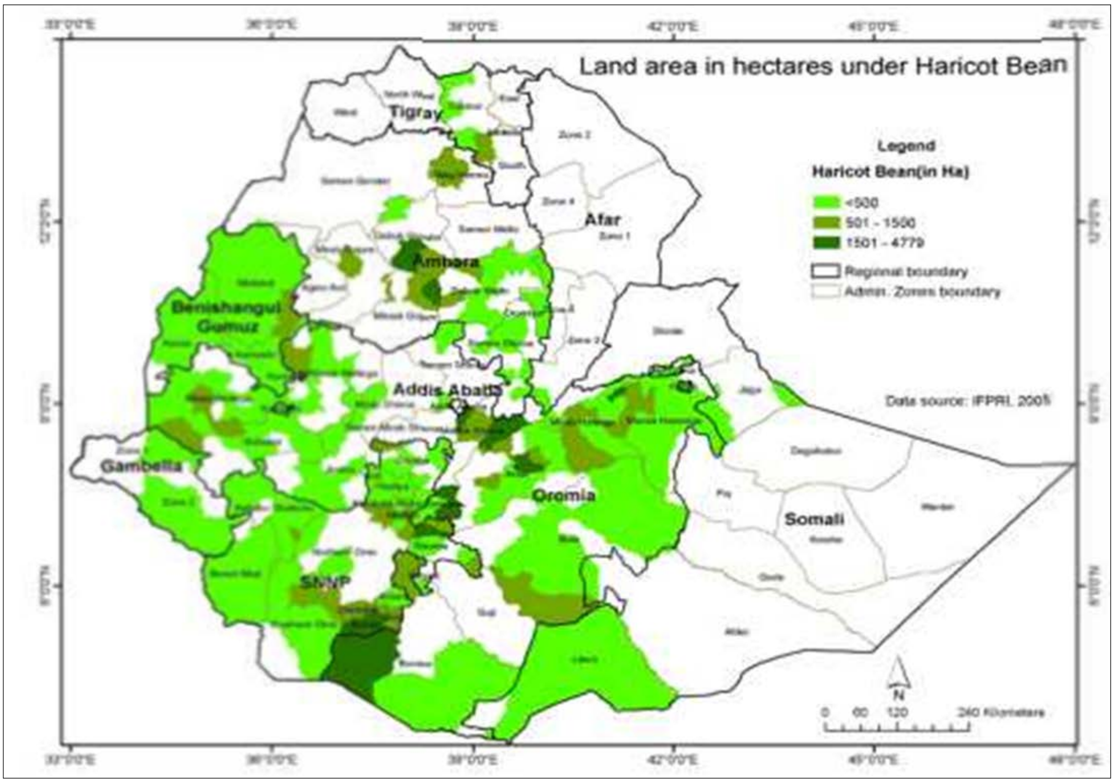
Common bean is an important pulse crop in Ethiopia and in the world. The crop ranks first globally while it stands second next to faba bean in the country. The major common bean producing regions include Oromia, Amhara and Southern Nations Nationalities and Peoples Region (SNNPR). Their share to the national common bean production is 51% for Oromia, 24 % for Amhara and 21% for SNNPR (Fig. 1). Common bean is the most important pulse crop in the SNNPR. It is grown both as sole crop and in association with other crops. Though it is produced in most parts of the southern region, the leading zones of production are Sidama, Wolayita and Gamo Gofa (Fig. 2). (Walelign Worku, 2015)

In Ethiopia, common bean is one of the most important cash crops and source of protein for farmers in many lowlands and mid-altitude zones. The country's export earnings is estimated to be over 85 % of export earnings from pulses, exceeding that of other pulses such as lentils, faba bean and chickpea (Negash

Hailu, 2007). Common bean ranks third as an export commodity in Ethiopia, contributing about 9.5 % of total export value from agriculture (FAOSTAT, 2010) [21]. Total national production was estimated at 421,418 ton in 2008, with a market value of US$ 132,900,609 million (FAOSTAT, 2010) [21]. Common bean is also highly preferred by Ethiopian farmers because of its fast maturing characteristics that enables households to get cash income required to purchase food and other household needs when other crops have not yet matured (Legesse D.G., *et al.*, 2006) [35].

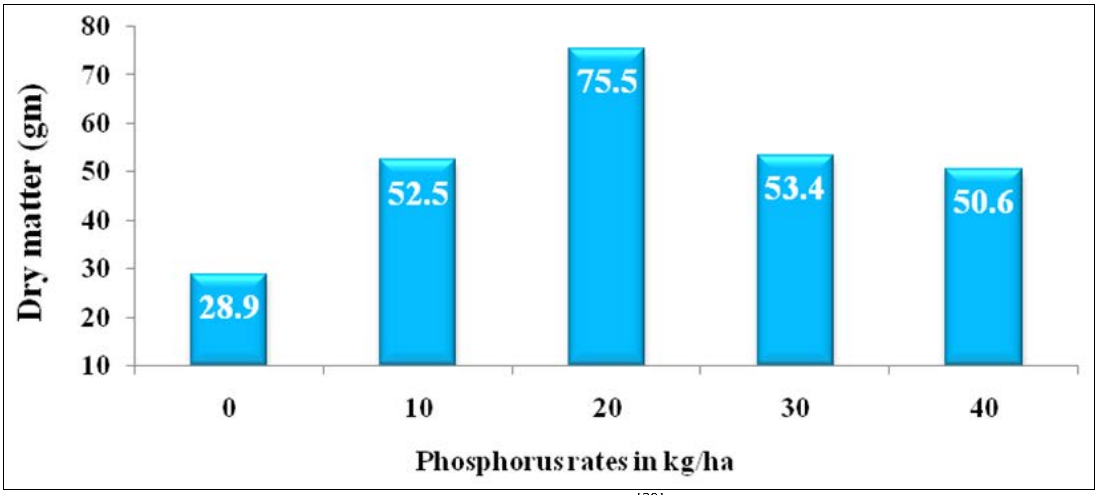
The crop ranks second next to faba bean in the country in area of production (CSA, 2018) [14]. The major common bean producing regions are Oromia, Southern Nations Nationalities and Peoples Region (SNNPR) and Amhara. Their share to the national common bean production is 44.45% for Oromia, 31.01% for SNNPR and 21.67% for Amhara (CSA, 2018) [14]. Common bean is also one of the most important cash crops and source of protein for farmers in many lowlands and mid-altitude zones. The country's export earnings is estimated to be over 85% of export earnings from pulses, exceeding that of other pulses such as lentils, faba bean and chickpea (Fissha and Yayis, 2015) [23]. National average yield of common bean in Ethiopia was 1.70 tons ha^{-1} and totally 520,979.33 tons yield was produced from 306,186.59 ha of land in 2017/18 cropping season (CSA, 2018) [14].

The national total area of common bean production is estimated at 290,202.43 ha of land and from which about 4, 839, 22.65 tons was produced per annum. According to this report, the current national average yield of common bean is 1.67 tons' ha-1. However, this yield is far less than the attainable yield (2.5-3.6 tons' ha-1) under good management conditions (CSA, 2016/2017) [15].



***Source*:** Alemu *et al.* 2009, cited in IFPRI, 2010

Fig 1: Common bean production areas in Ethiopia



***Source*:** Meseret Turuko, and Amin Mohammed (2014) [39]

Fig 2: Effect of different rates of phosphorus fertilizer on dry matter of common bean.

Effect of nitrogen fertilizer

Nitrogen fertilizer is very essential for plant growth and development because it participates directly in photosynthesis and it is a basic component of protein (RUBISCO) and also it participates in activation of enzymes. The rate of side dressed N fertilization recommended in ranges from 20 to 90 kg N ha-1, depending on expected grain yield and N response class of the soil (Ambrosano, E. J. *et al.*, 1997) [7]. In order to increase irrigated common bean grain yield with N rates exceeding 100 kg N ha-1 (Alvarez, A. C. C. *et al.* 2005) [5]. an increase in common bean grain yield with the addition of 120-140 kg N ha-1 and attributed this effect to the increase of pods per plant (Soratto, R.P., *et al.* 2006) [54], (Soratto, R. P., *et al.* 2014) [55], and (Moreira *et al.*, 2013) [40].

In this review IPR 139 and Pérola common bean cultivars had a greater number of pods per plant when cultivated at the lower plant density (Rogério, P. S., *et al.* (2017)) [47]. This review can be attributed to more vigorous aboveground growth in this treatment, which, in turn, reported in the production of more branches and inflorescences (Shimada, M. M., *et al.*, 2000) [48]. In addition, the number of pods per plants in the cultivar Pérola increased linearly with increasing N rates (Table 1). According to Silva, E. F. *et al.*, (2009) [51], this response can be related due to the greater production of reproductive branches promoted by N fertilization. The pronounced effect of N application in the cultivar Pérola compared to that in the cultivar IPR 139 can be attributed to the growth habit type II/III, since this type of growth habit has a greater stimulation of branching with greater soil N availability. However, no interaction between plant density and N rate for number of pods per plants was found. Previous studies also reviewed an increase in number of pods per plant with increasing N rates up to 100 and 120 kg N ha-1 in the cultivar Pérola (Crusciol, C. A. C. *et al.*, 2007 [13]; (Soratto, R. P., *et al.* 2014) [55], (Moreira, G. B. L. *et al.*, 2013) [40]. In this review it is supported that application of N rates up to 180 kg N ha-1 can increase the number of pods per plant.

The review shows that the number of grains per pod was only influenced by the interaction between plant density and N rate in the cultivar Pérola (Table 1). At 180 kg N ha-1, intermediate plant density resulted in a greater number of grains per pod. According to Crusciol, C. A. C. *et al.*, (2007) [13], 100 grain weight of the common bean has a low variation when the grow conditions are changed, due to its high heritability characteristic, which means that this characteristic more heavily depends on the cultivar than on the crop practices adopted. Nitrogen application linearly increased grain yield in both common bean cultivars. In IPR 139, the highest N rate (180 kg ha-1). However, in the cultivar Pérola, grain yield increased by52.2% with the application of 180 kg N ha-1. This review shows that even with a reasonable soil nutrient availability. The common bean crop could be influenced by N application (Soratto, R. P., *et al.* 2014) [55] also reviewed an effect of N application on grain yields of common bean cultivated. There was an increase in grain yield of common bean up to the highest applied N rate (120 kg N ha-1) (Moreira *et al.*, 2013) [40]. The greater grain yield response to N application in the cultivar Pérola, compared to that of IPR 139, can be related to the effect of N application on the number of pods per plant (Table 1). This review indicates that number of pods per plant and grain yield of the cultivar Pérola is more limited by low soil N availability compared to the cultivar IPR 139.

Table 1: Effect of nitrogen rates in different varieties of common bean

Treatment	plants (ha^{-1})	Pods per plant	Grains per pod	100-grain weight (g)	Grain yield (kg ha^{-1})	Protein concentration (%)
Nitrogen (kg ha^{-1})						
0	145,679	16.5	4.9	28.6	3,099	21.3
30	132,716	17.5	4.8	28.6	3,099	22.3
60	145,679	18	4.8	29.1	3,019	22.3
120	148,765	19.2	5.1	28.5	3,511	21.4
180	135,802	18.8	4.8	27.6	3,634	24.4
CV (%)	9.3	13.5	11	5.4	10.5	5.8
Nitrogen (kg ha^{-1})						
0	150,000	12.8	4.1	31.4	2,428	20.7
30	137,654	13.1	4.3	32.9	3,221	21.5
60	150,617	14.4	4.3	31.9	3,182	20.9
120	146,296	14.8	4.5	31.1	3,302	21.4
180	145,679	16.8	5.2	32.1	3,695	21.3
CV (%)	9.1	14.7	26.6	4.2	10.4	4.7

***Source*:** Rogério, *et al.* (2017)

Effect of phosphorus fertilizer

Phosphorus is the most important element for adequate grain production (Brady N.C. and R.R. Weil. 2002), next to nitrogen. An adequate supply of P early in the life of a plant is important in the development of its reproductive parts. Large quantities of P are found in seed and fruit, and it is considered essential for seed formation. A good supply of P is associated with increased root growth. P is also associated with early maturity of crops, particularly grain crops. The quality of certain fruit, forage, vegetable, and grain crops is improved and disease resistance increased when these crops have satisfactory P nutrition (Havlin L., *et al.*, 1999) [29].

Legumes including common bean have high P requirement due to the production of protein containing compounds, in which N and P are important constituents, and P concentration in legumes is generally much higher than that found in grasses. High seed production of legumes primarily depends on the amount of P absorbed (Khan B.M., *et al.*, 2003) [34]. The yield of common bean increases with P application and its nodulation can be improved with the application of phosphorus (Gemechu Gedeno, 1990) [24].

Effect of phosphorus fertilizer on plant height, leaf area and number of branches per plant

As Meseret Turuko, and Amin Mohammeds (2014) [39] reported that P application at all rates except at P 40 kg ha-1, resulted in significant higher leaf area than the control (Table 2). The highest leaf area was reviewed at rate application of P 20 kg ha-

1and 30 kg ha-1, respectively. In contrast, the lowest leaf area was reviewed from the treatment with application of 40 kg P ha-1. This result was in agreement with that the application of 75 kg P2O5 ha-1 was significantly increased leaf area over rest level reviewed by (Shubhashree, K.S., 2007) [49]. They also reviewed that leaf area was reviewed with increment in P application from 25 to 75 kg ha-1 (Veeresh, N.K., 2003) [58].

As indicated in Table 2, application of P fertilizer has no significant effect on plant height. The high plant height was reviewed on application rate of 20 kg P ha-1. Moreover, application of 30 kg P ha-1 has revealed high plant height next to P 20 kg ha-1. On the other hand, there was no significant difference between means of applied P fertilizer rates as reviewed by (Birhan Abdulkadir, 2006) [10], a non- significant response of plant height to P application on common bean. The lowest plant height was reviewed at application rate of P 40 kg ha-1 reviewed by (Eden T., 2003) [18]. The highest rate of P application had no effect on plant height. This might be due to high dose of phosphorus fertilizer tends to form nutrient interaction and may affects the availability of other nutrients which are essential for growth of the bean.

The application of P fertilizer significantly affected the number of branches per plant (Table 2). The number branch per plant increased with increasing phosphorus application rates up to optimum level. The highest number of branches per plant was reported at rate of 20 kg P ha-1. This is also similar to result reporteded by (Shubhashree, K.S., 2007) [49] significantly higher number of branches per plant is reviewed with 75 kg P2O5 ha-1. The Mean of P fertilizer applied revealed significantly higher number of branches per plant over control. The lowest number of branches per plant was reviewed at control. The increment in number of branches per plant might be importance of P for cell division activity, leading to the increase of plant height and number of branches and consequently increased the plant dry weight (Tesfaye, M.J., *et al.*, 2007) [57].

Similarly, Shumi (2018) [50] reported that NPS fertilizer rates had highly significant ($p<0.01$) effect on number of primary branches per plant where increasing rates of NPS fertilizer from 0 to 250 kg ha^{-1} showed progressive increase in the number of primary branches per plant.

Table 2: Effect of different rates of phosphorus fertilizer on common bean production

Phosphorus rates kg/ha	Plant height (cm)	Leaf area (cm^2)	Number of branch Branches/plant	Pods/plant	Seeds/pod
0	91	57.673	2.33	24.83	3.14
10	96.83	79.07	4	31.16	5.16
20	125.5	119.8	5.67	48.16	5.85
30	114.41	99.86	5	39.67	5.81
40	82.41	53.03	3.58	30.33	4.20
CV (%)	19. 55	19.766	24	21.4	13.19
LSD (5%)	NS	31.45	1.84	14.04	1.2

Source: Meseret Turuko, and Amin Mohammed (2014) [39]

Effect of phosphorus fertilizer on number of pods per plant and number of seeds per pod

The application of P fertilizer had significantly increased the number of pod per plant (Table 2). And higher number of pods per plant was reviewed with P rates of 20 kg ha-1 over rest of the levels. All applied P fertilizer rates significantly increased pods per plant over the control. The lowest pods per plant is produced at control (no application of P fertilizer) (Meseret Turuko, and Amin Mohammed (2014) [39]. The result is similar to (Shubhashree, K.S., 2007) [49], that the applications of different rates of phosphorus fertilizer influence number of pod per plant. Similarly, (Veeresh, N.K., 2003) [58] and (Singh, A.K. and Singh S.S. 2000) [52] reviewed that significantly more number of pods per plant of common bean increase in number of pods per plant, due to increased P fertilization. Thus, the increment of number of pods per plant due to application of P fertilizer confirms with P fertilizer promotes the formation of nodes and pods in legumes.

The analysis of variance for seeds per pod (Table 3) showed significant response to P rates levels. The highest number of seeds per pod was reviewed at applied P rate of 20 kg ha-1, whereas the lowest seed per pod was reviewed in the control treatment. The report of

The number of seeds per pod increased significantly to levels of phosphorus added. The increment of seeds per pod with increasing P fertilizer application up to optimum level might be P fertilizer for nodule formation, protein synthesis, fruiting and seed formation (Shubhashree, K.S., 2007) [49].

Nodule number was significantly increased with increasing levels of phosphorus where the lowest and the highest significant values of this parameter were obtained from the control treatment and application of 20 kg P2O5/ha, respectively. The effects of 20kg P2O5/ha and 40 kg P2O5/ha were statistically at par. Similarly, the minimum and maximum significant nodule numbers were reviewed due to Ibbado and Nasir, respectively (Table-2). The difference between Dume and Nasir was statistically at par. Numerically, Nassir variety gave the highest nodule number (Amare Girma, *et al.*, (2014) [6]. However, increasing phosphorus rate beyond 20 kg P2O5/ha did not produce any further significant variation on total dry matter.

In this review we have seen only number of nodules/plant, 1000seed weight and seed yield were significantly affected by the interaction effect of variety and fertilizer (Table-4). The increasing rates of fertilizer were reviewed to be associated with significant increment in all of these parameters. The maximum values were reviewed from application of 20kg P/ha for each variety (Amare Girma, *et al.* (2014) [6].

Table 3: Main effect of common bean varietie and phosphorus rates

Variety	PHT (cm)	NN	DM (kg/ha)	NP	NSP	TSW (g)	HI	Seed yield (kg/ha)
H. Dume	46.51a	32.39a	4512a	19.21a	5.37a	174.00a	0.53ab	2376a
Ibbado	41.70a	3.82b	3478b	10.81b	4.02b	388.67b	0.55a	1924b
Nasir	58.72b	37.13a	4495a	17.62a	5.16a	197.43c	0.50b	2246c
LSD0.01	6.98	4.997	217.56	4.59	0.55	0.2954	0.027	63.73
P rates (kg/ha)								

0	46.18	12.89c	3764c	12.94c	4.73	253.17d	0.51	1922d
20	51.85	31.85d	4384d	15.68cd	4.93	253.57e	0.53	2326e
40	48.90	28.60d	4336d	19.01d	4.88	253.67f	0.53	2297e
LSD 0.05	Ns			4.12	Ns		Ns	
LSD 0.01		4.997	217.56			0.2954		63.73
LSD 0.001								
CV	14.27	20.45	5.23	28.91	11.50	0.12	5.17	2.92

Source: Amare Girma *et al.* (2014) [6]

Table 4: Interaction effect of varieties and phosphorus rate

Variety	P rates (kg/ha)	NN	TSW (g)	SY (kg/ha)
Hawassa Dume	0	22.0c	173.7e	2090.5c
	20	34.63b	174.3d	2553.8a
	40	40.53b	174.9c	2483.7ab
Ibbado	0	1.00e	388.6a	1762.7e
	20	2.33e	388.9a	2013.5cd
	40	8.13de	388.50a	1997.84cd
Nasir	0	15.67cd	197.2b	1916.48d
	20	58.60a	197.5b	2412.55b
	40	37.13b	197.6b	2410.3b
LSD0.05		8.65	0.51	110.39
CV		20.45	0.12	2.92

Source: Amare Girma *et al.* (2014) [6]

Effect of phosphorus *fertilizer on common bean dry matter yield*

In addition to the above parameters the review also covered that the rates of P fertilizer have increased the dry matter yield of common bean (Meseret Turuko, and Amin Mohammed 2014) [39]. There was also difference among five levels P fertilizer rates (Figure 1). This is in agreement with the study conducted on soybean indicated that increasing the phosphorus concentration in the soil increased the whole plant dry matter accumulation and total leaf area (Jennifer D.C., 2000) [31]. This increment in dry matter yield with application of P fertilizer might be due to the adequate supply of P could be attributed to an increase in number of branches per plant, and leaf area. This in turn increased photosynthetic area and number of pods per plant, which demonstrates a strong correlation with dry matter accumulation and yield.

Interaction effect of NP fertilizer

Wondwosen and Tamado (2017) [60] reported increase in number of pods per plant with increased levels of NP fertilization from 0 kg N; 0 kg P_2O_5 to 36 kg N; 92 kg P_2O_5 ha^{-1} and the highest number of pods per plant (31.37) was reported from the application of 36 kg N; 92 kg P_2O_5 ha^{-1} whereas the lowest number of pods per plant (14.58) was reported from the no fertilizer plot in common bean. Likewise, Abdela *et al.* (2018) [1] also reported that Average pod weight for common bean showed significantly increase from 3.64 to 5.59 and 4.31 to 5.45 gram per plot with increasing levels of NP kg ha^{-1} from 0 to 82 and 0 to 92 respectively. Similarly, Shumi (2018) [50] reported the highest number of pods per plant (18.52) at application rate of 250 kg NPS ha^{-1} whereas the lowest number of pods per plant (8.7) from the unfertilized plot of common bean.

Phosphorus availability in soil is a major constraint to common bean production in the tropics (Allen D.J. *et al.*, 1997) [3]. In Ethiopia 69kg P2o5/ha recommended for common bean production in semi-arid zones of Central Rift Valley (Girma, A., 2009) [25]. Low phosphorus and nitrogen in the soil often limits production of common bean (Singh, Y., 2006) [53]. Thus, addition of inorganic fertilizer primary nitrogen and phosphorus to satisfy nutrient demand of the crop is crucial. In addition, determining the optimum rates for higher yield is economically profitable, socially acceptable and environmentally sustainable. According to Ambrosano, E. J. *et al.*, (1997) [7], the rate of side dressed N fertilization recommended in São Paulo State ranges from 20 to 90 kg N ha-1, depending on expected grain yield and N response class of the soil. (Alvarez, A. C. C. *et al.*, 2005) [5] reviewed an increase of irrigated common bean grain yield with N rates exceeding 100 kg N ha-1. Also, (Soratto, R. P., 2006) [54], (Soratto, R. P., 2014) [55], and Moreira *et al.* (2013) [40] reviewed an increase in common bean grain yield with the addition of 120-140 kg N ha-1 and attributed this effect to the increase of pods per plant.

Common bean has high nitrogen requirement for expressing their genetic potential. However, as 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, 1998) [12].

Moreover, 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 (Freire J.R., 1984) 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. Here for, phosphorus is the basis for the formation of useful energy, which is essential for sugar formation and translocation (Graham P.H., 1984) [28] reviewed that common bean crop dependent on nitrogen fixation needs more inorganic phosphorus than the same crop provided with mineral nitrogen. Beans are therefore especially susceptible to low soil phosphorus when accompanied by low soil.

Leaf area and leaf area index

Among common bean varieties of Chercher and Red Wolayita have highest value of leaf area and leaf area index while Awash 1 had lowest value of leaf area and leaf area index. There was increase in leaf area and leaf area index with increased rates of NP application from 0 kg N, 0 kg P2O5 to 36 kg N, 92 kg P2O5 ha^{-1} among the varieties. The highest leaf area and leaf area index was reviewed for the application of 36 kg N, 92 kg P2O5 ha^{-1} (Wondwosen Wondimu and Tamado Tana 2017) [60].

The Increased leaf area and leaf area index with increasing rates of NP application might have been due to the positive effect of NP on branches formation, leaf expansion and canopy development. This finding was in line with Shubhashree, K.S., *et al.* 2007 [49] who reported significant improvement in leaf area of common bean (P. *vulgaris* L) (Shubhashree, K.S., *et al.* 2007) [49].

Number of pods per plant and number of seeds per pod

The highest number of pods at the highest rates of NP might be attributed by the fact that NP enhance the formation of and canopy development and pod setting in common beans (Tesfaye, E., *et al.* 2002) [56]. Shubhashree, K.S., *et al.* (2007) [49] also

reviewed that the application of different levels of nitrogen and phosphorus significantly affected number of pods per plant in common bean. It was also reviewed that number of pods per plant in common beans showed significantly linear increase with increasing levels NP fertilization (Shubhashree, K.S., *et al.* 2007) [49]. The number of seeds per pod highly significant differences among the varieties accordingly, variety Awash Melka had the highest number of seed per pod and Red Wolayita had to be the lowest number of seeds per pod This could be due to genotypic difference of the varieties. Number of seed per pod was also highly significantly affected by different rate of NP application (Wondwosen Wondimu and Tamado Tana 2017) [60].
The highest hundred seed weight was reviewed for variety Red Wolayita whereas the lowest value of hundred seed weight was also reviewed for variety Awash 1. This variation might be attributed by genotypic difference of the varieties (Table 5). This result is in line with Olofintoye TJ who showed increased hundred seed weight might be due to the influence of phosphorus on cell division, phosphorus content in the seeds and the formation of fat in the seed of common bean (Olofintoye, T.J., 2007) [43] But, hundred seed weight was not influenced by the interaction effect of common bean varieties and rates of combined NP application. The interaction of variety Awash Melka with 27 kg N: 69 kg P2O5 ha^{-1}.followed by variety Awash Melka with 36 kg N, 92 kg P2O5 ha^{-1} and variety Red Wolayita at the rate of 36 kg N: 92 kg P2O5 ha^{-1}, had highest grain yield while the lowest grain yield was reviewed for variety Awash 1 at no fertilizer. This could be due to poor fertility status of the soil. Poor nodulation and poor plant vigor have been reviewed in beans grown in soils low in extractable NP. Hence, increased phosphorus fertilization increases yield of common bean and cause optimum nodulation early during bean growth. Therefore, it is indispensible to use mineral fertilizers basically NP in common bean for sustainable production and to get optimum yield of the crop (Wondwosen Wondimu and Tamado Tana 2017) [60]. Similarly, Singh Y *et al.* also reported significantly higher grain yield of (*Phaseolus vulgaris* L.) with 80 kg N ha^{-1} application (Singh, Y., *et al.*, 2006) [53].

Table 5: Main effect of common bean varieties and combined rates of nitrogen and phosphorus

Varieties	DFF	DNM	LAP (cm2)	LAI
Awash 1	42.00	93.80	1227.00	3.06
Awash Melka	45.47	95.27	1440.00	3.59
Red Wolayita	39.00	93.33	1565.00	3.91
Chercher	48.60	93.33	1934.00	4.85
LSD (0.05)	1.032	0.705	164.40	0.41
NP rates (kg h-1)				
0,0	45.83	96.83	783.00	1.94
9,23	44.50	96.08	1138.00	2.86
18,46	43.92	96.08	1353.00	3.38
27,69	42.92	94.50	1353.00	3.38
36,92	42.50	91.42	2570.00	6.42
LSD (0.05)	1.15	0.788	183.80	0.46
CV%	3.20	1.300	14.40	4.40

Source: Wondwosen Wondimu and Tamado Tana (2017) [60]

Conclusion

Common bean is one of the most important cash crops and source of protein for farmers in many lowlands and mid-altitude zones. The management of fertilizer is an important factor that greatly affects the growth and yield of the crop. Sustaining soil and soil fertility in intensive cropping systems for higher yields and better quality can be achieved through higher levels of fertilizer application. Thus, information on fertility status the soils and crop response to different soil fertility management is very important to come up with profitable and sustainable crop production. In line with this, review was compiled to summarize the effect of N and P Fertilizer Rates on yield and yield Components of common Bean [*phaseolus vulgaris (*L.)] varieties, from the review of Effect of Nitrogen Fertilizer We can conclude that increased N rates linearly increased grain yields in both common bean cultivars IPR 139 and perola up to a rate of 180 kg N ha-1, regardless of the plant density.
When we come the effects of Phosphorus Fertilizer, Hawassa Dume variety showed the best performance followed almost in all measured parameters followed by Nasir where as Ibbado showed the least except in 1000 seed weight and harvest index. Generally, application of phosphorus at the rate of 20 kg P2O5 was the best in all parameters which were measured under this study on each variety. These review revealed the benefit of phosphorus fertilizer application and variety consideration for yield improvement, nodulation and better nutrient use efficiency of common bean.
In addition to the above points the Interaction Effect of NP Fertilizers also have its own effect on yield and yield Components of common Bean varieties which implies that the interaction effect of common bean varieties and rates of nitrogen and phosphorus showed significant differences on, number of effective nodules, number of non-effective nodules and total number of nodules, stand count at harvest, biological yield, grain yield, shoot tissue nitrogen and phosphorus concentration. A significant difference in shoot tissue NP content of the leaves was reviewed due to the main effect of varieties, NP rates and their interactions. The review also concluded that no significant increase in growth and phonological characters as well as yield attribute with increased rates of NP fertilizers above 27 kg N: 69 kg P2O5 ha-1. And optimum grain yields can be produced in response to combined application of 27 kg N and 69 kg P_2O_5 ha^{-1} for common bean varieties.

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