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A Review of the Response of the Faba Bean to the Integrated Use of Inorganic and Organic Fertilization in Ethiopian Soil

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Abstract: The faba bean is important for both human and animal feed as well as for enhancing soil fertility. Despite having numerous advantages, the faba bean crop's productivity is significantly lower than its potential and is restricted by a number of limiting constraints in Ethiopia. Therefore, the objective of this review was to evaluate the integrated effects of organic and inorganic fertilizer on the growth and yield of faba bean in Ethiopian soil conditions. Accordingly, it can be seen from the evaluation that fertilizer application has an impact on all faba bean parameters. However, as observed from this review, faba bean highly significantly responded to P fertilizer more than other nutrients. As per inorganic fertilizer, the review indicated that the yield of faba bean was increased from 0 kg P_2O_5 ha^{-1} to 115 kg P_2O_5 ha^{-1}, 0 kg N ha^{-1} to 46 kg N ha^{-1}, and 0 kg NP_2O_5 ha^{-1} to 109.5/103.5 kg N/P_2O_5 ha^{-1}, respectively. In addition, as per integrated fertilizer use, the experiment showed that plots treated with Bio (FYM+IR) + NPS 150 had the maximum grain yield (5.85 t ha^{-1}), while the lowest grain yield (1.58 t ha^{-1}) was recorded from treatments receiving NPS (0) fertilizer and without bio-organic fertilizers. The results showed that the application of 4 t lime ha^{-1}, 120 kg NPSB ha^{-1}, and rhizobium inoculation produced the highest grain yield (2405.67 kg ha^{-1}), whereas a treatment without fertilizer or lime but with rhizobium inoculation and par with the absolute control treatment produced the lowest grain yield (864 kg ha^{-1}). According to the review, the type of soil, agroecology, and plant variety all influence how plants react to fertilizer. It can be concluded that to maximize the production and productivity of faba bean crops while also improving soil health, it is necessary to set the optimal rate of organic manures and inorganic fertilizer as per the site-specific location.

Keywords: Organic Fertilizer, Nitrogen, Yield, Phosphorus

1. Introduction

One of the largest pulse crops grown in Ethiopia's highlands is the faba bean (Vicia faba L.) [14]. It currently accounts for 31% of the country's pulse cultivation area (1,863,445 ha) ([9]). According to [23], the crop is important for human and livestock nutrition, as well as for enhancing soil fertility. As reported by [6], despite its numerous benefits, the faba bean yield is much below its potential and is hampered by a number of limiting factors. The productivity of faba beans among smallholder farmers is less than 1.89 t ha^{-1}, even with the availability of high-yielding varieties [19]. According to [26], the crop's susceptibility to biotic and abiotic stressors was a contributing factor in the low yield of faba beans. The main causes of the low productivity of most crops are low pH (acidity) and decreased soil fertility [29]. According to the majority of the data, applying chemical fertilizer increased faba bean yields significantly [18].

Nitrogen (N) is a crucial element in plant functions such as growth, leaf area expansion, photosynthesis, yield, protein, and dry matter production. Inadequate N in the plant may hamper growth and development, lowering the yield of crops. Excess N value in the plant, on the other hand (due to heavy applications of N chemical fertilizer), can reduce yield by decreasing sugar content and increasing diseases and pests. Excessive nitrogen fertilizer use is not economical and can damage groundwater. However, Legumes and symbiotic N2 fixation both benefit from phosphorus nutrition. Plants with a P deficit have particularly poor seed and fruit development. As a result, P-deficient soils not only produce low yields but also low-quality seeds and fruits [13]. According to [20], faba bean requires a lot of P for the energy expenditure involved in nodule development.

A number of researchers [18, 3] have studied on faba bean in various parts of Ethiopia. The majority of the surveys demonstrated considerable increases in faba bean yield due to the use of chemical fertilizers and manure. As a result, the primary objective of this review was to assess the combined impacts of organic and inorganic fertilizer on faba bean growth and yield under Ethiopian soil conditions.

2. Effect of Phosphorus on Growth Parameters, Yield, and Yield Traits of Faba Bean

Yield (kg ha^{-1}): As a study conducted by [17] to evaluate the response of faba bean to different levels of phosphorus (P) and potassium (K) fertilizers in Sekela district of West Gojam Zone of Amhara region from 2014 to 2015. According to their reports, there was a significant yield response to the application of P fertilizer in the two experimental years. The highest yield with the maximum net economic return was obtained from the application of 46 kg ha^{-1} of P_2O_5 fertilizer. This shows that P-fertilizer is more important to faba bean growth and yield than other plant nutrients. The crop's seed yield was unaffected by increasing the phosphorus rate from zero to 10 kg P ha^{-1}. Although the grain yields at 30 and 40 kg P ha^{-1} were statistically equal, the maximum seed yield was obtained at 40 kg P ha^{-1} (Table 1). On the other side, the untreated (control) plots produced the lowest yield. Therefore, it might be believed that since the highest yield was already being achieved at this rate of fertilizer, there would be no need to increase P application beyond 30 kg per hectare. In the study conducted by [8], the results showed that the application of 115 kg ha^{-1} P_2O_5 produced a considerably higher mean grain yield and dry biomass yield (4099.6 kg ha^{-1}), while the control produced the lowest mean grain yield and dry biomass yield (3073.3 kg ha^{-1}). Compared to the treatment that received only 46 kg ha^{-1} of P_2O_5, the addition of K_2O fertilizer had no effect (Table 2). As a result, phosphorus fertilizer is a vital nutrient for faba beans, as this study's findings indicated.

Table 1. *Effect of phosphorus fertilizer application on faba bean growth, yield and yield parameters.*

Treatment (kg P ha^{-1})	Plant height (cm)	Number of nodules plant^{-1}	Nodules dry weight (mg plant^{-1})	Number of pods plant^{-1}	Number of seeds pod^{-1}	Biomass yield (kg ha^{-1})	seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
0	104.2b	63.96c	105.5c	8.50c	2.39	8137d	1939c	6198c	0.24
10	112.6a	64.87bc	127.8bc	9.40c	2.34	9215c	2318b	6896bc	0.26
20	113.1a	76.12b	147.5abc	10.36b	2.38	10252b	2570b	7683ab	0.25
30	114.6a	9.74a	165.7a	14.46a	2.33	11294a	3105a	8189a	0.28
40	118.1a	94.52a	170.9a	13.08a	2.29	11451a	3303a	8148a	0.29
LSD (5%)	6.69	11.4	23.95	1.8	NS	1033.53	354.13	1021.51	NS

Source: [10]

Table 2. *Faba bean growth, yield, and yield-related characteristics are affected by phosphorus fertilizer rates.*

Treatments (kg P_2O_5 ha^{-1})	Plant height (cm)	Number of pod per plant	Number of seed per pod	Number of spike per 50cm	Grain yield (kg ha^{-1})	Biomass yield (kg ha^{-1})	Thousand seeds weight (g)
0	102.7b	11.66c	2.88b	5.35b	3075.3d	5713.8d	834.95
23	110.8ab	13.04ab	2.94ab	5.67ab	3552.9c	6773.3c	834.35
46	113.6a	12.53bc	2.99ab	5.9a	3772.0abc	6917.5bc	830.73
69	117.0a	13.89a	3.02a	6.05a	3996.8ab	7539.6ab	837.49
92	119.6a	13.98ab	3.0ab	5.96a	4048.6a	7678.5a	830.49
115	118.8a	13.33ab	2.93ab	6.18a	4099.6a	8127.4a	836.65
46 + 40 K_2O	110.5ab	13.3ab	2.97ab	6.02a	3598.2bc	6734.2a	835.89
LSD (5%)	9.7	1.3	0.1	0.5	401.8	741.7	Ns

Source: [8]

A field experiment was carried out by [1] for three consecutive years (2014/15–2018/19) to identify the influence of lime and P fertilizer on the acid properties of soils under the faba bean crop grown on Nitisol and acidic loam Haplic Alisols of Hankomolicha, Southern Region of Ethiopia. The treatments included four levels of phosphorus (0, 23, 46, and 69 kg ha^{-1}) and five levels of lime (0, 58.5, 117, 175.5, and 234 kg ha^{-1}). He stated that the minimum faba bean yield from the control treatment was 5.4 t ha^{-1}, whereas the maximum grain yields of 6.6 t ha^{-1} was reached at 46 kg P ha^{-1}. To ascertain the ideal P rate and population densities in faba bean (Vicia faba l.) genotypes grown on Vertisols, [21] carried out a field experiment at Ambo University Research Farm, Ethiopia. When the faba bean was fertilized with 46 kg of P_2O_5 per hectare, the biological yields (7,172 kg ha^{-1}) and seed yields (3,531 kg ha^{-1}) were significantly higher than when no fertilizer was applied (2,654 kg ha^{-1} seed and 5,602 kg ha^{-1} haulm yield). According to a study conducted on a farmer's field during the main cropping season of 2017 at Lemu Bilbilo, south-eastern Ethiopia, [25] reported that the largest grain yield of faba bean (6323 kg ha^{-1}) was obtained from the application of 40 kg P ha^{-1} and the lowest yield (5076 kg ha^{-1}) was observed from 0 kg P ha^{-1}, respectively. As phosphorus rates increased from 0 kg ha^{-1} to 40 kg ha^{-1}, the grain yield of faba bean increased by 25%.

Agegnehu, G. and Fessehaie, R. [2] investigated how phosphorus fertilizer and weed management affected faba bean (Vicia faba L.) yield and yield components in the Ethiopian highlands. Two levels of weeding (W1 = no weeding and W2 = hand weeding once every six weeks following crop emergence) and four levels of phosphorus fertilizer (0, 10, 20, and 30 kg P ha^{-1}) as triple super phosphate (TSP) were used as treatments. They discovered that over the duration of three years, the interaction between phosphorus level and weed management significantly ($P < 0.05$) reduced faba bean seed yield at Rob Gebeya but not at Welmera. At 30 kilogram P per hectare, the largest yield (1763 kg ha^{-1}) was discovered, whereas at 0 kg P ha^{-1}, the lowest yield (1165 kg ha^{-1}) was noted. The application of P fertilizer at rates of 10, 20, and 30 kg P ha^{-1} produced a linear response, as can be observed, with mean seed yield advantages of 20, 41, and 53%, respectively, over sites, and 13, 33, and 51%, respectively, at Welmera. The same rates, however, produced linear and quadratic responses at Rob Gebeya, where the mean seed yield advantages over the control were 26, 48, and 55%, respectively.

Plant height (cm): With the treatment of 115 kg P_2O_5 ha^{-1}, the mean plant height was much higher (119.6 cm), while the control yielded the lowest mean plant height (102.7 cm) (Table 2). Other findings indicated that the use of phosphorus had a significant influence ($P < 0.05$) on the plant height of faba beans (Table 1). As a result of this, the treatment that received the 40 kg P ha^{-1} fertilizer levels had the tallest plants (104.2 cm), though the treatment which had the smallest height of plant (118.1 cm) had been given no fertilizer (0 kilogram P hectare fertilizer rates) (Table 1). The application of 40 kg P ha^{-1} resulted in the tallest plants, which were 11.7% taller than the unfertilized control.

The highest mean plant height, in accordance with [1], was attained at 0 kilogram P ha^{-1} and 69 kg P ha^{-1} (Table 1). The application of lime did, however, have a positive and significant impact on plant height; the highest pooled mean plant height was attained at 117 kg lime ha^{-1}, whereas the lowest was that of the control. Similar to this, [24] found that the Tumsa variety produced plants with a much greater mean plant height of 157 cm, whereas the Gebelcho variety produced plants with the shortest stature (138 cm), followed by the Dosha variety (141 cm). In comparison to the other two types, the Gebelcho variety is regarded as a dwarf variation.

Number of pods per plant: The results showed that the lowest mean number of pods per plant of faba beans (8.5) was achieved from 0 kg P ha^{-1}, and the highest mean number of pods per plant (14.46) was recorded from 30 kg P ha^{-1} (Table 1). Similar findings showed that the 69 kg P ha^{-1} treatment yielded the highest number of pods per plant (13.89) and the plot treated with no fertilizer yielded the lowest number of faba bean pods per plant (11.66) (Table 2).

Biomass yield: In the findings of [24], varied fertilizer levels had a substantial ($P < 0.001$) influence on the mean dry biomass yield of faba beans. The application of 40 kg P ha^{-1} resulted in a significantly higher mean dry biomass production of 14158 kg ha^{-1}, which was identical to 20 kg P ha^{-1} and 30 kg P ha^{-1}, respectively. 0 kg P ha^{-1} produced the lowest yield of dry biomass (10970 kg ha-1), followed by 10 kg P ha^{-1} (12092 kg ha^{-1}). The dry biomass yield increased by 29% when phosphorus levels rose from 0 kg P ha^{-1} to 40 kg P ha^{-1}.

3. Effect of Nitrogen on Growth Parameters, Yield, and Yield Traits of Faba Bean

Yield (kg ha^{-1}): The main effect of nitrogen had a substantial ($P < 0.01$) impact on grain yield at Haramaya, whereas the main effect of sulfur and their interaction had no impact on grain yield at either location (Table 3). The application of 23 kg N ha^{-1} resulted in significantly greater grain yields at Haramaya. At Hirna, the maximum grain yield was statistically greater than that at Party, where the highest grain yield was produced in response to the application of 46 kg N ha^{-1}. The application of zero resulted in the lowest grain yields being scored. In general, optimal grain yields were produced at both locations with 23 kg N ha^{-1} (Table 3). In Alaje, northern Ethiopia, [22] carried out the experiment on farmer fields; the treatment contained four N levels and three P levels. As a result, compared to the plot with no nutrient input, the yield of faba beans rose by 304 kg ha^{-1} with the single application of 20 kg N ha^{-1}.

Table 3. *The main effects of nitrogen and sulfur on growth, yield, and yield components.*

Treatment	Plant height (cm)		Number of effective nodules plant^{-1}		Number of pods plant^{-1}		biomass yield (t ha^{-1})		Grain yield (t ha^{-1})	
Kg N ha^{-1}	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna
0	98b	114.7b	45.5	31.3	15b	27b	9.4b	10.6c	5.0b	5.6b
23	103.3a	119.5a	44.6	32.7	22a	33a	10.4a	11.4b	5.6a	6.7a
46	106.8a	122.7a	48.0	25.2	21a	37a	10.6a	12.1a	5.2b	6.4a
LSD (5%)	6.94	4.1	Ns	Ns	4.4	5.5	0.8	0.3	0.3	0.24
Kg S ha^{-1}										
0	99.9	118.7	28.5c	18.6b	20	31	10.18	11.5	5.3	6.2
20	104.2	117.8	47.3b	30.9a	20	32	10.3	11.4	5.2	6.1
40	103.7	120.1	45.2b	38.1a	19	35	9.9	11.3	5.4	6.3
60	104.1	119.1	63.6a	31.4a	18	33	10.1	11.3	5.2	6.4
LSD (5%)	Ns	Ns	15.7	11.2	Ns	Ns	Ns	Ns	Ns	Ns

Source: [27]

Plant height (cm): The analysis of variance revealed substantial ($P < 0.05$) changes in plant height at both locations due to the major impacts of nitrogen application (Table 3). At Haramaya and Hirna, however, there was no interaction effect on plant height. Thus, at Haramaya and Hirna, the largest plant heights (106 cm and 122.7 cm) were observed from 46 kg N ha^{-1} fertilizer levels, while the shortest plant heights (98 cm and 114.7 cm) were recorded from 0 kg N ha^{-1} fertilizer rates (Table 3).

Number of pods per plant: The analysis of variance revealed highly significant ($P < 0.05$) differences in the number of pods per plant due to the main impacts of nitrogen use at Haramaya and Hirna (Table 3). As a result, the most number of pods per plant (21, 37) was collected from the application of 46 kg N ha^{-1} fertilizer levels, while the lowest number of pods per plant (15, 27) was registered from the application of 0 kg N ha^{-1} fertilizer rates at Haramaya and Hirna, respectively.

Aboveground dry biomass: The main effects of nitrogen treatment had a notable ($P < 0.05$) impact on aboveground dry biomass at both sites (Table 3). This result suggested that the greatest percentage of aboveground dry biomass (9.4 t ha^{-1}, 10.6 t ha^{-1}) came from the treatment not treated with any fertilizer (0 kg N ha^{-1} fertilizer rates at Haramaya and Hirna, respectively). However, the lowest aboveground dry biomass (10.6 t ha^{-1}, 12.1 t ha^{-1}) was obtained from the treatment that received the 46 kg N ha^{-1} fertilizer levels.

4. Effect of Nitrogen and Phosphorus on Growth Parameters, Yield, and Yield Traits of Faba Bean

Grain yield (kg ha^{-1}): [18] conducted field trials in Ethiopia at three locations in 1991, seven locations in 1992 and 1993, and one location in both 1993 and 1995 to learn more about the faba bean's response to N and P fertilization. In the manner outlined above, they identified that P application beneficially affected yield, plant height, above-ground biomass, and number of pods per plant, but N application had a generally insignificant effect on these. Only two out of eight sites showed a faba bean seed yield response to N; the vast majority of sites showed nonsignificant and inconsistent seed yield responses to N fertilization, and there was additionally an insignificant NP rate interaction. However, during the main cropping season (June-December) 2017/18, [11] conducted a field experiment at Arsi Zone in Ethiopia with the aim of determining how varied fertilizer levels affected various faba bean (Vicia faba L.) variety responses. The treatments comprised three faba bean varieties (Degaga, Gora, and Moti) and three fertilizer rates (RNP, 150% RNP, and RNPS). They found that the Degage variety and fertilization with 150% RNP produced the greatest grain yield (4230 kg ha^{-1}), followed by the Gora variety and fertilization with RNP, which produced a grain yield of 4002 kg ha^{-1}, whereas the Gora variety, which interacts with RNPS, produced the smallest grain yield (2158 kg ha1). In a comparable manner, [4] found that applying phosphate fertilizer in the form of diammonium phosphate (DAP) boosted seed yields of faba bean substantially ($P < 0.01$) over the control, with the amplitude of responses varying with fertilizer rates. The yield advantages of faba beans over the control were 24, 66, and 80% as a result of the application of phosphate fertilizer at the rates of 9/10, 18/20, and 27/30 kg N/P ha^{-1}. In summary, in dila and dimile soils, applying 18/20 kg N/P ha^{-1} for faba bean as DAP can be suggested. Likewise, findings from [28] revealed that the highest grain yield (4.97 t ha^{-1}) produced by faba bean in response to the interaction effect of 23 kg N ha^{-1} 92 kg P_2O_5 ha^{-1}, and 60 kg K_2O ha^{-1} was 360% higher than the grain yield produced in response to zero application of the three fertilizers (control treatment), or roughly a 4-fold increase.

Plant height: [4] disclosed that the results pointed out that the use of phosphate fertilizer in 1999 and 2001 had a significant ($p < 0.05$) effect on the plant height of the faba bean. As a result of these experiments, in 1999 and 2001, respectively, the largest plant heights (88 and 125 cm) were documented using 18/46 NP_2O_5 kg ha^{-1} and 27/69 NP_2O_5 kg ha^{-1} fertilizer, though the smallest plant heights were obtained using 0/0 NP_2O_5 kg ha^{-1} fertilizer rates. According to [11], the study showed that fertilization at 150% RNP resulted in the longest (154.1 cm) plant height, which was followed by fertilizer treatments made with RNPS and RNP fertilizer that produced plant heights of 142.8 cm and 140.1 cm, respectively. Nitrogen's activity, which boosts vegetative development when other growth factors are present, may be directly linked to such an increase in plant height as well as an increase in nitrogen fertilizer rate.

As noted by [11], the results of their study revealed that the fertilization with 150% RNP resulted in the largest number of pods per plant (23.2), whilst RNP and RNPS fertilization was associated with the lowest values (17.7 and 19.2, respectively). As a result, increasing the number of pods per plant was directly related to the role of NP fertilizer in promoting root growth in crop plants by enhancing soil aeration, photosynthetic efficiency, carbohydrate partitioning, and nutrient supply—all of which are crucial for increasing the number of pods per plant. Along with increasing rates of P and K applications, increasing the rate of N application considerably and consistently increased the number of pods per plant. [28] found that the combination of N, P, and K at 46: 92: 60 kg ha^{-1} resulted in the highest number of pods per plant (17), which was statistically comparable to the number of pods per plant obtained with N, P, and K at 46: 92: 30 kg ha^{-1}. Conversely, plants that received no fertilizer produced the lowest average number of pods per plant (4).

Biomass yield: In the study by [28], the crop produced the maximum aboveground biomass yields when 23 kg N ha^{-1} and 46 kg N ha^{-1} were combined with 46 kg P_2O_5 ha^{-1} or 92 kg P_2O_5 ha^{-1} + 60 kg K_2O ha^{-1}. However, the lowest aboveground biomass yield was obtained when none of the three fertilizers were applied. They came to the conclusion that applying N, P, and K fertilizers at a rate of 23: 92: 60 kg ha^{-1} resulted in a 4-fold increase in biomass over the unfertilized plot. Furthermore, the results demonstrated that total biological yield was significantly ($P < 0.05$) and significantly ($P < 0.05$) impacted by NP_2O_5 fertilizer application in the 2000 and 2001 crop seasons, respectively [4].

5. Effect of Organic and Inorganic Fertilizer on Growth Parameters, Yield, and Yield Traits of Faba Bean

Yield (kg ha^{-1}): [12] developed a study to assess the effect of NPS and bio-organic fertilizers on faba bean yield as well as yield-related factors at Debre Markos University's research farm in Ethiopia. In total, there are four NPS levels (0, 50, 100, and 150 kg ha^{-1}) and four bio-organic fertilizer levels (Nil BOF, Rhizobium, 10 t FYM ha^{-1}, and FYM + Rhizobium). The experiment found that plots that were given Bio (FYM+IR) + NPS 150 had the best grain yield (5.85 t ha^{-1}) but were statistically no different from Bio (FYM+IR) + NPS100, all while treatments getting NPS (0) fertilizer and nothing bio-organic fertilizer had the lowest grain yield (1.58 t ha^{-1}). The treatment using Bio (FYM+IR) +NPS150 exhibited a 270.25% improvement against the NPS (0) fertilizer alongside no bio-organic fertilizers. In another study, [30] discovered substantial differences in grain yield due to the main effects of fertilizer and lime treatment, even though rhizobium inoculation did not significantly increase when compared to an uninoculated plot. The maximum economic yield, averaged over rhizobium strains and lime rates, was obtained by 100 kg DAP ha^{-1} utilization, which was actually equal to the yield produced with 125 kg DAP ha^{-1} (4157 kg ha^{-1}). Fortunately, a 12% drop in yield was seen when 75 kilograms of DAP ha^{-1} were used as opposed to 100 kg of DAP ha^{-1}.

In line with [5], the combination of 0.75 kg ha^{-1} bio-fertilizer rates and 50cm of space between rows resulted in the strongest growth, yield, and yield attributes of faba bean during the main growing period in 2019 at Kaffa zone, Southwestern Ethiopia. According to their findings, the greatest yield of grains (2540 6 kg ha^{-1}) was achieved with the use of 0.75 kg ha^{-1} of bio-fertilizer and 50cm of row spacing; however, the least yield (1083.3 kg ha^{-1}) was achieved with the absence of treatments and 30cm of row spacing. As reported by [15], a combination of 4 t lime ha^{-1}, 120 kg NPSB ha^{-1}, and rhizobium inoculation gave rise to the highest (245.67 kg ha^{-1}) grain yield, whilst the minimal (864 kg ha^{-1}) grain yield was obtained from an application with neither fertilizer nor lime but inoculated with rhizobium and par with the absolute control treatment. The grain production increase considered being a result of the simultaneous use of lime, NPSB, and rhizobium could be attributed to enhanced nutrient supply, which improved photo interception and hence high dry matter partition to grain.

Table 4. *The main effects of bio-fertilizer rates and inter-row spacing on the pods per plant, number of seeds per pod, 100 seed weight, and above-ground biomass yield.*

Treatments	Number of pods per plant	Number of seeds per pod	100 seed weight (g)	Biomass yield (kg ha^{-1})
Bio-fertilizer rate (kg ha^{-1})				
	21.6	3.2	62.9	3379.1
	25.1	3.1	77.1	4505.6
	29.5	3.1	89.3	6193.3
	32.9	3.4	98.8	7994
LSD (5%)	3.2	Ns	1.92	574.2
Row spacing (cm)				
	25.4	3.25	76.0	5035.0
	30.6	3.25	82.9	5478.3
	36.5	3.16	90.2	6041.0
LSD (5%)	4.96	Ns	6.8	434.3

Source: [5]

Table 5. *The interaction effects of biofertilizer rates (kg/ha) and inter-row spacing (cm) on the grain yield of faba bean.*

	Bio-fertilizer rate (kg ha^{-1})			
	0	0.25	0.5	0.75
Row spacing (cm)				
30	1083.3hij	1450.0fg	1586.7e	2316.7b
40	1150.0hi	1483.3f	1916.7d	2383.3ab
50	1215.7h	1550.0ef	2150.0c	2540.0a
LSD (5%)	148.36			

Source: [5]

Getachew Agegnehu and Chilot Yirga [16] evaluated the effects of farmyard manure (FYM) at three different levels (0, 4, and 8 t FYM ha^{-1}) and five levels of phosphorus fertilizer (0, 13, 26, 39, and 52 kg P ha^{-1}) on faba bean yield as well as the components of yield on Holetta Nitisols in Ethiopia. Their findings suggested that both FYM and P treatments had a positive effect on seed yield. With regard to the control, FYM treatments with 4 and 8 t ha^{-1} raised faba bean seed yield by 34 and 53%, respectively. The application of P fertilizer enhanced seed yield drastically, with yield advantages ranging from 16 to 32% ahead of the control. As a result, phosphorus from FYM interaction increased faba bean seed yield dramatically. The addition of 8 t FYM ha^{-1} and 39 kg P ha^{-1} resulted in a tremendous mean faba bean seed yield.

Plant height: According to various authors, the use of organic and inorganic amendments boosted plant height beyond that of the control. As an instance, [14] observed that an application of 8 t FYM ha^{-1} + 30 kg P ha^{-1} + 3.6 t lime ha^{-1} produced the longest plant height of faba bean (99.8 cm), whereas a fertilizer of 30 kg P ha^{-1} resulted in its smallest plant height (33.7 cm). In the other finding, it was noted that the plant with the highest height was measured from the plot treated with the (FYM+IR)+NPS150 (161.53 cm) fertilizer, followed by Bio (FYM+IR)+NPS100 (139.57 cm), which was statistically the same level with Bio (FYM)+NPS150, Bio (FYM) + NPS100, Bio (FYM) + NPS50, Bio (IR) + NPS100, and Bio (IR) + NPS150, while the lowest plant height was recorded in Bio (Nil) +NPS0 (94.13 cm) ([12, 15] did a rain-fed field experiment on a farmer's field in the Kiremu district of West Oromia, Ethiopia, to determine the effect of different rates of lime and NPSB-blended fertilizer application with and without inoculation on the different aspects of yield and faba bean yield. Three treatments were used: lime rates (0, 2, and 4 t ha^{-1}), mineral fertilizer rates (0, 60, 120, and 180 kg ha^{-1} NPSB), and rhizobium inoculation (with and without). Based on their findings, the greatest (94.7 cm) and shortest (43.2 cm) heights of plants were obtained using rhizobium inoculation (500 g ha^{-1}), 4 t lime ha^{-1}, and no rhizobium as well as no lime, respectively. The use of 4 t lime ha^{-1} and 180 kg ha^{-1} NPSB gave the highest height of the plants (95.5 cm), which is statistically equivalent to 4 t lime ha^{-1} and 120 kg ha^{-1} NPSB, whereas the plot that received neither lime nor fertilizer provided the lowest plant height (43.2 cm).

Number of pods per plant: As reported by [7], the number of pods per plant showed a significant ($p < 0.001$) response to phosphorus fertilization and rhizobium inoculation but not to potassium fertilization. Rhizobium inoculation increased the number of pods per plant from 7.00 to 13.08. The highest number of pods per plant (36.5) was recorded in the row spacing (50cm), while the number of seeds recorded was the smallest (25.4) and the row spacing was the narrowest (30cm) (Table 4). This could be due to the increased distance between plants as a result of reduced competition, which improves plants' ability to utilize environmental inputs to build an abundance of metabolites for the development of new tissues and enhance their yield and their component parts. As per [12], the greatest number of pods per plant (20.3) was noted in (FYM+IR) +NPS100 over the other treatments, which is comparable to (FYM+IR) + NPS150 treatment (19.43); however, the least number of pods per plant was measured in the plot receiving Bio (Nil) +NPS0 (10.57), which was comparable to Bio (FYM) + NPS0 (11.57). Maximizing the number of pods per plant was linked to FYM's involvement in boosting seed germination and root growth of agricultural plants by improving water holding capacity, soil aeration, and nutrient availability, all of which are necessary for increasing the number of pods per plant.

Number of seeds per pod: In the study conducted by [14], the highest number of faba bean seeds per pod (3.6) came from 4 t FYM ha^{-1} + 15 kg P ha^{-1} + 3.6 t lime ha^{-1} and 4 t FYM ha^{-1} + 15 kg P ha^{-1} + 7.2 t lime ha^{-1}, while the lowest number of seeds per pod (2) was gathered from 8 t compost ha1 and control plots. The main effects of lime, NPSB rate, and rhizobium inoculation, as well as the combination of lime and NPSB rate, on the number of seeds per pod were significant ($P < 0.001$) effects [15]. Additionally, they noted that the use of 120 kg NPSB ha^{-1} and 4 t lime ha^{-1} produced the largest number of seeds per pod (2.97), whereas the control treatment produced the lowest number of seeds per pod (1.67). The synergistic effects of lime, blended NPSB fertilizer, and rhizobium inoculation may have boosted the number of seeds per pod by enhancing crop nutrition and promoting grain development and filling. The analysis of variance revealed that there was no statistically significant difference in the number of seeds or pods between the main and interaction effects of the bio-fertilizer application dose and inter-row spacing of faba beans. Similar to what [7] reported, results from this study showed that there was no statistically significant distinction ($p > 0.05$) in the number of seeds per pod between the rhizobium inoculation and potassium fertilizer rates. Although it was not significant, inoculation and potassium supplements often increase the number of seeds produced per plant.

Hundred seed weight (g): As stated by [12], the greatest 100 seed weight was observed in the treatment (FYM + IR) + NPS100 (76.11 g), which was analogous to the treatment (FYM+IR) + NPS150 (72.64 g). On the other hand, the Bio (Nil) + NPS0 (43.14 g) treatment yielded the same minimum 100-seed weight as (FYM) + NPS0 (49.29 g). This could be because of the considerable contribution of extra N from N2-fixation and FYM to crop chemical fertilizer, as it is a major constituent of amino acids and numerous biological molecules that play important roles in photosynthesis, resulting in raised seed weight. The usage of the maximum (0.75 kg ha^{-1}) rate of bio-fertilizer inoculation brought about the highest 100-grain weight (98.8 g), whereas the control produced the lowest value of 100-grain weight (62.9 g) (Table 4). According to [7], the study found that 100-seed weight responded significantly (p 0.05) to fertilization containing phosphorus and rhizobium inoculation but did not differ significantly ($p > 0.05$) from potassium fertilizations. The treatment that got rhizobium inoculation yielded the highest 100-seed weight (50.66 g), whereas the uninoculated plants yielded the lowest (44.86 g). When weighed against uninoculated plants, inoculation increased seed weight by 11.44%.

Biomass yield (kg ha^{-1}): Numerous authors observed that as fertilizer rates increased, aboveground dry biomass increased. Among them, [15] findings revealed that the highest aboveground dry biomass (5551.3 kg ha^{-1}) came from the combined application of 2 t lime ha^{-1}, 180 kg NPSB ha^{-1}, and rhizobium inoculation, which was statistically comparable to the treatments that received 4 t lime ha^{-1}, 120 kg NPSB ha^{-1}, and rhizobium inoculation, as well as 2 t lime ha^{-1} and 120 kg NPSB ha^{-1}, whereas the lowest aboveground dry biomass (2000.3 kg ha^{-1}) was obtained from the absolute control treatment. The increase in aboveground dry biomass yield could be attributed to integrated fertilizer management. Liming, as reported by [14], improves the biological, chemical, and physical characteristics of soil. The utilization of 8 tons of FYM ha^{-1} + 30 kg of P ha^{-1} + 3.6 t of lime ha^{-1} enhanced straw yield from 1037 to 2904 kg ha^{-1}, and biological yields increased from 1910 to 4431 kg ha^{-1}.

In the other trial, the maximum above-ground dry biomass yield (7994.4 kg ha^{-1}) was obtained from the bio-fertilizer application rate (0.75 kg ha^{-1}); however, the control had the lowest biomass yield (3379.1 kg ha^{-1}) (Table 4). This could be attributed to the beginning of rhizobia inoculation to boost vegetative performance and increase grain crop yields when given in large dosages. The highest biomass yield (6041 kg ha^{-1}) was obtained at the widest inter-row spacing (50cm), while the lowest biomass yield (5035 kg ha^{-1}) was obtained at the tightest inter-row spacing (30cm) (Table 4).

6. Conclusion

In general, it can be seen from the review that fertilizer application has an impact on all faba bean parameters. However, as observed from this review, faba bean highly significantly responded to P fertilizer more than other nutrients. As per inorganic fertilizer, the review indicated that the yield of faba bean was increased from 0 kg P_2O_5 ha^{-1} to 115 kg P_2O_5 ha^{-1}, 0 kg N ha^{-1} to 46 kg N ha^{-1}, and 0 kg NP_2O_5 ha^{-1} to 109.5/103.5 kg N/P_2O_5 ha^{-1}, respectively. In addition, as per integrated fertilizer use, the experiment showed that plots treated with Bio (FYM+IR) + NPS 150 had the maximum grain yield (5.85 t ha^{-1}), while the lowest grain yield (1.58 t ha^{-1}) was recorded from treatments receiving NPS (0) fertilizer and without bio-organic fertilizers.

The results showed that the application of 4 t lime ha^{-1}, 120 kg NPSB ha^{-1}, and rhizobium inoculation produced the highest grain yield (2405.67 kg ha^{-1}), whereas a treatment without fertilizer or lime but with rhizobium inoculation and par with the absolute control treatment produced the lowest grain yield (864 kg ha^{-1}). According to the review, the type of soil, agroecology, and plant variety all influence how plants react to fertilizer. It can be concluded that to maximize the production and productivity of faba bean crops while also improving soil health, it is necessary to set the optimal rate of organic manures and inorganic fertilizer as per the site-specific location.

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