Original research Article

Response of Mung bean [*Vigna radiata* (L.) Wilczek] to Levels of Nitrogen and Phosphorus Fertilizer under Irrigation in Central Ethiopia

ABSTRACT

Mung bean has become an important cash and food crop in dry land areas of Ethiopia. However, there is no sufficient research information on the nitrogen (N) and phosphorus (P) fertilizers rates for the crop in the study area. Thus, field experiment was conducted to determine the effects of N and P fertilizer rates on growth, yield components and yield of mung bean under irrigation at Nura-Era, central Ethiopia. The treatments consisted of factorial combinations of three N fertilizer rates (0, 23 and 46 kg N ha^{-1}) in the form of Urea (46% N) and five P fertilizer rates (0, 10, 20, 30 and 40 kg P ha^{-1}) in the form of Triple Superphosphate (20% P) laid out in randomized complete block design (RCBD) with three replications. Result of the main effect of nitrogen rate showed significantly highest number of primary branches per plant (4.25), number of pods per plant (17.7), and 100 seed weight (4.94 g) at 23 kg N ha^{-1}. Similarly, the main effect of P fertilizer rate showed that the application of 40 kg P ha^{-1} produced significantly the highest number of primary branches per plant (4.79), highest number of pods per plant (20.85), the highest number of seeds per pod (6.24), the highest aboveground dry biomass (6838.83 kg ha^{-1}), the highest 100 seed weight (5.21 g) and the highest harvest index (25.96%). The interaction of N and P rates showed that the combination of 23 kg N ha^{-1} and 40 kg P ha^{-1} gave the highest grain yield (1902.78 kg ha^{-1}). Thus, the combination of 23 kg N ha^{-1} and 40 kg P ha^{-1} can be used to increase the productivity of mung bean in the study area.

Keywords: Grain yield, mung bean, nitrogen, phosphorus, central Ethiopia

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1. INTRODUCTION

Mung bean [*Vigna radiata* (L.) Wilczek] is an eco-friendly food grain leguminous crop of dry land areas with rich source of proteins, vitamins, and minerals [1]. The seeds of mung bean contain an average of 26% protein, 62.5% carbohydrates, 1.4% fat, 4.2% fibers, vitamins and minerals [2]. It is used as fodder for livestock as well as green manure. It is a warm season annual grain legume and the optimum temperature range for good production is 27-30°C [3].

Mung bean is of recent introduction to Ethiopian pulse crops production but its importance especially as an export crop is increasing. It is mostly grown by smallholder farmers under drier marginal environmental condition as food and cash crop due to its short growth duration and high market value [4]. According to CSA [5] the estimated area under mung bean in Ethiopia during the main cropping season of 2014/2015 was 14562 ha with a total production of 14067 t and productivity of 966 kg ha^{-1}.

As with other leguminous crops, the root nodules of mung bean fix atmospheric nitrogen. However, it was found that mung bean produced few nodules as a result of low levels of Rhizobia bacteria in Ethiopian soils and as a result yields were lower than might have been expected [6]. Pulse crops although fix atmospheric nitrogen (N) by symbiotic association, application of nitrogenous fertilizer as starter or initial dose is helpful in increasing the growth and yield of legume crops [7]. Most agricultural soils in the tropics, including Ethiopia, are deficient in nitrogen (N) and phosphorus (P). These two nutrients often limit crop production in Ethiopia [6]. Phosphorus deficiency followed by nitrogen is the major constraint in pulse production as it affects growth, nodule formation and development and N fixation [8].

Ardeshna et al. [9] reported that seed yield of green gram (*Phaseolus radiatus*). was increased with N application up to 20 kg N ha^{-1} as urea, and with increasing P levels up to 40 kg P_2O_5 as single superphosphate. Similarly, Patel and Patel [10] stated that green gram given 20 kg N + 40 kg P_2O_5 ha^{-1} gave the highest seed yield (1.74 t ha^{-1}). However, such fertilizer recommendations vary with soil type, climate of the area, varieties and management system used. Thus, there is a need develop site specific fertilizer rates for mung bean.

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Therefore, the objectives of this study was to determine the effect of N and P fertilizer rates on growth, yield components and yield of mung bean grown under irrigation in central Ethiopia.

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2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted at research field of Nura Era farm of upper Awash Agro Industry Enterprise, central Ethiopia. Geographically, the area is located at 8º37'N latitude and 39º43' E longitude and it lies at an altitude of 1200 meters above sea level. The area is semi-arid with the mean annual rainfall of 500 mm and the annual average minimum and maximum air temperatures of 15.3 ^{o}C and 32.6 ^{o}C, respectively.

The soil of the study was clay in texture, moderately alkaline (pH = 7.4), very low in organic matter (1.46%), low in total nitrogen (0.15%), moderate in available phosphorus (18.43 ppm) and moderate in Cation Exchange Capacity (25 cmol $^{(+)}$ kg^{-1} soil) according to rate by Landon [11].

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2.2 Treatments and Experimental Design

The treatments consisted of factorial combination of the three rates of N (0, 23, and 46 kg ha^{-1}) and five rates of P (0, 10, 20, 30 and 40 kg ha^{-1}). The experiment was laid out in randomized complete block design (RCBD) with three replications. The net plot size was 2.8 ×2.4 m (6.72 m^{2}). Mung bean variety NVL-1 with green seed colour and maturity duration of 60-70 days was used for the experiment. Urea (46% N) and Triple Super Phosphate (20% P) were used as sources of nitrogen and phosphorus fertilizers, respectively.

2.3 Experimental Field Management

The experiment was conducted under irrigation from December 2016 to February 2017. The experimental field was ploughed and disked by tractor and pulverized to a fine tilth. The plots were leveled manually. The mung bean seeds were treated with fungicide (Mancozeb 80% WP, 0.5 kg per 100 kg of seed) in order to protect from soil borne diseases. Inter-row spacing of 40 cm and intra-row spacing of 5 cm was used. To ascertain full stand in a plot, two seeds per hill were planted at depth of about 2.5 cm and lightly covered with soil and later thinned to one plant per hill after the emergence of the crop. Nitrogen as Urea (46% N) was applied first half split at sowing and the remaining half was applied just before flowering about 2 cm away from the plants. Phosphorus in the form of Triple Super Phosphate was applied basally at planting. All the other agronomic practices were followed as per the recommendation made for the crop for all plots throughout the experimental time uniformly. As the maturity time of mung bean was not uniform, harvesting was carried out by hand picking of pods at different dates as it reached harvest maturity.

2.4 Data Collected

The plant height and number of primary branches per plant were recorded at physiological maturity of the crop from pre-tagged five plants per net plot. The plant height was measured using meter tape from the base to the tip of a plant and averaged on a plant basis. Similarly, the number of primary branches per plant was determined by counting the total number of branches from the main plant and then averaged on per plant basis.

At harvest maturity, the number of pods per plant was recorded from five randomly taken plants in each net plot and the average was taken as number of pods per plant and the total number of seeds in the pods of the five plants was counted and divided by total number of pods to find the number of seeds per pod. Hundred seed weight (g) was determined from 100 seeds randomly sampled from the bulk of the threshed seeds using a sensitive balance, then the seed moisture content was determined and the 100 seeds weight was adjusted to a moisture content of 10%.

The aboveground dry biomass yield was determined at physiological maturity from five randomly taken plants from the destructive rows of each plot after sun drying till a constant weight. The dry biomass per plant was then multiplied by the total number of plants per net plot at harvest and was converted in to kg ha^{-1}. This value was used to calculate the harvest index as well. The grain yield was measured by harvesting and threshing the crop from the net plot area using a sensitive balance. The seed moisture content was determined and the grain yield was adjusted to a moisture content of 10% and expressed in kg ha^{-1}. Finally, the harvest

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index was calculated by dividing grain yield per plot by the total aboveground dry biomass per plot and multiplied by 100.

2.5 Data Analysis

Data were subjected to analysis of variance (ANOVA) appropriate to the experimental design using GenStat 18th edition software [12]. Fisher's protected Least Significant Difference (LSD) test at 5% level of significance was used for the treatment mean separation.

3. RESULTS AND DISCUSSION

3.1. Growth Parameters

3.1.1 Plant height

The main effects of both nitrogen and phosphorus rates and their interaction had significant ($p<0.01$) effect on the plant height of the mung bean (Table 1). The tallest plant (61 cm) was recorded from the combined use of 46 kg N ha^{-1} and 40 kg P ha^{-1} while the shortest plant (41.33 cm) was recorded from no fertilizer application (Table 1). In general, as the rates of both nitrogen and phosphorus were increased, the plant height showed an increasing trend. The increase in plant height with the increment of the rates of both N and P might be due to the fact that both nutrients were involved in vital plant functions and contributed to enhanced growth in the height of the crop. In line with this result, Abdul Kabir Khan et al. [13] reported maximum plant height (36.81 cm) of mung bean with the application of 20:50:30 kg N:P:K ha^{-1} and the shortest plants (29.64 cm) in plots with no fertilizer. Similarly, Sanaullah Jamro et al. [14] reported the maximum plant height of mung bean (59.54 cm) when it was applied with 50 kg N ha^{-1} and 75 kg P ha^{-1}.

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Table 1. Interaction effects of N and P fertilizer rates on plant height (cm) of mung bean

	P (kg ha^{-1})				
N (kg ha^{-1})	0	10	20	30	40
0	41.33^{h}	44.28^{gh}	43.86^{gh}	45.23^{fg}	46.77^{efg}
23	43.33^{gh}	44.92^{fgh}	48.61^{def}	51.00^{cd}	56.83^{b}
46	43.27_{gh}	46.33^{efg}	49.33^{de}	54.14^{bc}	61.00^{a}
Significance (N ×P)	**				
LSD (0.05)	3.87				
CV (%)	4.84				

** = Significant at P = 0.01; LSD (0.05) = Least Significant Difference at 5% probability level;

CV (%) = Coefficient of variation.

Means in the table followed by the same letter are not significantly different at 5% level of significance.

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3.1.2 Number of primary branches

The main effects of N and P rates were significant ($p<0.05$) on number of primary branches per plant while the interaction effect of N and P rates was not significant (Table 2). Application of 23 kg N ha^{-1} produced the highest number of primary branches per plant (4.25) and it was statistically at par with 46 kg N ha^{-1} whereas the lowest number of primary branches per plant (3.59) was recorded from the control (Table 2). The increase in number of primary branches per plant in response to the increased N fertilizer application rate might be due to higher vegetative growth of the plants under higher N availability. In agreement with this result, Abdul Kabir Khan et al. [13] reported maximum number of branches per plant (3.83) with the application of 100:50:30 kg N:P:K ha^{-1} and recorded the minimum number of branches per plant (3.17) from the control.

The highest number of primary branches per plant (4.79) was recorded at the highest P rates (40 kg P ha^{-1}) while the lowest number of primary branches per plant (3.09) was recorded from the control (Table 2). The increased number of primary branches per plant with increasing P rates might be due to availability of P for cell division leading to the increased number of branches per plant. In conformity with this result, Nadira Akter et al. [15] recorded the highest number of branches per plant (9.9) with the application of 40 kg P ha^{-1} with *Rhizobium* inoculation.

Table 2. Main effects of N and P fertilizer rates on number of branches per plant, number of pods per plant and number of seeds per pod of mung bean

Treatments	Number of branches per plant	Number of pods per plant	Number of seeds per pod
N rate (kg ha^{-1})			
0	3.5^{b}	16.11^{b}	5.44^{a}
23	4.25^{a}	17.70^{a}	5.90^{a}
46	4.01^{a}	17.39^{a}	5.75^{a}
Significance	*	**	NS
LSD (0.05)	0.34	0.92	NS
P rate (kg ha^{-1})			
0	3.09^{d}	15.26^{e}	5.03^{c}
10	3.54^{c}	15.78^{d}	5.44^{b}
20	4.07^{b}	16.11^{c}	5.89^{a}
30	4.25^{b}	17.75^{b}	6.01^{a}
40	4.79^{a}	18.80^{a}	6.24^{a}
Significance	*	**	**
LSD (0.05)	0.44	1.19	0.38
CV (%)	11.80	7.55	6.96

NS, * and ** = Non-significant, significant at P=0.05, and significant at P=0.01, respectively;
LSD (0.05) = Least Significant Difference at 5% % probability level; CV (%) = Coefficient of variation.
Means in the columns followed by the same letter are not significantly different at 5% level of significance.

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3.2. Yield Components and Yield

3.2.1 Number of pods per plant

The number of pods per plant was significantly ($p<0.01$) affected by the main effect of N and P rates while the interaction effect was non-significant (Table 2). The application of nitrogen at the rate of 23 kg N ha^{-1} produced significantly highest number of pods per plant (17.70) and it was statistically at par with the application of 46 kg N ha^{-1} (Table 2). The increase in number of pods per plant with the increased N levels might be due to adequate availability of N which facilitated the production of primary branches, and plant height which in turn contributed for the production of higher number of pods per plant. A greater leaf area also resulted in a corresponding increase in assimilate supply which has been reported to determine pod number in French bean (*Phaseolus vulgaris*) [16]. Corroborating this result, Sanaullah Jamro et al. [14] reported that mung bean fertilized with the combination of 50 kg N and 75 kg P ha^{-1} produced the maximum number of pods per plot (33.32).

Similarly, the highest number of pods per plant (18.80) was obtained from plots which received 40 kg P ha^{-1} while significantly the lowest number of pods per plant (15.26) was obtained in the control (Table 2). The increment of number of pods per plant with the increased application of P might be due to the function of P fertilizer that promotes the formation of nodes in legumes and various enzymatic activities which control flowering and pod formation. In conformity with this result, Nadira Akter et al. [15] reported significantly highest number of pods per plant (21.48) for mung bean with application of 40 kg P ha^{-1}. Likewise, Amanullah et al. [17] found that phosphorus application at the rate of 40 kg P_2O_5 ha^{-1} increased number of pod per plant of mung bean.

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3.2.2 Number of seeds per pod

The main effect of P rate was significant ($p<0.01$) on the number of seeds per pod. However, main effect of N rate and interaction of N and P had non-significant effect (Table 2). The highest number of seeds per pod (6.24) was obtained from plots applied with 40 kg P ha^{-1} and it was statistically at par with plots treated with 30 and 20 kg P ha^{-1} (Table 2). The increment in number of seeds per pod with increasing P fertilizer application rates might be due to the fact that P is essential component in seed formation as it plays key role in protein synthesis, phospholipids and phytin all of which are important in the formation of seeds [18]. In line with this result, Amanullah et al. [17] reported that application of 40 kg P_2O_5 ha^{-1} significantly increased the number of seeds per plant of mung bean. Nadira Akter *et al*. [15] also reported significantly the highest number of seeds pod^{-1} (9.98) for mung bean with the application of 40 kg P ha^{-1} and the lowest number of seeds per pod (6.78) without phosphorus application.

3.2.3 Hundred seeds weight

The main effects of N and P application rates were significant ($p<0.05$) on hundred seed weight while the interactions effect was not significant (Table 3). The highest hundred seeds weight (4.94 g) was recorded at 23 kg of N ha^{-1} and it was statistically at par with the application of 46 kg of N ha^{-1} whereas the lowest hundred seeds weight (4.24 g) was recorded from plots with no nitrogen fertilizer application (Table 3). This result was in line with the finding of Basu and Bandyopadhyay [19] who reported that 100 seeds weight of mung bean was increased with increasing N rates up to 30 kg N ha^{-1}.

Hundred seeds weight was also significantly ($p<0.05$) affected by phosphorus application where the application of 40 kg P ha^{-1} produced the highest hundred seeds weight (5.21 g) while the lowest hundred seeds weight (4.07 g) was recorded from no application of P (Table 3). Phosphorus application significantly increased dry matter production and resulted in greater partitioning of dry matter to pods and improved the seed size. In agreement with this result, Nadira Akter et al. [15] reported significantly the highest 1000 seed weight (34.43 g) of mung

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bean with the application of 40 kg P ha^{-1}. Likewise, Malik et al. [20] obtained the maximum 1000-grain weight (35.60 g) of mung bean with the application of 50 kg N and 75 kg P ha^{-1}.

Table 3. Main effects of N and P fertilizer rates on hundred seeds weight, dry biomass weight and harvest index of mung bean

Treatments	Hundred seeds weight (g)	Aboveground dry biomass ((kg ha^{-1})	Harvest index (%)
N rate (kg ha^{-1})			
0	4.24^{b}	6437.64	24.83^{b}
23	4.94^{a}	6648.66	25.66^{a}
46	4.85^{a}	6484.52	25.71^{a}
Significance	*	NS	**
LSD (0.05)	0.34	NS	1.46
P rate (kg ha^{-1})			
0	4.07^{b}	6206.39^{c}	24.72^{b}
10	4.28^{b}	6276.63^{c}	25.05^{a}
20	4.83^{a}	6449.40^{abc}	25.75^{a}
30	4.98^{a}	6680.35^{ab}	25.85^{a}
40	5.21^{a}	6838.83^{a}	25.96^{a}
Significance	*	**	**
LSD (0.05)	0.44	292.99	1.89
CV (%)	9.94	12.60	12.50

NS, * and ** = Non-significant, significant at P=0.05, and significant at P=0.01, respectively; LSD (0.05) = Least Significant Difference at 5% % probability level; CV (%) = Coefficient of variation; Means in the columns followed by the same letter are not significantly different at 5% level of significance

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3.2.4 Aboveground dry biomass yield

The effect of P application rate was significant ($p<0.01$) on the aboveground plant dry biomass weight while the effects of N application rate and interaction of N and P rates were not significant (Table 3). The highest dry biomass weight (6838.83 kg ha^{-1}) was produced at the P rate of 40 kg ha^{-1} while the lowest dry biomass weight (6206.39 kg ha^{-1}) was obtained at 0 kg P ha^{-1}. The increment in the aboveground plant dry biomass with application of P fertilizer might be due to the adequate supply of P have increased the plant height, number of branches per plant, and yield components of the crop which have positive correlation with dry matter accumulation. In line with this result, Yemane and Skjelvag [21] reported positive responded in the dry biomass of *Pisum sativum* with an increase of P rate of 0, 30 and 60 kg ha^{-1} P_2O_5.

3.2.5 Grain yield

Main effects of nitrogen and phosphorus rates had significant ($p<0.01$) effect on grain yield (Table 3). Moreover, the interaction effect of N and P rates was significant ($p<0.05$) on grain yield of mung bean (Table 4). The highest grain yield (1902.78 kg ha^{-1}) was recorded from the plots applied with 23 kg N and 40 kg P ha^{-1} followed by 46 kg N and 40 kg P ha^{-1} (1792.52 kg ha^{-1}) (Table 4). The increase in grain yield due to the combined application of NP indicates the need of both nutrients to achieve maximum grain yield; which is consistent with the basic principles of plant nutrition. Adding NP increased the production of dry matter in plants which can increase the potential of plant to produce more plant height, number of branches, number of pods and number of seeds that ultimately results in high biological and grain yield.

Khan et al. [22] also reported that N application directly increases the plant protein content and it helps to make plants green and plays a major role in boosting crop yield. This result was in agreement with the finding of Patel and Patel [10] who obtained that green gram supplied with 20 kg N + 40 kg P_2O_5 ha^{-1} gave the highest seed yield of 1.74 t ha^{-1}. Similarly, Sanaullah Jamro *et al.* [14] reported the highest seed yield (2290.0 kg ha^{-1}) from mung bean applied with 50 kg N + 75 kg P ha^{-1}. Whereas, Sadeghipour et al. [23] reported the maximum seed yield (224.2 g m^{-2}) of mung bean with higher application rates of 90 kg N and 120 kg P_2O_5 ha^{-1}.

Table 4. Interaction effect of N and P fertilizer rates on grain yield (kg ha^{-1}) of mung bean

Nitrogen rates (kg ha^{-1})	Phosphorus rates (kg ha^{-1})				
	0	10	20	30	40
0	1328.86^{f}	1427.08^{ef}	1532.73^{de}	1574.89^{de}	1635.41^{d}
23	1427.08^{ef}	1644.34^{cd}	1741.99^{bc}	1823.91^{ab}	1902.78^{a}
46	1416.17^{ef}	1650.78^{cd}	1708.33^{bc}	1778.27^{ab}	1792.52^{ab}

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Significance	*
LSD (0.05)	84.09
CV (%)	14.84

* = Significant at P=0.05
LSD (0.05) = Least Significant Difference at 5 % level; CV (%) = Coefficient of variation. Means in the table followed by the same letter are not significantly different at 5 % level of significance.

3.2.6 Harvest index

The main effects of N and P fertilizer were significant ($p<0.01$) on harvest index of mung bean whereas the interaction effect was not significant (Table 3). The highest harvest index (25.71%) was obtained from plots which were fertilized with 46 kg N ha^{-1}, which was statistically at par with the application of 23 kg N ha^{-1}. Similarly, the highest harvest index (25.96%) was observed with application of 40 kg P ha^{-1} and it was statistically at par with the applications of 30, 20 and 10 kg P ha^{-1} (Table 3). The increased harvest index with the application of both N and P indicates the synergistic effect of both nutrients in enhancing growth, yield components and yield of mung bean. In line with this result, Malik et al. [20] obtained the highest harvest index (24.16%) of mung bean with application of 25 kg N ha^{-1} and 100 kg P ha^{-1}.

4. CONCLUSION

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Application of 23 kg N ha^{-1} and 40 kg P ha^{-1} produced the highest number of primary branches, number of pods per plant, and 100 seed weight of mung bean. Similarly, the combination of 23 kg N ha^{-1} and 40 kg P ha^{-1} resulted in the highest grain yield (1902.78 kg ha^{-1}). Thus, combination of 23 kg N ha^{-1} and 40 kg P ha^{-1} can be used for increased productivity of mung bean in the study area. However, to reach at a conclusive recommendation, the experiment has to be repeated for more years with inclusion of the economic analysis.

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