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Response of Common Bean (Phaseolus vulgaris L.) Varieties to Phosphorus Fertilizer Application at Damot Gale, Southern Ethiopia

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Abstract
Common bean productivity is greatly influenced by soil fertility especially phosphorous because it appears essential for both nodulation and N_2 fixation. It is also the basis for the formation of useful energy, which is essential for sugar formation and translocation. In this context, a field experiment was conducted during 2015/16 cropping season at Buge of Damot Gale district in southern Ethiopia with objective of determining optimum rate of P fertilizer for common bean varieties. Treatments consisted in three common bean varieties (Awassa Dume, Ibado and Nasir) and six P rates (0, 10, 20, 30, 40, 50 Kg/ha) were combined in factorial and laid out in a randomized complete block design (RCBD) with three replications. Phenological, growth, yield components and yield reacted to varieties, P rates and their interactions differently. Variety Nasir took the longest days to flowering and physiological maturity whereas Awassa Dume took the shortest days to flowering and physiological maturity. In line with this, the highest plant height was obtained from variety Nasir while the shortest plant heights were seen for variety Awassa Dume. Significantly the highest number of pods per plant and seeds per pod were recorded for variety Awassa Dume at P rate of 20 kg/ha and 30 kg/ha, respectively. Biomass and grain yield were significantly differed where both parameters were highest for variety Awassa Dume at P rate of 20 kg/ha. Agronomic efficiency and economic analysis also confirmed that application of 20 kg/ha P fertilizers gave the optimum efficiency and net benefit.
Keywords: Common bean, Phosphorus, Varieties, Phaseolus vulgaris L.

1. Introduction

Common bean (*Phaseolus vulgaris* L.) is one the most important food legumes for direct human consumption.. It is used as food and export crop in Ethiopia as source of protein and cash for poor farmers (Dereje *et al*., 1995). Common bean is highly preferred by Ethiopian farmers due to its early maturing characteristics that enables the households to get cash income required to purchase food and other house hold needs when others crops have not yet matured (Lagesse *et al.,* 2006). It is composed of 50% of the grain legume consumed worldwide and as sources of protein in the diet is the most important grain legumes in the world for direct human utilization (Broughton *et al.* 2003). It ranks first among the pulses and commonly known as "the poor man's meat" due to its high protein content, which compensates for the deficiency that could have occurred in a households with low income.

A wide range of common bean genotypes are grown in Ethiopia including mottled, red, white and black varieties (Ali *et al*., 2003). The most known commercial varieties currently in production include pure red and pure white colored beans with increasing market demand (Ferris and Kaganzi, 2008). Currently the total land area allocated to common bean is estimated to be 366,876.94 hectares with a total production of 4,630,084.90 tons with average productivity of 1.26 tons per hectare in Ethiopia. It is also an important food and cash crop at Damot Gale district (CSA, 2013). The demand for common bean is increasing because of its significance in human nutrition as a source of proteins, complex carbohydrates, vitamins and minerals (Bennink, 2005). It was reported that common bean plays roles in reducing blood cholesterol level and combating chronic heart diseases, cancers and diabetics increased its recognition from human health point of view. In Ethiopia common bean is also important in providing fodder for feeding livestock and contributes to soil fertility improvement through atmospheric nitrogen fixation during the cropping season (Singh, 1999; Asfaw 2013).

Phosphorus is one of the most important elements for proper grain production and its adequate supply at early life of a plant is essential in the development of its reproductive parts (Brady and Weil, 2002). Legumes including common bean have high P requirement due to production of protein containing compounds which N and P are major constitutes, where P concentration in legumes is generally much higher than that found in grasses. High seed production of legumes is primarily dependent on the amount of P absorbed (Khan *et al*., 2003). The presence of large quantities of P in seed and fruit is an indication of essentiality of P in seed formation. A proper supply of P is associated with increased root growth and early maturity of crops, particularly grain crops. Indeed, the quality of certain fruits, forages, vegetables and grain crops is improved and disease resistance increased when these crops have satisfactory P nutrition (Havlin *et al*., 1999).

Common bean productivity is 1greatly influenced by soil fertility especially phosphorous because phosphorus plays an important role in biological nitrogen fixation (Jakobson, 1985; Hamdi, 1999). Phosphorus appears essential for both nodulation and N2 fixation (Ssali and Keya, 1983). It is also the basis for the formation of useful energy, which is essential for sugar formation and translocation. Nitrogen fixation in beans needs more inorganic phosphorus and phosphorus availability in soil is considered to be the major constraint to common bean production (Israel, 1987). The national average yield (1.26 t/ha) of common bean till low as compared to African as well as Global averages (Alemu and Bekele, 2005; Katugi *et al.,* 2009).

This low productivity might be attributed to several factors such as declined soil fertility, rain fall variability, pest pressure, poor agronomic practices and shortage high yielding elite cultivars more importantly low soil P content (Katungi *et al*., 2011). Indeed, adequate utilization of P fertilization with adaptable high yielding variety is crucial with respect to maximize production and productivity. High seed production of legumes primarily depends on the amount of P absorbed (Khan *et al*., 2003). The yield of common bean increases with P application (Gemechu, 1990) and its nodulation can be improved with the application of phosphorus (Amare, 1987). Getachew (1990) reported that lack of optimum fertilizer rate is one of the several factors contributing to the low grain yield of the bean. This necessitates determining optimum rate of phosphorus to maximize the yield of bean. Hence, this study was initiated with objective to determine the optimum P rate for common bean production.

2.Materials and methods

2.1. Experimental Site

On farm trial was conducted during 2015/16 cropping season at Buge of Damot Gale district in southern Ethiopia. An approximate geographical coordinates of the site is 07°034’ N latitude and 36^{0}34' E longitude having an altitude of 1899 meters above sea level. The mean maximum and minimum temperatures are 24 and 18°C, respectively. The experimental area receives mean annual rainfall of 780 mm where high amount of rainfall occurs during "*Belg*" from February to June cropping season whereas relatively low amount of rainfall received in "*Meher*" from July to October. Indeed, the area is characterized with bimodal pattern of rainfall of erratic type. Some physical and chemical properties of soil of experimental site is presented in Table 1.

2.2. Treatments and Experimental Design

Experimental treatments consisted in three common bean varieties (Awassa Dume, Ibado and Nasir) and six rates of P (0, 10, 20, 30, 40 and 50 Kg/ ha P) were combined in factorial and laid out in a randomized complete block design (RCBD) with three replications. Description of common bean varieties used in trial is shown in Table 2. Each plot was 2.4 m wide and 1.5 m long with total growth plot area of 3.6 m^2. Beans were hand planted following the planting time of the respective location and on set of rainfall. Two seeds were planted per hill and thinned after emergence to maintain the proposed plant density per plot. Inter and intra rows spacing used were 40 and 10 cm, respectively. Triple super phosphate (TSP) was used as P source and the rated amount applied at planting to each plot. The experimental field was ploughed, pulverized and leveled in order to get smooth seed bed. The recommended amount urea which was non-treatment part applied at rate of 50 kg/ha uniformly to all plots in split where first half at planting and the remaining half near flowering. All crop management practices such as cultivation, weeding etc., carried out as desired. Diseases and insect damage were visually monitored during the crop growing season.

Table 1. Some physical and chemical properties of soils of experimental site

Parameter	Value
Particle size distribution (%)	
• Sand	58
• Silt	30
• Clay	12
pH	6.1
Organic carbon (%)	1.15
Total N (%)	0.15
Available P (mg/kg)	1.39
CEC (cmolckg^{-1})	26.04

Table 2. Description of **c**ommon bean varieties used in trial

Characteristics	Varieties		
	Awassa Dume	Ibado	Nasir
Growth type	Bushy	Bushy	Intermediate
Seed colour	Red	Brown	Dark-red
Seed size	Small	Large	Small
Days to flowering	50-53	51-56	50-57
Days to maturity	85-90	90-120	88-95

Source: (MOARD, 2012)

2.3. Data collection and measurements

Plant parameters recorded were days to flowering, physiological maturity, plant height, leaf area index (LAI), pods per plant, seeds per pod, thousand seed weight (TSW), biomass, grain yield and harvest index (HI). Days to flowering was recorded as the number of days from planting to 50% of the plants exhibit flowering per plot. Days to physiological maturity was recorded when 50% of plants in the plot lose green color of pod. Plant height, LAI, pods per plant and seeds per pod were taken from 5 randomly selected plants per plot. Grain yield was harvested from central rows by avoiding border effects and converted to kg/ha after adjusting moisture content at 10%. Biomass was determined as the sum of straw weighed and total grain yield. Harvest index (HI) is the ratio of grain to the total biomass and estimated as:

$$\text{HI} = \frac{Grain\ yield}{Biomass\ yield}$$

Agronomic efficiency (AE) is defined as the economic production obtained per unit of nutrient applied and estimated as:

$$\text{AE} = \frac{(Gf - Gu)\ nx}{Na}$$

Where:

G_f = Grain yield of the fertilized plot (kg);
Gu = Grain yield of the unfertilized plot (kg),
Na= Quantity of N applied (kg).

Economic analysis was conducted using partial budget analysis method (CIMMYT, 1988*)*. All cost and price estimations were done in Ethiopian Birr (currency). Net income (NI) was determined as the difference of gross income and variable cost (Babatunde, 2003). In order to use the marginal rate of return (MRR) as a basis for fertilizer recommendation, the minimum acceptable rate of return was set at 100% (CIMMYT, 1998). Thus, MRR calculated was the marginal net benefit (i.e., the change in net benefits) divided by the marginal cost (i.e., the change in costs), expressed as a percentage. Total Revenue (TR) was estimated by multiplying the field price by the adjusted yield. Net Revenue (NR) was computed by subtracting the total costs that vary from the gross field benefits for each treatment. Data were subjected to analysis of variance using the general linear model SAS version 9.1 (SAS Inst., 2003). Treatments means were compared using the least significant difference (LSD) at 5% probability level.

3.Results and discussion

3.1 Days to flowering, maturity, plant height and LAI

The data for days to flowering, physiological maturity, plant height and LAI as affected by varieties and P rates are depicted in Table 3. Main effects of varieties and P rates had significant effect on days to flowering, maturity and plant height. Variety Nasir took the longest days to flowering (55) and physiological maturity (94) followed by Ibado with mean days to flowering of 53 and physiological maturity 90 days. The shortest days to flowering (49) and physiological maturity (84) were seen for variety Awassa Dume. The differences of 6 days for flowering and 10 days for maturity recorded between the longest and shortest days for the parameters. This result suggests that variety Awassa Dume is relatively early maturing while Nasir is relatively late maturing. In line with this, the highest plant height (58 cm) was obtained from variety Nasir followed by Ibado with mean plant height of 43 cm. The shortest plant height (42 cm) was seen for variety Awassa Dume. On the other hand, increasing P rates tended to shorten the days to flowering and physiological maturity (Table 3). The longest days to flowering and physiological maturity were recorded at non P applications where the highest P rate shortened the parameters.

Significant differences were detected due to effect of varieties by P rates interaction on days to flowering and physiological maturity (Table 3). Days to flowering and physiological maturity showed tendency of shortening with increasing P rates for all varieties. The longest days to flowering (56) and physiological maturity (97) were observed for Nasir at P rate of 0 kg/ha followed by Ibado at the same P rate. The shortest days to flowering and physiological maturity were recorded for variety Awassa Dume from non P applications plots. The early flowering with P application reported for tomato (Menary and Staden, 1976), wheat (Rahman and Wilson, 1977) and tef (Alemayehu, 2014). Thus, P fertilization associated with increased cytokinins synthesis and supply of photosynthates for flower formation (Horgan and Wareing, 1980; Marschner, 2012). On other hand, P deficiency has been related to the reduction in foliar expansion (Fredeen *et al*., 1989), decrease in the number of leaves (Lynch *et al*., 1991) and loss in photosynthetic efficiency (Lauer *et al*., 1989). This result is also in agreement with findings of Havlin *et al.* (1999), Berhan (2006) and Gifole (2011) that P fertilization initiated early flowering in common bean. Moreover, days to physiology maturity followed the same trend as that of days to flowering where the longest days to maturity observed at 0 kg/ha of P. Brady and Weil (2002) and Gifole *et al.* (2011) reported the same result that increasing P supply hastened crop maturity. Marschner (2002) earlier finding also confirmed that P could reduce the days to physiological maturity by controlling some key enzyme reactions that involve in hastening crop maturity. Regarding LAI, only varieties exhibited significant differences where the greatest LAI (2.61) was recorded for Ibado with mean LAI value of 2.54. The lowest LAI (2.48) was obtained from Awassa Dume. In contrast, main effect of P rates and it interaction with varieties did not have significant effect on plant height and LAI.

Table 3. Days to flowering, physiological maturity, plant height and LAI as affected by varieties and P fertilizer rates

Variety	P rates (kg ha^{-1})	Days to flowering	Days to physiological maturity	Plant height (cm)	LAI
Awassa Dume	0	53b	88e-g	35	2.32
	10	51cd	87g	41	2.53
	20	49f-h	84h	46	2.47
	30	48h	83hi	41	2.60
	40	48h	81ij	44	2.44
	50	45i	79j	45	2.47
Ibado	0	55a	95b	44	2.67
	10	51cd	92cd	43	2.61
	20	50d-ff	90de	47	2.43
	30	49e-h	89ef	42	2.48
	40	49e-h	87g	44	2.58
	50	48h	88e-g	39	2.47
Nasir	0	56a	97a	56	2.62
	10	52bc	96a	59	2.55
	20	51cd	93bc	59	2.65
	30	50d-f	93bc	55	2.58
	40	50d-f	93bc	60	2.64
	50	48h	90de	58	2.64
	LSD	1.6	2.2	NS	NS
	Awassa Dume	49c	84c	42b	2.48b
Variety Mean	Ibado	53b	90b	43b	2.54ab
	Nasir	55a	94a	58a	2.61a
	LSD	0.6	0.9	3.6	0.08
P Mean	0	55a	93a	45	2.54
	10	50b	91b	48	2.57
	20	50b	89c	50	2.52
	30	50b	88cd	46	2.56
	40	49bc	88cd	49	2.57
	50	48d	87d	47	2.52
	LSD	1.0	1.3	NS	NS
	CV (%)	1.9	1.5	11.2	4.7

Means followed by different letters within a column are significantly different at 5% probability level, NS= not significant

3.2. Pods per plant, seeds per pod and thousand seed weight

The data for number of pods per plant, seeds per pod and thousand seed weight (TSW) as affected by varieties and P rates are presented in Table 4. Varieties were significantly differed for number of pods per plant, seeds per pod and TSW. Aawassa Dume exhibited the highest number of pods per plant (18.0), seeds per pod (5.0) and TSW (420 g) followed by Nasir with mean number of pods per plant 16, seeds per pod 4.7 and TSW 280 g. The lowest number of pods per plant (12.0), seeds per pod (4.) and TSW (250 g) recorded for Ibado. The differences among varieties for the parameters might be attributed to their inherent variations. Similarly, the main effect of P rates had significant differences on number of pods per plant and seeds per pod. Number of pods per plant as affected by main effect of P rates ranged from 12 to 19. The greatest number of pods per plant (19.0) was recorded at P rate of 20 kg/ha. The lowest number of pods per plant (12.0) was obtained from non P application plots. In line with this, the highest number of seeds per pod (5.0) was observed at P rate of 40 kg/ha whereas the least number of seeds per pod (3.9) was seen at P rate of 0 kg/ha. However, main effect of P and its interactions with varieties did not result in significant differences on TSW.

Significant differences were detected due to interaction of varieties by P rates on number of pods per plant and seeds per pod (Table 4). The highest number of pods per plant (23.0) obtained from Awassa Dume at P rate of 20 kg/ha followed the same variety at P rate of 30 kg/ha with mean number of pods per plant of 21.0. The lowest number of pods per plant (9.0) was seen for Ibado at P rate of 0 kg/ha. Such increment of pods number per plant with increasing rate of P might be attributed to the better availability of P for plants as the rate of external P application increase which in turn observed on better plant performance. However, P rates above a certain optimum probably might be in excess that could not be consumed by plants. Several researchers, Hajeal *et al.* (1994), Zafal *et al.* (2003), Tesfahun (2007), Girma (2009) and Gifole *et al.* (2011) reported that number of pods per plant tended to increase with increasing of P fertilization rates to a certain optimum. Regarding the number of seeds per pod, it tended to increase with increasing P rates up to 30 kg/ha and then showed the tendency of decreasing with P rates above it. The highest number of seeds per pod (5.8) was recorded for Awassa Dume at P rate of 30 kg/ha followed by the same variety at P rate of 20 kg/ha with mean number of seeds per pod of 5.1. The lowest number of seeds per pod (3.7) was observed for Ibado at P rate of 0 kg/ha. Tesema and Alemayehu (2015) reported the general tendency of increasing number of seeds per pod with increasing P rates. This result is also in conformity with finding of Kassa *et al.* (2014), Turuko and Mohammed (2014) that number of seeds per pod tended to increase with increasing P rates for common bean varieties.

Table 4. Number of pods per plant, seeds per pod and TSW as affected by varieties and P rates

Variety	P rates ($kg\ ha^{-1}$)	Pods per plant	Seeds per pod	TSW (g)
Awassa Dume	0	11j	3.8fg	420
	10	14h	4.4de	450
	20	23a	5.1b	480
	30	21b	5.8a	410
	40	17e-g	4.9bc	390
	50	16fg	4.9bc	390
Ibado	0	9k	3.7g	260
	10	12ij	4.2e-g	260
	20	13hi	4.3d-f	260
	30	12ij	4.4de	250
	40	12ij	4.4de	240
	50	12ij	4.3d-f	240
Nasir	0	15g	4.3de	270
	10	19cd	4.5c-e	280
	20	19cd	4.7b-d	290
	30	18c-e	5.0bc	290
	40	18c-e	5.0bc	280
	50	17e-g	4.9bc	260
	LSD	1.4	0.4	NS
	Awassa Dume	18a	5.0a	420a
Variety Mean	Ibado	12c	4.0c	250c
	Nasir	16b	4.7b	280b
	LSD	0.5	0.2	13.1
	0	12d	3.9c	320
P Mean	10	15c	4.4b	330
	20	19a	4.9a	340
	30	16b	4.8a	310
	40	16b	4.8a	310
	50	16b	4.7a	310
	LSD	0.8	0.3	NS
	CV (%)	5.5	6.3	14.6

Means followed by different letters within a column are significantly different at 5% probability level, NS= not significant

3.3. Biomass, grain yield and harvest index

The data for biomass, grain yield and harvest index (HI) as affected by varieties and P rates are depicted in Table 5. Varieties were significantly differed for biomass yield. The highest biomass yield (2602 kg/ha), averaged over P rates, was recorded for variety Awassa Dume followed by variety Nasir with mean biomass yield of 20785 kg/ha. The lowest biomass yield (1623 kg/ha) was obtained from variety Ibado. A biomass gain of 60.3 % and 24.8 % were obtained as compared Awassa Dume over Ibado and Nasir, respectively. Similarly, significant grain yield differences were observed for varieties. Awassa Dume was out yielded with mean yield of 1327 kg/ha which was followed by Nasir with mean grain yield of 1083 kg/ha. The lowest grain yield (882 kg/ha) was seen for variety Ibado. As this result indicated that a yield advantages of 50.5 % over Ibado and 22.5 % Nasir. Fageria *et al.* (2010), Girma *et al.* (2014) and Zewdu (2014) indicated that there is existence of yielding differences with respect to genotypes. Moreover, HI followed similar trend that it was highest for Awassa Dume and lowest for Ibado. In line with this, main effect of P rates had significant effect on biomass and grain yield. Both parameters were tended to increase with increasing P rate up to 20 kg/ha and relatively declined with further increase above that optimum rate. The highest biomass yield (2734 kg/ha) and grain yield (1415 kg/ha), averaged over varieties, were recorded at P rate of 20 kg/ha followed by P rate of 30 kg/ha with mean biomass of 2560 and grain yield 1331 kg/ha. The lowest biomass yield (852 kg/ha) and grain yield (437 kg/ha) were obtained from non P application plots. In contrast, main effect of P rates did not have significant effect on HI.

Significant differences were detected due to effect of varieties by P rate interactions on biomass and grain yield (Table 5). All treatments resulted in higher total biomass and grain yield over the non P application plots. Moreover, both parameters were relatively tended to increase with increasing P rates for all varieties up to 20 kg/ha and then showed tendency of declining above that rate. The highest biomass (3776 kg/ha) and grain yield (1900 kg/ha) for variety Awassa Dume at P rate of 20 kg/ha followed by the same variety at P rate 30 kg/ha with mean biomass yield 0f 2993 kg/ha and grain yield of 1518 kg/ha. The lowest biomass (654 kg/ha) and grain yield (343 kg/ha) were recorded for variety Ibado at P rate of 0 kg/ha. The declining trend of biomass after application of 20 kg/ha, which might be attributed to imbalance of P with other nutrients, especially with N (Mengel and Kirkby, 1987; Havlin *et a*l., 1999). Tesfaye (2015) indicated that there was general increase of biomass yield with increasing of P rate from the lowest to the highest where the highest biomass at P rate of 30 kg/ha and the lowest from non P application plots. This finding is in conformity with result of Girma *et al.* (20014) that grain yield was significantly increased with increasing P rates resulting in the highest grain yield at P rate of 20 kg/ha while the lowest grain yield from non P application plots.

Table 5. Biomass, grain yield and HI as affected by varieties and P rates

Variety	P rates (kg ha^{-1})	Biomass (kg/ha)	Grain yield (kg/ha)	HI
Awassa Dume	0	1175i	594h	0.50
	10	2056ef	1070de	0.50
	20	3776a	1900a	0.52
	30	2993b	1518b	0.51
	40	2828bc	1456b	0.51
	50	2782bc	1428b	0.51
Ibado	0	654j	343i	0.51
	10	1372hi	743gh	0.54
	20	1684f-h	1148cd	0.51
	30	2099e	1106de	0.51
	40	2032ef	1029def	0.51
	50	1898e-g	924efg	0.50
Nasir	0	727j	373i	0.50
	10	1612gh	847fg	0.51
	20	2742bc	1420b	0.50
	30	2599cd	1351bc	0.51
	40	2588cd	1326bc	0.51
	50	2242de	1177cd	0.51
	LSD	388	207	NS
	Awassa Dume	2602a	1327a	0.55a
Variety Mean	Ibado	1623c	882c	0.50b
	Nasir	2085	1083b	0.52b
	LSD	158	84	0.04
	0	852d	437d	0.50
P Mean	10	1680c	886c	0.52
	20	2734a	1415a	0.53
	30	2560ab	1331ab	0.52
	40	2426b	1269b	0.51
	50	2367b	1247b	0.52
	LSD	224	120	NS
	CV (%)	11.1	11.4	23.6

Means followed by different letters within a column are significantly different at 5% probability level, NS= not significant

3.4. Agronomic Efficiency and Profitability

Agronomic efficiency is the amount of additional yield produced for each additional amount of fertilizer applied (Mengel and Kirkby, 2001). The agronomic efficiency (AE) was increased with P rates up to 20 kg/ha and then declined for P rates above it (Table 6). The highest AE (65.3) was recorded for variety Awassa Dume at P rate of 20 kg/ha followed by Nasir at the same P rate with mean AE of 52.4. The lowest AE (14.1) was seen for variety Ibado at P rate of 50 kg/ha. Declining trend of AE above P rate of 20 kg/ha could be related to the reaching of P supply to the optimal level or limitation of yield potential of bean variety. Shehu *et al*. (2010) reported that AE on sesame decreased when the P levels increased above a certain optimum. In line with this, economic analysis revealed that the highest net benefit of 11109 Birr/ha with marginal rate of return (MRR) 1387% was obtained from Awassa Dume at P rate of 20 kg/ha (Table 6). An increase in output will always raise profit as long as the MRR is higher than the minimum rate of return *i.e.* 50 to 100% (CIMMYT, 1998). As long as the MRR between the treatments exceeds the minimum acceptable rate of return (100%), the change from one treatment to the next should be attractive to farmers and economically feasible. If the MRR falls below the minimum, on the other hand, the change from one treatment to another will not be acceptable. From the result it showed that fertilizer has a major role on yield of crop. Similarly, Terman and Engelated (1996) indicated that the most profitable nutrient rate can be determined by calculating the maximum net profit or minimum cost per unit of production. Therefore, the optimum fertilizer (P) combination with efficient variety is important to obtain maximum net profit.

Table 6. Profitability and agronomic efficiency of P application on common bean

Varieties	P rates (kg ha^{-1})	Total revenue	Net profit	MRR	AE
Awassa Dume	0	3780	3720	0	0
	10	5733	5186	301	46.7
	20	12083	11109	1387	65.3
	30	8266	7026	-1540	27.7
	40	9797	8207	337	23.1
	50	9003	7099.6	-352	16.8
Ibado	0	1890	1860	0	0
	10	4082	3566	350	39.9
	20	4284	3434	39.2	28.9
	30	6508	5296	515	22.3
	40	6823	5280	472	20.1
	50	6798	4930	-108	14.1
Nasir	0	1890	1860	0	0
	10	5040	4503	522	47.4
	20	8190	7408	1181	52.4
	30	7560	6333	-241	32.6
	40	7623	6068	-81	23.8
	50	7574	5706	-116	16.1

Conclusion

Phenological, growth, yield components and yield responded to varieties, P rates and their interactions differently. Significant differences were detected due to effect of varieties by P rate interactions on biomass and grain yield. The highest biomass and grain yield were observed for variety Awassa Dume at P rate of 20 kg/ha while both parameters were lowest variety Ibado at P rate of 0 kg/ha. Agronomic efficiency and economic analysis also confirmed that application of 20 kg/ha P fertilizers gave the optimum efficiency and net benefit. This result revealed that all varieties gave better yield that P rate of 20 kg/ha with superior performance of variety Awassa Dume. Based on this result variety Awassa Dume at P rate of 20 kg/ha could be recommended for common bean production at Damot Gale and similar agro-ecologies.

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