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Research Article

Effect of Common Bean (*Phaseolus vulgaris* L.) Varieties and Variable Rates of Potassium Fertilizer on Yield and Yield-Related Traits at Areka, Southern Ethiopia

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Yield and yield components of common bean varieties reacted differently in response to variable levels of potassium (K) fertilization under different growing areas. Hence, it is necessary to integrate varieties with optimum K rates in order to maximize bean yield. On the other hand, insufficient K supply has a negative influence on stomata's functionality, delaying stomatal closure and leaving pores partially closed. Thus, it is essential to find high-yielding varieties with balanced K fertilization. To evaluate common bean varieties at various K rates, a field experiment was carried out during the 2019/20 cropping seasons at the Areka Agricultural Research Center Experimental Field in Southern Ethiopia. Treatments consisted of three common bean varieties (SER 119, SAB 736, and Awassa Dume) and five K rates (0, 10, 20, 30, and 40 kg/ha K_2O) combined in factorial and laid out in a randomized complete block design with three replications. The phenological, growth, yield components, and yield of common bean varieties reacted differently to the varieties, K rates, and their interactions. Parameters such as branches per plant, leaf area, LAI, pods per plant, biomass, and grain yield were significantly affected by varieties, K rates, and their interactions. Conversely, plant height, seeds per pod, and HI were significantly affected only by the main effects of varieties and K fertilizer rates. This investigation indicated that variety SER 119 exhibited superior performance over others with the highest grain yield at K rate of 40 kg/ha. Hence, variety SER 119 at K rate of 40 kg/ha could be used for production in the study area and similar agroecologies.

1. Introduction

The common bean (*Phaseolus vulgaris* L.) is one of the most popular legumes consumed worldwide. The crop is grown for immediate human consumption and has a greater commercial value than all other legume crops combined [1–3]. Common bean is cultivated in almost all continents of the world for utilization of 50% of the grain legume consumed as a source of protein around the world [1, 4]. In Ethiopia, the crop serves two purposes: it is grown for food because it is a good source of protein, and it is also grown for export to help poor farmers make money [5]. Ethiopian farmers favor common beans above other crops because of their early maturing traits, which allow households to meet their food needs and obtain the necessary monetary revenue, while other crops are not yet fully developed and ready for consumption. The crop is the best among pulses and is referred to as "the poor man's meat" because it makes up for any potential protein deficiencies in low-income households [6].

One of the macroelements, potassium (K), is crucial for the production of protein and chlorophyll. It is a crucial nutrient component for photosynthesis, enzyme activation, the synthesis of amino acids and proteins, cell division, and growth in plants. As a result, it has more effects on plants than any other nutrient [7]. Potassium controls the opening of the leaf stomata, which in turn affects the rate of transpiration and gas exchange. It also minimizes lodging and helps build strong, rigid straw. Potassium is required by plants for the synthesis of sugars and starches that promote protein synthesis and cell division. Additionally, K raises the oil content of pistachios, which may improve their ability to withstand cold temperatures [8]. Potassium works to control the transport of nutrients, sugars, and water in the plant tissue but does not directly contribute to the structure of the plant. Additionally, it promotes the synthesis of protein, starch, and legume nitrogen fixation. The amount of K^+ in the plant tissue controls a number of physiological activities, including the maintenance of turgor under stressful conditions, transpiration, the creation of high-energy molecules, and the translocation of assimilates. Potassium is required for the activation of more than 80 plant enzymes [7]. Potassium increases a plant's resistance to diseases, drought, and salt [9, 10] and promotes quick water absorption, which aids in seed germination. According to research findings, K salts are effective catalysts for enhancing seed germination and the rate at which seedlings emerge. By using KNO_3^- as a priming agent, a good germination rate was obtained in cotton genotypes [11]. The intrinsic importance of K in plant growth, differentiation, and development makes it an essential mineral component [12]. Stomatal guard cells swell in the presence of K^+ by absorbing water, which is followed by stomatal opening and the authorization of gaseous flow between plant components and the environment. When there is a water shortage, K^+ is pushed out of the guard cell, which enables the pores to close completely. As a result, K regulates the evapotranspiration (ET) of water through pores in a soil environment with a water deficit and shields the plant from water stress. Stomata function is negatively impacted by insufficient K availability, which can cause incomplete or delayed pore closure. It is concluded that adding K to K-deficient soils can help maize deal with drought and could be a novel management option when they observed pronounced leaf rolling under a water deficit situation after K addition, which prevented water losses [11].

Numerous biotic and abiotic factors which include diseases, insect pests, drought, nutrient deficiencies, and most importantly, the lack of improved high-yielding varieties with balanced fertilization in the right amounts including K element are among the major causes for low crop yield [13, 14]. Macronutrients such as N, P, K, and S and micronutrient deficiencies such as B and Zn are the greatest yield limiting factors in crop production and productivity in Ethiopia [15]. Despite its many uses, the common bean has an average national yield of 1.71 t/ha, whereas its maximum yield is supposed to be around 4 t/ha [14]. This might be due to various constraints related to low adoption of improved agricultural technologies, drought, poor cultural practices, disease, and environmental degradation [6]. On the other hand, farmers in Ethiopia cultivate leguminous crops including common bean using blanket fertilizer recommendation at a rate of 100 kg/ha di-ammonium phosphate [16, 17]. Therefore, adopting technologies like high-yielding cultivars with proper utilization of balanced nutrients, including K element, could result in increased productivity and production of common beans. As a result, the purpose of this study was to determine optimum rates of K fertilizer for common bean varieties.

2. Materials and Methods

2.1. Description of the Experimental Site. Field study was carried out during the 2019/20 cropping seasons at Areka Agricultural Research Center Experimental Field in Southern Ethiopia. Geographically, the site is located at 7°4′24′ N latitude and 37°41′30′ E longitude having an elevation of 1830 meters above sea level. The average maximum and minimum temperatures are 26 and 14 degrees Celsius, respectively. The experimental area experiences a bimodal pattern of mean annual precipitation of 1460 mm that runs from March to October and is characterized by large amounts of precipitation during "Belg" (February to June) and comparatively low amounts during "Meher" (July to October) [18]. The soils at the trial site are classified as sandy loams with pH of 5.28, organic matter of 1.48%, total N of 0.13%, available P of 20.88 ppm, available K of 85.50 ppm, exchangeable K of 0.57 ppm, and cation exchange capacity of 16.30 cmolc/kg.

2.2. Treatments and Experimental Design. Treatments used in the trial were three common bean varieties (SER 119, SAB 736, and Awassa Dume), and five rates of K (0, 10, 20, 30, and 40 kg/ha K_2O) were arranged factorially and laid out in a randomized complete block design with three replications. The plot size was 2.4 m × 2.4 m with total gross plot area 5.76 m^2. The experimental field was ploughed, pulverized, and leveled in order to have smooth seed bed. The seeds were hand planted by putting two seeds per hill and thinned after establishment. Row and plant spacing adopted were 40 and 10 cm, respectively. Potassium chloride was used as the K source, and the rated amount was applied at planting to each plot. The recommended amount of P in the form of diammonium phosphate at the rate of 100 kg/ah was applied at planting, and urea was applied at the rate of 50 kg/ha uniformly to all plots in split taking into consideration the N content in diammonium phosphate where the first half at planting and the remaining second half near flowering. Cultural practices such as cultivation, weeding, monitoring diseases, and insect damages were visually monitored during the crop growing period.

2.3. Data Collection and Measurements. Days to flowering were determined as the number of days between planting and the time at which 50% of the plants on a plot begin to flower. Days to physiological maturity were measured as the time when 90% of the plants per plot lost their green pod color. Five randomly chosen plants per plot were measured for plant height from the ground to the tip at physiological maturity. The number of branches per plant was calculated by counting the number of major branches per plant for five randomly chosen plants at physiological maturity. Leaf area was recorded by taking a destructive sample of five plants per plot and measured using a leaf area meter. The leaf area index (LAI) was calculated as the ratio of total leaf area to ground area. Pods per plant were estimated for five randomly chosen plants per plot. Seeds per pod were counted for five randomly selected plants per plot. Thousand seed weight (TSW) was determined by counting 1000 seeds with seed counter and weighing it with sensitive balance. Biomass yield was determined as the sum of straw weighed and total grain yield. The grain yield was harvested from a plot net area and converted to kg/ha after adjusting the moisture content to 10%. Harvest index (HI) was estimated as follows:

$$HI = \frac{\text{Grain yield}}{\text{Biomass yield}}. \quad (1)$$

Data collected were analyzed using the general linear model of GenStat 16th edition [19], and interpretations were made following the standard procedure [20]. Whenever the effects of the treatments were found to be significant, the means were compared using the least significant differences (LSD) test at 5% level of significance.

3. Results and Discussion

3.1. Days to Flowering and Physiological Maturity. Data analysis revealed that days to flowering and physiological maturity were significantly affected by the main effect of varieties (Table 1). Days to flowering ranged from 44.40 to 51.60, whereas physiological maturity was from 93.60 to 98.09 for the main effect of varieties. Variety SER 119 showed the longest day to flowering (51.60) followed by variety Awassa Dume with mean days to flowering which was 48.00 days. The shortest day to flowering (44.40) was observed for variety SAB 736. Regarding two days to physiological maturity, the longest day (98.07) was observed for variety Awassa Dume followed by variety SER 119 with mean days to physiological maturity of 98.00. The shortest days to physiological maturity (93.60) was obtained from variety SAB 736. The difference of 7.20 days was observed between the longest and shortest days to flowering, while the difference of 4.47 days was seen between the longest and shortest days to physiological maturity. Variety SAB 736 flowered and matured earlier, while the other two varieties took relatively prolonged period of time to attain their physiological maturity. The variation among common bean varieties with respect to days to flowering and physiological maturity was likely attributed to their genetic differences. It was reported [21–23] that there were differences among common bean varieties for days to flowering. On the other hand, the main effect of K fertilizer rates and their interactions with varieties did not result in significant differences on days to flowering and physiological maturity (Table 1).

3.2. Plant Height and Number of Primary Branches. Plant height and the number of primary branches per plant were significantly affected by the main effect of varieties (Table 2). The tallest plant height (54.03 cm) and the highest number of primary branches (2.53) per plant were obtained from variety SER 119. Both parameters were lowest for variety SAB 736. The variations of common bean varieties regarding plant height and the number of primary branches per plant were likely due to their inherent variability. Likewise, analysis of variance indicated that significant differences were detected due to effect of K fertilizer rates on plant height and the number of primary branches per plant (Table 2). Plant height and the number of primary branches per plant tended to improve as K rates increased from 0 to 40 kg/ha. The tallest plant height (50.48 cm) and greatest number of primary branches (2.61) were recorded at the K fertilizer rate of 40 kg/ha and the lowest from unfertilized plots. However, the interactions of varieties by K fertilizer rates did not have a significant effect on plant heights (Table 2). Moreover, varieties by K fertilizer rate interactions resulted in significant differences on the number of primary branches per plant (Table 2). The number of primary branches per plant exhibited inconsistency for all varieties as K fertilizer rates increased from 0 to 40 kg/ha. All varieties produced a higher number of primary branches per plant at the highest K fertilizer rate. Regarding the overall effect, the greatest number of primary branches per plant (3.30) was observed for variety SER 119 at the K fertilizer rate of 40 kg/ha followed by the same variety K fertilizer rate of 20 kg/ha with a mean number of primary branches per plant of 2.57. This likely showed that common varieties reacted differently to variable rates of K fertilization. The number of primary branches per plant was significantly maximized with increasing fertilization of K nutrient [24].

3.3. Leaf Area and Leaf Area Index. Analysis of the data showed that the main effect of varieties resulted in significant differences on leaf area and LAI (Table 2). Leaf area for varieties ranged from 1222.30 to 1288.10 cm^2 and that of LAI from 3.05 to 3.22. Variety SER 119 had the greatest leaf area (1288.10 cm^2) and LAI (3.22) followed by variety Awassa Dume with mean leaf area of 1262.60 cm^2 and LAI of 3.15. The lowest leaf area (1222.30 cm^2) and LAI (3.05) were achieved from variety SAB 736. Similarly, analysis of variances indicated that the main effect of K fertilizer rates resulted in significant differences on leaf area and LAI (Table 2). Both parameters tended to increase with increasing K fertilizer rates from 0 to 40 kg/ha with the greatest leaf area (1346.00 cm^2) and LAI (3.36) that were recorded from the highest K rate followed by the K rate of 30 kg/ha with a mean leaf area of 1299.60 cm^2 and LAI value of 3.25. The lowest leaf area (1169.10 cm^2) and LAI value (2.92) were obtained from unfertilized plots. In line with this, analysis of variance showed that varieties by K fertilizer rates interactions resulted in significant differences on leaf area and LAI (Table 2). Common bean varieties responded differently to variable rates of K fertilization with respect to leaf area and LAI. Varieties SER 119 and SAB 736 produced the greatest leaf area and LAI at the highest K fertilizer rate and the lowest leaf area and LAI from unfertilized plots. With respect to variety Awassa Dume, it yielded the highest leaf area at the K fertilizer rate of 30 kg/ha and LAI value at a K rate of 20 kg/ha. Regarding the overall effect, the greatest leaf area (1445.90 cm^2) and LAI (3.61) were recorded for variety SER 119 at a K fertilizer rate of 40 kg/ha followed by the same variety at a K fertilizer rate of 30 kg/ha with a mean leaf area of 1335.10 cm^2 and LAI value of 3.34. The lowest leaf area (1117.00 cm^2) and LAI value (2.79) were obtained for variety SAB 736 from unfertilized plots (Table 2). This result clearly showed common bean varieties reacted differently to variable rates of K fertilization in production of leaf area and LAI. It was reported [25] that LAI is variable from variety to a variety of common beans in response to growing environmental conditions and management practices.

Table 1: Days to flowering and physiological maturity as affected by varieties and K rates during 2019/20 cropping seasons.

Varieties	K rates (kg/ha)	Days to flowering	Days to physiological maturity
SER 119	0	52.00	97.33
	10	52.67	101.00
	20	51.00	97.00
	30	50.00	98.67
	40	52.33	96.00
SAB 736	0	44.33	93.00
	10	44.67	95.00
	20	44.33	93.00
	30	44.00	93.67
	40	44.67	93.33
Awassa Dume	0	48.33	98.00
	10	48.00	97.33
	20	48.33	98.33
	30	46.67	98.33
	40	47.67	98.33
	LSD	NS	NS
Varieties mean	SER 119	51.60[a]	98.00[a]
	SAB 736	44.40[c]	93.60[b]
	Awassa Dume	48.00[b]	98.07[a]
	LSD	1.88	2.53
K rate mean	0	48.22	96.11
	10	48.44	97.78
	20	47.89	96.11
	30	47.22	96.89
	40	48.22	95.89
	LSD	NS	NS
	CV (%)	5.24	3.50

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

Table 2: Plant height, primary branches, leaf area, and LAI as affected by varieties and K rates during 2019/20 cropping seasons.

Varieties	K rates (kg/ha)	Plant height (cm)	Primary branches/plant	Leaf area (cm^2)	LAI
SER 119	0	47.97	2.00[de]	1195.70[fg]	2.99[fg]
	10	52.97	2.33[b–d]	1214.00[f]	3.03[f]
	20	55.20	2.57[b]	1249.70[de]	3.12[de]
	30	54.63	2.47[bc]	1335.10[b]	3.34[b]
	40	59.40	3.30[a]	1445.90[a]	3.61[a]
SAB 736	0	26.73	1.07[f]	1117.00[h]	2.79[h]
	10	30.60	1.83[e]	1167.00[g]	2.92[g]
	20	35.77	1.77e	1257.80[d]	3.14[d]
	30	38.10	1.83[e]	1254.60[d]	3.14[d]
	40	37.50	2.10[c–e]	1315.00[b]	3.29[b]
Awassa Dume	0	41.67	2.07[c–e]	1194.80[fg]	2.99[fg]
	10	48.00	2.17[b–e]	1218.80[ef]	3.05[ef]
	20	52.67	2.17[b–d]	1313.30[b]	3.28[b]
	30	54.67	2.43[bc]	1309.20[bc]	3.27[bc]
	40	54.53	2.43[bc]	1277.10[cd]	3.19[cd]
	LSD	NS	0.41	33.41	0.08
Varieties mean	SER 119	54.03[a]	2.53[a]	1288.10[a]	3.22[a]
	SAB 736	33.74[b]	1.72[c]	1222.30[c]	3.05[c]
	Awassa Dume	50.31[a]	2.25[b]	1262.60[b]	3.15[b]
	LSD	6.27	0.18	14.94	0.03
K rate mean	0	38.79[b]	1.71[c]	1169.10[e]	2.92[e]
	10	43.86[ab]	2.11[b]	1200.0[d]	2.99[d]
	20	47.88[a]	2.17[b]	1273.60[c]	3.18[c]
	30	49.13[a]	2.24[b]	1299.60[b]	3.25[b]
	40	50.48[a]	2.61[a]	1346.00[a]	3.36[a]
	LSD	8.09	0.23	19.29	0.04
	CV (%)	18.22	11.34	1.59	1.62

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

3.4. Number of Pods per Plant, Seeds per Pod, and Thousand Seed Weight. The main effect of varieties had significant differences on the number of pods per plant and seeds per pod (Table 3). The highest number of pods per plant (45.99) and seeds per pod (5.09) was observed for variety SER 119 followed by variety Awassa Dume with mean number of pods per plant of 40.39 and seeds per pod of 4.57. The lowest number of pods per plant (34.14) and seeds per pod (4.13) was seen for variety SAB 736. Conversely, varieties did not show significant differences on TSW (Table 3). In line with this, significant differences were detected due to the main effect of K fertilizer rates on the number of pods per plant, seeds per pod, and TSW (Table 3). The number of pods per plant and seeds per pod as affected by the main effect of K fertilizer rates showed a tendency of increasing with increasing K fertilizer rate up to 30 kg/ha and then tended to decline. The highest number of pods per plant (46.68) and seeds per pod (5.37) was recorded at a K fertilizer rate of 30 kg/ha followed by a K fertilizer rate of 40 kg/ha with mean number of pods of 44.59 and seeds per pod of 5.24. Likewise, the highest TSW (296.67 g) was recorded at a K fertilizer rate of 40 kg/ha followed by a K fertilizer rate of 30 kg/ha with mean TSW of 276.89 g. The lowest number of pods per plant (26.13), seeds per pod (3.56), and TSW (195.22 g) were obtained from unfertilized plots.

Analysis of variance showed that varieties by K fertilizer rate interactions resulted in significant differences on the number of pods per plant (Table 3). Common bean varieties responded differently to variable rates of K fertilizer in production of pods per plant. In general, the number of pods per plant as affected by the interaction of varieties by K fertilizer rates varied from 20.97 to 63.37. For varieties SAB 736 and Awassa Dume, the number of pods per showed the tendency of increasing up to 30 kg//ha and then declined as K fertilizer rates above that optimum level. Both varieties yielded the highest number of pods per plant at a K fertilizer rate of 30 kg/ha and the lowest from unfertilized plots. With respect to the overall effect, the greatest number of pods per plant (63.37) was obtained from variety SER 119 at a K fertilizer rate of 40 kg/ha followed by variety Awassa Dume at a K fertilizer rate of 30 kg/ha with mean number of pods per plant of 51.00. The lowest number of pods per plant (20.97) was achieved from variety SAB 736 from unfertilized plots. Growth and yield attributes of common bean varieties were significantly improved by the application of different K rates [22]. In contrast, varieties by K fertilizer rate interactions did not have a significant effect on the number of seeds per pod and TSW (Table 3).

3.5. Biomass Yield. The data analysis indicated that the main effect of varieties resulted in significant differences on biomass yield (Table 4). Biomass yield for varieties ranged from 6464 to 6982 kg/ha with the highest biomass yield (6982 kg/ha) being recorded for variety SER 119. The lowest biomass yield (6464 kg/ha) was obtained from variety SAB 736. The main effect of K fertilizer rates also resulted in significant differences on biomass yield (Table 4). Biomass yield increased with increasing K fertilizer rates up to 30 kg/ha and then declined for K rates above that level. The greatest biomass yield (7419 kg/ha) was observed at a K fertilizer rate of 30 kg/ha followed by a K rate of 40 kg/ha with mean biomass yield of 7024 kg/ha. The lowest biomass yield (6183 kg/ha) was obtained from unfertilized plots. A biomass gain of 3.54%, 7.92%, 19.99%, and 13.60% at K fertilizer rates of 10, 20, 30, and 40 kg/ha, respectively, over their respective unfertilized plots.

Analysis of the data revealed that varieties by K fertilizer rate interactions resulted in significant differences on biomass yield (Table 4). Generally, biomass yield as affected by the interaction of varieties with K fertilizer rates ranged from 5563 to 7613 kg/ha. Biomass yield tended to increase with increasing K fertilizer rates for all varieties up to 30 kg/ha and then declined for K fertilizer rates above that optimum level. Thus, common bean varieties responded differently to variable rates of K fertilizer rates in accumulation of dry matter. Variety SER 119 exhibited superiority with respect to biomass yield at all rates of K fertilizer and followed by variety Awassa Dume. Variety SAB 736 showed relatively lower performance regarding biomass yield accumulation. This probably suggests that variety SER 119 relatively better consumer of soil nutrient as it accumulated more dry matter on unfertilized plots, whereas variety SAB 736 relatively less tolerant to K deficiency in the soil. A biomass yield gain of 3.48%, 19.92%, 22.10%, and 13.46% was achieved for variety SER 119 of respective fertilized over its unfertilized control. As to variety SAB 736, a yield gain of 15.28%, 17.04%, 25.90%, and 22.29% was achieved over its unfertilized control. Regarding the variety Awassa Dume, biomass yield production gain of 6.29%, 23.29%, 30.66%, and 23.54% was observed over its unfertilized check. Based on this simple arithmetic computation, variety Awassa Dume showed relative superiority over other in response to increasing K fertilization rates with respect to dry matter accumulation and followed by variety SAB 736. Variety SER 119 exhibited relative lower response to K fertilizer rates with regard to dry matter accumulation. Moreover, at an optimum K rate (30 kg/ha), variety SER 119 yielded the highest biomass followed by variety Awassa Dume. The lowest biomass production was observed for variety SAB 736. This was an indication that common bean varieties exhibited variability in response to deficiency and availability of nutrients in the soils for uptake. Regarding the overall effect, the highest biomass yield (7613 kg/ha) was recorded for variety SER 119 at a K fertilizer rate of 30 kg/ha followed by variety Awassa Dume at a K fertilizer rate of 30 kg/ha with mean biomass yield of 7581 kg/ha. The lowest biomass yield (5563 kg/ha) was obtained from variety SAB 736 from unfertilized plots (Table 4).

3.6. Grain Yield. Analysis of variance showed that the main effect of varieties had significant differences on grain yield (Table 4). Grain yield for varieties ranged from 2009 to 2413 kg/ha with the highest grain yield (2413 kg/ha) being recorded for variety SER 119 followed by variety Awassa Dume with mean grain yield of 2203 kg/ha. The lowest grain yield (2009 kg/ha) was obtained from variety SAB 736.

Table 3: Pods per plant, seeds per pod, and TSW as affected by varieties and K rates during 2019/20 cropping seasons.

Varieties	K rates (kg/ha)	Pods per plant	Seeds per pod	TSW (g)
SER 119	0	31.33^{d-g}	3.83	180.00
	10	40.50^{b-e}	4.53	224.67
	20	45.53^{bc}	5.17	242.00
	30	49.20^{bc}	5.63	267.00
	40	63.37^{a}	6.27	287.00
SAB 736	0	20.97^{g}	3.33	198.33
	10	29.00^{e-g}	4.07	252.67
	20	39.20^{b-e}	3.87	273.00
	30	48.53^{bc}	4.90	287.00
	40	33.00^{d-g}	4.50	309.67
Awassa Dume	0	26.1^{fg}	3.50	207.33
	10	41.73^{b-d}	4.57	248.00
	20	45.73^{bc}	4.23	256.33
	30	51.00^{b}	5.57	276.67
	40	37.4^{c-f}	4.97	293.33
	LSD	12.28	NS	NS
Varieties mean	SER 119	45.99^{a}	5.09^{a}	240.13
	SAB 736	34.14^{c}	4.13^{c}	264.13
	Awassa Dume	40.39^{b}	4.57^{b}	256.33
	LSD	5.49	0.39	NS
K rate mean	0	26.13^{b}	3.56^{c}	195.22^{d}
	10	39.97^{a}	4.39^{b}	241.78^{c}
	20	43.49^{a}	4.42^{b}	257.11^{bc}
	30	46.68^{a}	5.37^{a}	276.89^{ab}
	40	44.59^{a}	5.24^{a}	296.67^{a}
	LSD	7.09	0.51	33.66
	CV (%)	18.28	11.56	13.75

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

Research findings [9, 17, 26, 27] indicated that there is existence of yielding differences with respect to genotypes. Similarly, significant differences were detected due to the main effect of K fertilizer rates on grain yield (Table 4). Grain yield in response to K fertilizer rates, averaged over varieties, increased with increasing K fertilizer rates from 0 to 40 kg/ha. The highest grain yield (2469 kg/ha) was recorded at a K fertilizer rate of 40 kg/ha followed by a K fertilizer rate of 30 kg/ha with mean grain yield of 2451 kg/ha. However, the grain yield difference between the two treatments was not statistically significant. The lowest grain yield (1813 kg/ha) was obtained from unfertilized plots. A grain yield gain of 14.45%, 23.28%, 35.19%, and 36.18% was recorded over unfertilized at K rates of 10, 20, 30, and 40 kg/ha, respectively.

Analysis of the data indicated that varieties by K fertilizer rate interactions had significant differences on grain yield (Table 4). Common bean varieties reacted differently to variable rates of K fertilizer. For variety SER 119, grain yield increased with increasing K fertilizer rates from 0 to 40 kg/ha and then peaked at a K fertilizer rate of 40 kg/ha and lowest grain obtained from unfertilized plots. Thus, grain yield varied from 2067 to 2820 kg/ha with respective K fertilizer rates that ranged from 0 to 40 kg/ha. For varieties SAB 736 and Awassa Dume, the grain yield increased with increasing K fertilizer rates up to 30 kg/ha and then declined above that rate. Indeed, both varieties gave the highest grain yield at a K fertilizer rate of 30 kg/ha and the lowest grain yield from unfertilized plots. Variety SER 119 gave a yield gain of 7.26%, 18.84%, 23.17%, and 36.43% with increasing grain as K fertilizer rates increased from 0 to 40 kg/ha over its unfertilized control. Similarly, variety SAB 736 resulted in a yield gain of 23.75%, 43.36%, 54.24%, and 48.90% with grain yield gain increment up to 30 kg/ha of K fertilizer rate over its unfertilized check. As to variety Awassa Dume, the observed grain yield gain was 4.43%, 25.00%, 33.23%, and 25.85% over their respective unfertilized control. Thus, variety SAB 736 was relatively more responsive to K fertilizer rates of different levels and followed by variety Awassa Dume. In contrast, variety SER 119 was relatively less responsive to different levels of K fertilization regarding the grain yield gain over unfertilized control. With respect to the overall result, the greatest grain yield (2820 kg/ha) was observed for variety SER 119 at a K fertilizer rate of 40 kg/ha followed by the same variety at a K fertilizer rate of 30 kg/ha with mean grain of 2546 kg/ha. The lowest grain yield (1499 kg/ha) was seen for variety SAB 736 from unfertilized plots. The linear regression analysis carried out in relation between K fertilizer rates with grain yield as of equation $Y = -1279.13 + 0.52X$ (K rates) with $R^2 = 0.86$ was highly significant ($P < 0.01$) indicating that grain yield of common bean was highly dependent and responsive to K fertilizer rates. Thus, for a unit changes in factor A (K rates), dependent factor B (grain yield) changes at rate of 0.52 in increasing order.

Table 4: Biomass, grain yield, and HI as affected by varieties and K rates during 2019/20 cropping seasons.

Varieties	K rates (kg/ha)	Biomass yield (kg/ha)	Grain yield (kg/ha)	HI
SER 119	0	6235^{d-f}	2067^{f-h}	0.33
	10	6452^{c-e}	2217^{d-f}	0.34
	20	7477^{ab}	2415^{b-d}	0.32
	30	7613^{a}	2546^{b}	0.33
	40	7074^{a-c}	2820^{a}	0.39
SAB 736	0	5563^{f}	1499^{i}	0.23
	10	6413^{c-e}	1855^{h}	0.34
	20	6511^{c-e}	2149^{e-g}	0.33
	30	7004^{a-d}	2312^{c-e}	0.33
	40	6831^{b-d}	2232^{d-f}	0.33
Awassa Dume	0	5802^{ef}	1872^{h}	0.32
	10	6167^{d-f}	1955^{gh}	0.33
	20	7153^{a-c}	2340^{b-e}	0.32
	30	7581^{ab}	2494^{bc}	0.33
	40	7168^{a-c}	2356^{b-e}	0.33
	LSD	837	221	NS
Varieties mean	SER 119	6982^{a}	2413^{a}	0.35^{a}
	SAB 736	6464^{b}	2009^{c}	0.31^{b}
	Awassa Dume	6774^{ab}	2203^{b}	0.33^{ab}
	LSD	374	98	0.02
K rate mean	0	6183^{d}	1813^{d}	0.29^{c}
	10	6402^{cd}	2075^{c}	0.33^{b}
	20	6673^{bc}	2235^{b}	0.33^{b}
	30	7419^{a}	2451^{a}	0.34^{ab}
	40	7024^{ab}	2469^{a}	0.35^{a}
	LSD	483	127	0.03
	CV (%)	7.43	5.99	8.21

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

3.7. Harvest Index. The main effect of varieties resulted in significant differences on HI values (Table 4). Harvest index (HI) values for varieties varied from 0.31 to 0.35. The highest HI (0.35) was recorded for variety SER 119 followed by variety Awassa Dume with mean HI value of 0.33. The lowest HI (0.31) value was seen for variety SAB 736. The variation in HI values among treatments might be attributed to variability in varieties in response to applied rates of fertilization [17, 28]. Moreover, it was indicated [27] that variation in HI values might be attributed to inherent differences in common bean cultivars. Similarly, the main effect K fertilizer rates had a significant effect on HI values (Table 4). The greatest HI value (0.35) was recorded at a K rate of 40 kg/ha followed by a K rate of 30 kg/ha with mean HI value of 0.34. The least HI value (0.29) was obtained from unfertilized plots. On the other hand, varieties by K fertilizer rate interactions did not have a significant effect on HI values (Table 4).

4. Conclusion

Common bean varieties responded differently to variable rates of K fertilizer. For variety SER 119, grain yield peaked at a K fertilizer rate of 40 kg/ha, whereas for varieties SAB 736 and Awassa Dume, it gave the highest grain yield at a K fertilizer rate of 30 kg/ha. With respect to the overall effect, the greatest grain yield was observed for variety SER 119 at a K fertilizer rate of 40 kg/ha followed by the same variety at a K fertilizer rate of 30 kg/ha. Hence, variety SER 119 at a K fertilizer rate of 40 kg/ha could be used for production near the study area and similar agroecologies.

Data Availability

The data used to support the findings of this research are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

The authors collected, analyzed, interpreted, and prepared the manuscript of the study.

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