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Research Article

Potato (*Solanum tuberosum* L.) Growth and Quality as Influenced by Inorganic Fertilizer Rates in Northwestern Ethiopia

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Potato (*Solanum tuberosum* L.) is an important tuber crop that is highly affected by poor soil fertility and nutrient disparities. Nutrient depletion due to intensive monocropping and poor soil management practices is a serious problem in Ethiopia, including in northwestern areas. Therefore, an experiment was conducted in the East Gojjam zone of northwestern Ethiopia to evaluate the influence of phosphorus and potassium fertilizer rates on potato tuber production. Three phosphorus levels (0, 34.5, and 69 kg/ha^{-1}) and four potassium levels (0, 100, 200, and 300 kg/ha^{-1}) were set out in a factorial arrangement and replicated three times using a randomized complete block design. Data on growth and quality parameters, as well as plant tissue analysis results, were collected. According to the results, the main effects of phosphorus and potassium fertilizer rates statistically affected growth components. The combined effects of phosphorus and potassium fertilizers had a significant influence on quality components (tuber size distribution). Similarly, the interaction effects of phosphorus and potassium fertilizer rates gave the highest response in all nutrient use efficiency parameters. The combined application of 34.5 kg P_2O_5 and 200 kg K_2O fertilizers resulted in the highest medium (28.32 ton/ha^{-1}) and large-sized (20.0 ton/ha^{-1}) tuber yields. The interaction effect of 34.5 kg P_2O_5 with 100 kg K_2O ha^{-1} yielded the highest agronomic and recovery efficiency values. Hence, a combination of 34.5 kg P_2O_5 ha^{-1} and 200 kg K_2O ha^{-1} fertilizer rates can be recommended for the optimal production of potato in the northwestern area.

1. Introduction

Potato (*Solanum tuberosum* L.) is an important food crop worldwide and an extremely popular vegetable crop [1]. It is the first crop among root and tuber crops, followed by cassava, sweet potato, and yams in production [2]. Potato is consumed almost daily by more than a billion people [3]. Hundreds of millions of people in developing countries depend on potatoes for their survival. It is an extremely important crop for countries such as Ethiopia, where inadequate protein and supplies of calories are apparent nutritional problems [4]. It also provides employment opportunities in the production, processing, and marketing chains [5].

The crop is grown throughout the world but is of particular importance in temperate climates [6]. The potato is only cultivated at high elevations in tropical countries such as Egypt, Sudan, Kenya highlands, and Ethiopia [7].

Potato preferred altitudes of approximately 1500–4200 meters and temperatures of 18–20°C for its ideal growth and production [8]. Potatoes can grow in a deep, well-drained, friable, pH range of 5 to 6.5 [9].

According to the Ethiopian Central Statistical Agency report of 2016, the annual world production of potato is approximately 330 million metric tons (18,651,838 ha), and in Africa, the total production is approximately 17,625,680 tons (1,765,617 ha).

Over a century and two decades, potatoes in Ethiopia grew from a garden crop in a few regions to a staple crop produced in many regions under different agroecological conditions [10]. For nearly a century, the growth in potato production and productivity in Ethiopia was steady and very low, approximately 863,348 tons (74,935 ha), despite the agroecology being favorable for potato [11].

In the 2019 and 2020 central statistics agency reports, potato production in Ethiopia during 2019 was 1,044,436.359 (76,677.64 ha), with a yield of 13.62 tons/ha^{-1}, whereas in 2020, the yield was 924528.361 tons (70362.22 ha), with a productivity of 13.13 ton/ha^{-1}. In the two years of production, 119,907.998 tons (6315.42 ha) of yield difference was recorded by reduction. The major factors for this yield reduction were the lack of improved and well-adapted potato varieties, insufficient fertilizer supply such as nitrogen, phosphorus, sulfur, boron, and zinc (NPSBZn), and disease and pest problems together with COVID-19. Coronavirus has a significant impact on the potato production subsector, similar to other agricultural sectors. It possibly interrupted fertilizer stock and related units as a whole.

Similarly, the central statistical agency reported that, in the Amhara region and East Gojjam Zone, 19164.57 ha (279392.773 tons with a yield of 14.58 ton/ha^{-1}) and 4308.67 ha (66453.174 tons with an average yield of 15.42 ton/ha^{-1}), respectively, were noted in 2020. From the potential yield of the region, the yield and productivity of potato were very low. The challenges identified at the national level were also the deterrents of the region. Thus, the production trend and productivity efficiency of potato in Ethiopia are not comparable with the world level. The current world average is approximately 17.6 ton/ha^{-1}, which is relatively higher than that in Ethiopia.

Potato by its nature is a heavy feeder crop that requires a large amount of nutrients, particularly nitrogen, phosphorus, and potassium (NPK) [12]. Phosphorus is considered one of the required elements for the whole function of plants, especially for tuber formation, dry matter accumulation, and hardening of potato stalks [13]. Therefore, the efficient usage of phosphorus is crucial to minimize its losses in agroecosystems [14].

Similarly, the potassium effect has been reported by many scholars. Potassium plays a vital role in the yield and quality of potatoes [15]. An increase in potato tuber yield is a result of increasing the levels of potassium fertilization [15]. For this response, the medium-sized tuber removes 1.5 times as much potassium as nitrogen and 4-5 times the amount of phosphate [16]. Potato requires higher potassium than nitrogen and phosphorus rates, but cultivation is performed without potassium fertilizer application in major potato growing areas [17]. Although potato is highly reactive both for phosphorus and potassium nutrients, practical experiences are enormously poor in Ethiopia. In potato production, the application of fertilizers to supply the optimum amount of NPK nutrients is not based on soil and tissue test analysis [18]. Potassium is a deserted nutrient, while nitrogen and phosphorus (NP) are applied in the usual trend of random soil testing approaches [19]. In northern Ethiopia of the Tigray region, 76% of vertisols are lacking in potassium [20]. A soil fertility map developed by the Ethiopian Soil Information System (Ethio-SIS) in the Tigray region of the Atlas area identified a deficiency of potassium nutrients [21]. On the other hand, conferences that were thronged to announce potassium-containing blended fertilizers to Ethiopian conditions did not provide evidence to justify the formula to meet the crop potassium demand [21]. It is also clear that potato is a susceptible crop for late blight and wilt. As potassium has a significant contribution to pest and disease resistance, its absence in potato production is a major problem [22].

However, the blanket recommendation is the usual application approach of urea and diammonium phosphate (DAP) fertilizers to supply NP elements. Since Ethiopia is found at 33° and 14.8° latitudes and 33° and 48° longitudes in the eastern part of Africa, soil erosion and nutrient depletion via runoff are common hindrances. Of these, potassium and nitrogen leaching is very high. This study was, therefore, undertaken to investigate the rates of inorganic fertilizers and nutrient use efficiency of potato in the rainy season in general and specifically.

To evaluate phosphorus and potassium fertilizer rates on the growth and quality of potato.

To evaluate the nutrient use efficiency of potato crops in northwest Ethiopia.

2. Materials and Methods

2.1. Experimental Site. The experiment was conducted under field conditions in northwestern Ethiopia in the East Gojjam Zone during 2018/2019 under rainfed conditions. The site is located 299 km away from Addis Ababa, the capital city of Ethiopia. It is situated at an altitude of 2470 meters above sea level. The temperature ranges between 17 and 19°C, with an average annual rainfall of 1345 mm. For the preplanting soil test, a representative soil sample at a depth of 30 cm using the diagonal (x) method was taken by an auger tool, and the samples were further air-dried, ground, and sieved through a 2 mm sieve for analysis. The Kjeldahl digestion and distillation method, Olsen procedures, and Morgan methods were used for total nitrogen, available phosphorus, and exchangeable potassium analysis, respectively [23]. The preplanting soil test results of the site are presented in Table 1.

2.2. Experimental Material, Treatment, and Design

2.2.1. Experimental Material. The International Potato Center (CIP) 393371.58 potato variety, triple superphosphate (TSP), and potassium chloride (KCl) were used for the experimental material.

2.2.2. Treatment. Three phosphorous levels (0, 34.5, and 69 kg/ha^{-1} P_2O_5) and four potassium levels (0, 100, 200, and 300 kg/ha^{-1} K_2O) were the treatments considered in the experiment.

2.2.3. Design. A 3 × 4 factorial arrangement and randomized complete block design (RCBD) with three replications was used during the experimental period.

Table 1: Former soil characteristics of the experimental site.

No.	Soil properties	Test result	Category
1	Soil type	14 : 64 : 22 (sand, clay, silt %)	Clay soil
2	pH (H_2O)	5.5	Strongly acidic
3	Cat ion exchange capacity (CEC)	23.64 mole	Medium
4	Total nitrogen	0.09%	Low
5	Available phosphorus	8.30 (ppm)	Medium
6	Exchangeable potassium	0.135 mole	Low

Figure 1: Yield harvesting operation photo (partial).

2.3. Experimental Procedures and Management. Land preparation was performed from May and June 2018.3 m × 3.75 m = 11.25 m^2 was the size of the plot, and fifty plants in each plot (5 rows and 10 plants/row) were set appropriately. Medium-sized and well sprouted tubers were used for planting material, and they were planted on the first week of June 2018. The spacing considered in the experiment was 75 cm × 30 cm. The whole TSP based on the treatment was applied during planting at a depth of 5 cm, whereas KCl applied in two equal splits, that is, half at emergence and the remaining half approximately 40 days after planting. Urea at a rate of 176 kg N/ha^{-1} was applied at two splits; that is, half was applied during planting and half at tuber initiation (approximately 40 days after planting) [24]. Other management practices, including cultivation, weeding, and insect pest and disease control, were performed equally for all plots as per the recommendations [25].

2.4. Plant Tissue Analysis. Shoot and tuber samples were taken from the net plot area, and composites were made per treatment base [26]. Available phosphorus and exchangeable potassium contents were analyzed following the guidelines described by scholars [27].

2.5. Data Collected

2.5.1. Growth Parameters. Stem number per hill (number): the average stem number per hill from five randomly selected plants was taken at 70 days after planting [28].

Number of primary branches per hill (number): the average number of primary branches per hill from five randomly selected plants was recorded at 70 days after planting [28].

2.5.2. Quality Parameters. Tuber size distribution by weight (ton/ha^{-1}): potato tubers were harvested (Figure 1) and categorized based on weight in the laboratory (Figure 2). In this respect, tubers in the weight category of <25 grams, 25–39 grams, 40–75 grams, and >75 grams were considered very small, small, medium, and large-sized, respectively [29]. Accordingly, tubers harvested from the net plot area were proportionally weighted using a sensitive balance and expressed in terms of tons per hectare.

2.6. Nutrient Use Efficiency Study

2.6.1. Agronomic Efficiency (kg). This parameter was used to evaluate the added yield of potato through the applied units of phosphorus and potassium fertilizers [30]. It was calculated using the following formula:

$$\mathrm{AE} = \frac{(Y - Y_0)}{F}, \quad (1)$$

where AE = agronomic efficiency, Y = total yield of potato with applied nutrients, Y_0 = total yield of potato without nutrient application, and F = amount of fertilizers/nutrients applied.

2.6.2. Apparent Recovery Efficiency (%). Was used to evaluate how much of the applied phosphorus and potassium fertilizers were taken up by the crop [30]. Additionally, it was calculated using the following formula:

$$\mathrm{RE} = \frac{(U - U_0)}{F}, \quad (2)$$

where RE = recovery efficiency, U = total nutrient uptake in aboveground crop biomass with nutrient application, U_0 = nutrient uptake in aboveground biomass without nutrient application, and F = amount of fertilizers/nutrients applied.

2.6.3. Physiological Efficiency (kg). This parameter was used to express the ability of potato plants (Belete var.) to

FIGURE 2: Grading and tube size distribution photo.

TABLE 2: Mean squares values of potato growth and quality components as influenced by phosphorus and potassium and their interaction.

Parameters		Phosphorus	Potassium	Phosphorus × potassium
Degree of freedom		2	3	6
Growth parameters	Primary stem number/hill	1.60*	0.46ns	0.25ns
	Primary branch number	0.35ns	2.08*	0.52ns
Quality components	Very small-sized (ton/ha^{-1})	0.023***	0.012***	0.004**
	Small-sized (ton/ha^{-1})	0.06***	0.06***	0.01**
	Medium-sized (ton/ha^{-1})	204.1***	144.7***	25.3***
	Large-sized (ton/ha^{-1})	154.8***	68.7***	21.4**

***, **, *: significant differences at 1 and 5% level of significance, respectively; ns = nonsignificant at 1 and 5% level of significance.

transform the applied fertilizers into economic yield, which was calculated using the following formula:

$$PE = \frac{(Y - Y_0)}{U - U_0}, \tag{3}$$

where PE = Physiological Efficiency, Y = Total yield of the harvested crop with nutrient applied, Y_0 = Total yield without nutrient applied, U = Total nutrient uptake in aboveground crop biomass with nutrient applied, and U_0 = Total nutrient uptake in aboveground crop biomass with no nutrient applied.

2.7. Data Analysis. The data on growth and quality parameters were first checked for all assumptions and subjected to analysis of variance [31], and the least significant difference procedure was used to separate means whenever analysis of variance showed a significant difference between treatment means at the 5% and 1% significance levels (Table 2).

3. Results

3.1. Influences of Phosphorus and Potassium on Growth Parameters

3.1.1. Primary Stem Number. The main effect of phosphorus fertilizer showed a significant difference ($p < 0.05$) and a nonsignificant ($p > 0.05$) effect for potassium and its interaction with phosphorus on the stem numbers of potatoes (Table 2). Applying 34.5 kg P_2O_5 ha^{-1} attained the maximum number of stems (3.45) over the control (2.75), and it was statistically the same as the results for those that received 69 kg P_2O_5 ha^{-1} (Table 3).

TABLE 3: Growth components of potato as influenced by phosphorus and potassium fertilizer application.

Treatments	Primary stem number	Primary branch number
P_2O_5 (kg/ha^{-1})		
0	2.75^{b}	3.96
34.5	3.45^{a}	4.30
69	3.28^{ab}	4.06
LSD	0.54	0.66
K_2O (kg/ha^{-1})		
0	2.82	3.46^{b}
100	3.31	4.60^{a}
200	3.26	4.31^{a}
300	3.24	4.06^{ab}
LSD	0.63	0.76
CV (%)	20.43	19.06

LSD = least significant difference, means with the same letter within a column are not significantly different, and CV = coefficient of variation.

3.1.2. Primary Branch Number. Phosphorus fertilizer alone and its interaction with potassium fertilizer showed a statistically nonsignificant ($p > 0.05$) effect, and potassium had a statistically significant ($p < 0.05$) response on the primary branch number of potato (Table 2). At 100 kg K_2O ha^{-1}, the largest (4.60) primary branch numbers were recorded, and they were statistically similar to the results obtained under 200 and 300 kg K_2O ha^{-1}, whereas the smallest primary branch numbers (3.46) were recorded under 0 kg K_2O ha^{-1}(Table 3). and they were statistically similar to the results obtained under 300 kg K_2O ha^{-1} (Table 3).

Table 4: Interaction effects of phosphorus and potassium fertilizers on the tuber size distribution of potato.

P_2O_5 (kg/ha^{-1})	K_2O (kg/ha^{-1})	Tuber size distribution (ton/ha^{-1})			
		Very small-sized	Small-sized	Medium-sized	Large-sized
0	0	0.133^{c}	0.22^{d}	11.2^{f}	10.0^{c}
	100	0.15^{c}	0.23^{d}	12.5^{ef}	10.0^{c}
	200	0.16^{c}	0.30^{d}	13.9^{ef}	11.0^{c}
	300	0.16^{c}	0.23^{d}	13.7^{ef}	8.3^{c}
34.5	0	0.13^{c}	0.20^{d}	11.4^{f}	9.0^{c}
	100	0.26^{b}	0.40^{bc}	20.2^{cd}	18.3^{ab}
	200	0.33^{a}	0.50^{a}	28.3^{a}	20.0^{a}
	300	0.23^{b}	0.43^{ab}	21.9^{bc}	18.0^{ab}
69	0	0.17^{c}	0.26^{d}	14.7^{e}	11.0^{c}
	100	0.23^{b}	0.33^{c}	18.2^{d}	15.6^{b}
	200	0.23^{b}	0.46^{ab}	24.1^{b}	18.2^{ab}
	300	0.23^{b}	0.40^{bc}	20.1^{cd}	18.0^{ab}
LSD		0.06	0.05	2.79	2.84
CV (%)	27.3	15.2	9.7	12.1	

3.2. Phosphorus and Potassium Influences on Quality Parameters

3.2.1. Tuber Size Distribution as Influenced by Phosphorus and Potassium Fertilizers

(1) Very Small Tubers. Very small tubers were not significantly ($p > 0.05$) influenced by the main effects of phosphorus and potassium fertilizers, but they were statistically and significantly ($p < 0.05$) affected by the interaction effects (Table 2). The highest very small-sized tubers (0.31 ton/ha^{-1}) were recorded from the combined application of 34.5 kg P_2O_5 and 200 kg K_2O ha, whereas the smallest very small-sized tuber (0.13 ton/ha^{-1}) was recorded from the control and was statistically similar to the treatments treated with 0 kg P_2O_5 100, 200, and 300 kg K_2O ha; 34.5 kg P_2O_5 with 0 kg K_2O, and 69 kg P_2O_5 with 0 kg K_2O ha (Table 4).

(2) Small-Sized Tubers. Small tubers were not significantly ($p > 0.05$) influenced by the main effects of phosphorus and potassium fertilizers, whereas they were statistically and highly significantly ($p < 0.01$) affected by the interaction effects (Table 2). The maximum small-sized tubers (0.50 ton/ha^{-1}) were recorded from the combined application of 34.5 kg P_2O_5 and 200 kg K_2O ha, and it was statistically similar to the results of the treatments that received 34.5 kg P_2O_5 with 300 kg K_2O ha and 69 kg P_2O_5 with 200 kg K_2O ha, whereas the minimum small-sized tuber (0.21 ton/ha^{-1}) was recorded from 34.5 kg P_2O_5 with 0 kg K_2O ha, and it was statistically similar to 0 kg P_2O_5 ha with all levels of K_2O ha and 69 kg P_2O_5 with 0 kg K_2O ha (Table 4).

(3) Medium-Sized Tubers. Medium-sized tubers were not significantly ($p > 0.05$) influenced by the main effects of phosphorus and potassium fertilizers, whereas they were statistically and very highly significantly ($p < 0.001$) affected by the interaction effects (Table 2). The maximum medium-sized tuber (28.32 ton/ha^{-1}) was recorded from the combined application of 34.5 kg P_2O_5 and 200 kg K_2O ha, whereas the minimum medium-sized tuber (11.1 ton/ha^{-1}) was recorded from the control, and it was statistically similar to the results obtained with 0 kg P_2O_5 with 100, 200, and 300 kg K_2O ha and 34.5 kg P_2O_5 with 0 kg K_2O ha (Table 4).

(4) Large-Sized Tubers. The analysis of variance revealed that large-sized tubers were not significantly ($p > 0.05$) influenced by the main effect of phosphorus and potassium fertilizers, whereas they were statistically and highly significantly ($p < 0.01$) influenced by the interaction effects (Table 2). The highest large-sized tuber (20.0 ton/ha^{-1}) was obtained from the combined application of 34.5 kg P_2O_5 and 200 kg K_2O ha, and it was statistically similar to the results of those that received 34.5 kg P_2O_5 with 100 and 300 kg K_2O ha and 69 kg P_2O_5 with 200 and 300 kg K_2O ha, whereas the lowest large-sized tuber (8.3 ton/ha^{-1}) was harvested from 0 kg P_2O_5 with 300 kg K_2O ha, and it was statistically similar to the results of the treatments that received 0 kg P_2O_5 with 0, 100, and 200 kg K_2O ha, 34.5 kg P_2O_5 with 0 kg K_2O ha, and 69 kg P_2O_5 with 0 kg K_2O ha (Table 4).

3.3. Phosphorus and Potassium Use Efficiency of Potato

3.3.1. Agronomic Use Efficiency of Potato for Phosphorus and Potassium Fertilizers. The highest agronomic efficiency was obtained from the interaction effect of 34.5 kg P_2O_5 with 100 kg K_2O ha, followed by the combinations of 34.5 kg P_2O_5 with 200 kg K_2O ha and 69 kg P_2O_5 with 200 kg K_2O ha. On the other hand, the lowest efficiency was recorded from the combination of 34.5 kg P_2O_5 with 0 kg K_2O ha, followed by the combination of 0 kg P_2O_5 with 300 kg K_2O ha (Table 5). The remaining values ranged in between.

However, the highest agronomic efficiency was obtained from the main effect of 34.5 kg P_2O_5 ha and 100 kg K_2O ha, while the lowest was recorded from 69 kg P_2O_5 ha and 300 kg K_2O (Table 6).

3.3.2. Apparent Recovery Efficiency of Potato for Phosphorus and Potassium Fertilizers. Similar recovery efficiency was

Table 5: Phosphorus and potassium use efficiency of potato crop (Belete var.) for the interaction effects of phosphorus and potassium fertilizers.

Treatments ($P_2O_5 \times K_2O$)	Total yield (ton/ ha^{-1})	Agronomic efficiency (kg/ kg^{-1})	Apparent recovery efficiency (%)	Physiological efficiency (kg/ kg^{-1})
T1-0 × 0	21.55	—	—	—
T2-0 × 100	22.87	13.2	0.01	2.13
T3-0 × 200	25.38	19.15	0.01	2.35
T4-0 × 300	22.41	2.87	0.01	0.50
T5-34.5 × 0	20.81	−21.45	0.00	−14.80
T6-34.5 × 100	39.22	131.38	0.01	27.18
T7-34.5 × 200	49.14	117.65	0.01	15.95
T8-34.5 × 300	40.59	56.92	0.01	10.88
T9-69 × 0	26.13	66.38	0.00	35.23
T10-69 × 100	34.46	76.39	0.00	17.45
T11-69 × 200	43.08	80.04	0.01	11.64
T12-69 × 300	38.76	46.64	0.01	9.35

Table 6: Nutrient use efficiency of potato crops for the main effects of phosphorus and potassium fertilizers.

Phosphorus fertilizer treatment (P_2O_5)	*Total yield (ton/ha^{-1})*	*Agronomic efficiency (kg/kg^{-1})*	*Apparent recovery efficiency (%)*	*Physiological efficiency (kg/kg^{-1})*
0	23.06	—	—	—
34.5	37.45	0.42	0.0013	319.78
69	35.61	0.18	0.0021	86.55
Potassium fertilizer treatment (K_2O)	*Total yield (ton/ha^{-1})*	*Agronomic efficiency (kg/kg^{-1})*	*Apparent recovery efficiency (%)*	*Physiological efficiency (kg/kg^{-1})*
0	22.84	—	—	—
100	32.19	0.09	0.030	311.63
200	39.20	0.08	0.002	44.23
300	33.93	0.04	0.002	19.46

obtained from the combined application of all of the treatments except 34.5 kg P_2O_5 with 0 kg K_2O ha, 69 kg P_2O_5 with 0 kg K_2O ha and 69 kg P_2O_5 with 100 kg K_2O ha (Table 5). On the other hand, the highest recovery efficiency was attained from the main effect of 69 kg P_2O_5 and 100 kg K_2O ha, whereas the lowest was recorded from the 34.5 kg P_2O_5 ha at all levels of K_2O fertilizer (Table 6).

3.3.3. Physiological Efficiency of Potato for Phosphorus and Potassium Fertilizers. The highest physiological efficiency was attained from the combined application of 69 kg P_2O_5 with 0 kg K_2O ha, followed by 34.5 kg P_2O_5 ha with 100 kg K_2O ha, whereas the lowest was recorded from 34.5 kg P_2O_5 with 0 kg K_2O ha, followed by 0 kg P_2O_5 with 300 kg K_2O ha (Table 5).

However, the highest physiological efficiency was recorded from the main effects 34.5 kg P_2O_5 ha and 100 kg K_2O ha, whereas the lowest was attained from 69 kg P_2O_5 ha and 300 kg K_2O ha (Tables 5 and 6).

4. Discussion

4.1. Influences of Phosphorus and Potassium on Growth Parameters. Phosphorus is a component of nucleic acids that provides energy for cell division, sprouting, tuber initiation, and formation. Similarly, because the test plant was a Belete variety, the tuber size was medium (40–60 grams) with the maximum number (6-7) of sprouts, which encourages the most main stems per plant. With increasing phosphorus rates, the average number of stems per hill increased [32]. Phosphorus fertilizer has a positive relationship with stem number increase because it has a strong association with plant growth, development, and reproduction [33].

The relationship between the number of tubers, yield, and stem population was quantified similarly, and nutrient management may affect the number of tubers per stem and the total yield [34]. The number of eyes per seed tuber used influences the number of main stems per hill, but the number of eyes in the tubers cannot be uniform [13]. As a result, the number of stems per hill increased. The possible relationship between other factors and the rate of phosphorus and nitrogen inputs equivalent to potato growth and yield increment is also significant [35].

Phosphorus and potassium fertilization, on the other hand, had no significant effect on the number of stems that were initiated [36]. Phosphorus application at a high rate causes nutrient imbalance and, as a result, yield depression and low potato production [37].

Potassium is primarily required for good potato growth and superior tuber development, which leads to commercial yields [38]. Meanwhile, potassium is highly mobile in the plant; it regulates the movement and translocation of minerals and starch, and it distributes to other parts of the plant, including branches, supporting the initiation of several branches from the axial, aboveground, and underground plant portions [39]. Potassium also had a positive effect on vegetative growth (branch and leaf numbers, leaf area, and total fresh weight) [40]. Other researchers, on the other hand, reported that increased leaf and stem numbers increase competition for resources and result in lower tuber yield [41].

4.2. Phosphorus and Potassium Influences on Quality Parameters

4.2.1. Tuber Size Distribution as Influenced by Phosphorus and Potassium Fertilizers. When nitrogen was fixed at 0 levels, the interaction of potassium and phosphorus produced the smallest and largest potato tuber sizes. Similarly, applying phosphorus and potassium fertilizers at rates higher than or lower than the recommended rate may have a negative impact on tuber size and reduce tuber size [42]. Similarly, soil nutrient depletion had a significant impact on potato crop tuber sizes [43].

Increasing potash had a less pronounced effect on the yield of small-sized tubers when combined with increased phosphorus rates than increased phosphate across potash rates. As a result, small-sized tubers in the field may increase due to soil infertility issues [44]. Furthermore, the rate of mineralization of soil mineral and organic matter nutrients influences potato tuber size [45].

On the other hand, the effect of potassium and phosphorous on potato tuber size distribution is clear, with decreasing levels of both potassium and phosphorous fertilizers having a positive effect on potato tuber size distribution [46].

The tuber size categories were significantly influenced by crop management, fertilization, and watering regime.

Potato fertilization had a significant impact on large, medium, and small tuber yield [32]. Optimal phosphorus and potassium fertilizer levels are critical for determining optimum sized tubers and proportionally reduced over and undersized potato [47].

On the other side, potassium application alone had a significant main effect on medium- and large-sized tuber yields, whereas phosphorus had no effect on these parameters, and the two factors did not interact to affect medium- and large-sized tuber yields [48].

In overall, the application of phosphorus and potassium resulted in a higher proportion of large and medium-sized tubers in this reading. In contrast, a single application of phosphorus and potassium fertilizer had no effect. In line with this, the interaction of potassium and phosphorus resulted in the smallest and largest potato tuber sizes [49]. Phosphorus supply is critical for the production of larger tubers, and medium phosphorus availability increased tuber mean weight [50].

In contrast, there was a weak and negative correlation between potassium and potato tuber size distribution [51].

4.3. Phosphorus and Potassium Use Efficiency

4.3.1. Agronomic Use Efficiency of Potato for Phosphorus and Potassium Fertilizers. Fertilizer overapplication significantly reduced crop efficiency, whereas optimal application may improve crop effectiveness [52].

4.3.2. Apparent Recovery Efficiency of Potato for Phosphorus and Potassium Fertilizers. Phosphorus is more important than other nutrients, including potassium, in the apparent recovery of potato.

4.3.3. Physiological Efficiency of Potato for Phosphorus and Potassium Fertilizers. The nutrient use efficiency values may be affected by the quality of the data used in the calculation. When data from short-term trials are used, the nutrient use efficiency values may be underestimated or overestimated. As a result, data from long-term trials could be generated to reduce the residual effects of nutrient application. Despite the fact that potatoes are relatively resistant to acidic conditions, soil pH can affect nutrient utilization efficiency [44].

5. Conclusion

The experiment showed the presence of potassium deficiency in Ethiopian soil, which had been overlooked for more than 40 years due to the perception that all Ethiopian soil is not potentially potassium deficient. The study found that the main effects of phosphorus and potassium fertilizers statistically influenced growth components (stem number and branch number). However, the interaction effects of phosphorus and potassium had a significant effect on all quality components (tuber size distribution). Correspondingly, the combined effects of phosphorus and potassium fertilizer rates produced the greatest response in all nutrient use efficiency components (agronomic, recovery, and physiological efficiencies).

In general, a combination of 34.5 kg P_2O_5 ha and 200 kg K_2O ha fertilizer rates can be recommended for the reasonable production of potato tubers in northwestern Ethiopia.

Data Availability

The dataset that supports the findings in the study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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