

## Research Article

# Effect of Tuber Size and Intra-Row Spacing on the Yield and Quality of Potato (*Solanum tuberosum* L.) Varieties

Miressa Regasa <sup>1</sup>, Weyessa Garede <sup>2</sup> and Ambecha Olik <sup>3</sup>

<sup>1</sup>Department of Horticulture, Wachemo University College of Agricultural Sciences, P.O. Box 667, Hossana, Ethiopia

<sup>2</sup>Department of Horticulture and Plant Sciences, Jimma University College of Agriculture and Veterinary Medicine, P.O. Box 307, Jimma, Ethiopia

<sup>3</sup>Department of Plant Science, Dambi Dolo University College of Agriculture and Veterinary Medicine, Dambi Dolo, Ethiopia

Correspondence should be addressed to Miressa Regasa; [miressarega@wcu.edu.et](mailto:miressarega@wcu.edu.et)

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A field experiment was conducted at Nono Benja District from December 2013 to May 2014 under irrigation to assess the response of different sizes of seed tubers and intra-row spacing on the yield and quality of potato varieties. The treatments consisted of a factorial combination of two varieties (Jalenie and Gudenie): five levels of tuber size (20–35, 36–50, 51–65, 66–80, and 81–95 g) and five levels of intra-row spacing (20, 25, 30, 35, and 40 cm). The treatments were arranged in a split-split plot design (variety on main plot, intra-row spacing on subplot, and tuber size on sub-sub plot) with three replications. There were significant interaction effects of variety, intra-row spacing, and tuber size ( $P < 0.05$ ) on plant height, number of main stems per plant, average tuber weight, tuber number per plant, total tuber yield, marketable tuber yield, unmarketable tuber yield, large tuber mean yield, medium tuber mean yield, and small tuber mean yield. Variety of tuber size and intra-row spacing was also influenced by dry matter content and tuber specific gravity. The interaction effect of intra-row spacing and seed tuber size was significantly ( $P < 0.05$ ) influenced by the number of days to emergence. The day to flowering was also significantly ( $P < 0.05$ ) influenced by the interaction effect of variety and intra-row spacing. The maximum plant height (80.38 cm) was recorded with variety Gudenie with a tuber size of 66–80 g and planted at an intra-row spacing of 35 cm. The maximum (9.79) number of main stems was recorded in variety Jalenie with a tuber size of 81–95 g and planted at intra-row spacing of 40 cm. The maximum of total tuber yields (24.84 t/ha) was recorded from Jalenie variety with tuber size 66–80 g and planted at intra-row spacing of 25 cm. The maximum (10.18 t/ha) larger tuber was recorded with variety Gudenie with a tuber size of 66–80 g and planted at 25 cm. Variety Jalenie with tuber size of 66–80 g and planted at 25 cm produced the maximum (8.04 t/ha) medium-sized tubers. The maximum small tuber (8.59 t/ha) was recorded from both varieties with intra-row spacing of 20 cm and tuber size 81–95 g. Variety Gudenie planted at intra-row spacing of 40 cm gave higher (19.98%) dry matter content, and variety Gudenie with a tuber size of 66–80 g gave higher (20.61%) dry matter content. The higher (1.077) tuber specific gravity was obtained with variety Gudenie planted at intra-row spacing of 35 and 40 cm, and the higher (1.074) tuber specific gravity was registered with variety Gudenie with a tuber size of 66–80 g and/or 81–95 g and planted at intra-row spacing of 40 cm. The study needs in-depth investigation by repeating in multilocations with more seasons, varieties, processing quality, and other agronomic practices of the crop to reach a conclusive recommendation. The result of this research was presented to Jimma University since 2015.

## 1. Introduction

Potato (*Solanum tuberosum*) ranks fourth most important food crop in the world after maize, wheat, and rice in terms of human consumption, and the total world potato production was estimated at 388,191,000 tonnes from

19302600 ha of land in 2017 [1]. In Ethiopia, potato is a high potential food security crop due to its high yield potential per hectare and nutritious tubers [2]. Ethiopia is endowed with suitable climatic and edaphic conditions for high-quality potato production [3]. The average national yield of potato in Ethiopia is 14 t/ha; in some regions of Ethiopia, the

productivity average indicated: Oromia 12.39 t/ha, Amhara 15.38 t/ha, Tigray 8.09 t/ha, and SNNPR 15.52 t/ha [4]. The potato yield is low, which is attributed to biotic and abiotic factors, in which a lack of optimal agronomic practices including poor seed tuber size, plant density, lack of improved crop variety, and high-quality seed potatoes, and late blight and inadequate pest management practices are the prominent ones [5].

Seed tuber size and intra-row spacing are among the major factors affecting the production and productivity of potatoes [6, 7]. The amount of seed tuber used per ha is quite bulky, which is about 1.8 to 2.2 t/ha [8], and hence, inappropriate seed tuber size and intra-row spacing result in ware potato wastage [9]. Potato seed rate might be reduced to less than 40% if optimum size seed tubers are used [10]. The yield performance and quality of potato tuber with large seed tuber size were higher than small seed tuber size [3].

Potato intra-row spacing is important due to the increased opportunity to manipulate the plant population to target a marketable tuber size [11]. The performance of the seed is related to size uniformity and optimum intra-row spacing to increase yields and ensure uniform planting [12]. The use of small size seeds is a major problem in Ethiopia [13].

Potato tuber size and different intra-row spacing were suggested in the production of good quality potato tubers in different parts of Ethiopia [14]. Seed tuber size of 45–55 mm diameter (90 g) was suggested for ware potato production at Adet Agricultural Research Center [15]. Harnet et al. [16] also concluded that the narrow intra-row spacing of 20 cm in variety Jalenie produced higher potato tuber yield and marketable yield per hectare than other intra-row spacing in the southern zone of Tigray.

In the study area, potato production was started long years ago by potato-producing farmers. Despite its low productivity, potato is becoming an emerging cash vegetable crop, which should be getting attention in the area after cereals. The productivity average of potato at northwest area of Ethiopia ranges from 14 to 15 t/ha [17]. Potato productivity in the area was even less than the regional and national average yield and poor quality that might be attributed to variations in seed size, intra-row spacing, and related agronomic practices. Growers use bulk seed, that is, either large or small seed tubers, thus resulting in nonuniform seed tubers. Few years ago, Jimma Agricultural Research Center (JARC) demonstrated Jalenie and Gudenie varieties on the farmer's field in the area. Although JARC introduced varieties to the area, growers have been using inappropriate intra-row spacing and variable seed tuber size for potato production due to the lack of recommended intra-row spacing for the area. Hence, it is important to investigate the suitable intra-row spacing and tuber size for the area, because it plays the great role to settle information in this regard for the area to identify the effects of seed tuber size and intra-row spacing on the yield and quality of potato. Thus, it was hypothesized that different seed tuber sizes and intra-row spacing would result in different yield and quality of potato varieties. Therefore, the objective of the study was to evaluate the impact of seed tuber size and intra-row spacing on potato yield and quality.

## 2. Materials and Methods

**2.1. The Study Site.** The experiment was conducted in Jimma zone, Nono Benja District Office of Agriculture, horticulture nursery site at Alga in the year 2014 G.C under irrigation. The site is located 156 km away from Jimma town and 252 km west of Addis Ababa city. The altitude of the site was 1670 m.a.s.l. The rainfall is unimodal and in the range of 780–1500 mm with about 70% of the precipitation falling in a two-month period, that is, July and August. The annual minimum and maximum temperature are 14 and 26°C, respectively. The soil was fine textured heavy loamy clay soil with a pH of 6.0 (soil physicochemical analysis).

**2.2. Experimental Materials.** Two potato varieties (Jalenie and Gudenie) were used for this study (Table 1). The potato seed tubers were obtained from Holleta Agricultural Research Center. The varieties were selected due to their adaptability to the study area.

**2.3. Experimental Treatment and Design.** The intra-row spacing treatments of 20, 25, 30 (national recommendation), 35, and 40 cm were used in this study. The seed tubers were weighed and categorized under five weight ranges (20–35, 36–50 (mostly used as blanket recommendation), 51–65, 66–80, and 81–95 g), which are used as seed tuber treatments.

The experiment was arranged in the split-split plot design with three replications. The two varieties (Jalenie and Gudenie) were assigned to the main plots, intra-row spacing treatments to the subplots, and tuber sizes were assigned to the sub-sub plots.

**2.4. Land Preparation and Management.** The area of each and net total plot were  $3\text{ m} \times 3\text{ m} = 9\text{ m}^2$ , and  $50 \times 9\text{ m}^2 = 1350\text{ m}^2$ , respectively, with inter-row spacing of 75 cm throughout all experimental plots. The area for each main plot is  $450\text{ m}^2$ , and each subplot is  $45\text{ m}^2$ . Distances between blocks and plots are 50 cm and 20 cm, respectively. Each plot has four rows, and per row, 10 plants were there and total 40 plants per each plot. As per the national recommendation, 165 kg/ha UREA and 195 kg/ha diammonium phosphate were applied [19]. Fertilizer was applied twice; on planting date by side dressing, all recommended DAP and one-third of UREA, and on the first weeding (mostly after three weeks), the remaining UREA applied. The irrigation was applied twice a day on morning and night time.

**2.5. Data Collection.** There are four rows of plants. Data are collected from two middle rows consisting of eight plants per row.

**2.5.1. Days to 50% Emergence.** Emergence data were taken at five days of interval until three weeks after planting. It was recorded by counting the number of days from the planting

TABLE 1: Description of varieties [18].

Name of varieties	Ecological requirement		Yield (t/ha)		Year of release	Breeder/center	Maturity days
	Altitude (m)	Rainfall (mm)	RM	FM			
Jalenie	1600–2800	750–1000	44.8	29.1	2002	HARC	90–120
Gudenie	1600–2800	750–1000	29.2	21	2006	HARC	120

RM = research field management; FM = farmers field management.

date to the date at which about 50% of the plants in a plot is germinated. Final data used were that taken at 20<sup>th</sup> date.

**2.5.2. Days to 50% Flowering.** It was recorded by counting the number of days in which about 50% of plants flower from each plot.

**2.5.3. Days to 50% Physiological Maturity.** It was recorded when 50% of the plant populations have been shown yellowish or senescence of the haulms (vines).

**2.5.4. Number of Main Stem per Plant.** Data were recorded by counting those arising directly from the seed piece or tuber from each middle row during tuber initiation stage.

**2.5.5. Plant Height (cm).** Plant height was measured from 16 plants of middle row from the base of main shoot to the apex when 50% of the stand was in bloom.

**2.5.6. Tuber Number per Plant.** The tuber number per plant was a count of tubers from 16 plants of middle row plants, which was taken at harvest.

**2.5.7. Average Tuber Weight (g).** It was recorded by dividing total fresh weight of tubers per plot by the total number of tubers at harvest.

**2.5.8. Marketable Tuber Yield (t/ha).** At harvesting, the middle row plants were collected from each plot for the determination of marketable tuber yield. The estimation of marketable tuber yield from a plot was calculated on a hectare basis for weight of healthy tubers with a size of greater than 20 g, which was taken as marketable [20].

**2.5.9. Unmarketable Tuber Yield (t/ha).** Rotten, diseased, insect damage, deformed tuber, and tubers with weight of smaller than 20 g were considered as unmarketable tuber yield.

**2.5.10. Total Tuber Yield (t/ha).** It was recorded by adding both marketable and unmarketable tuber yields per plot and then converted to hectare. This was taken at harvest.

**2.5.11. Tuber Size Categories.** Tubers were collected, sorted by size, and counted from two central rows into three groups

considering size of tubers as small (20–49 g), medium (50–75 g), and large (>75 g).

**2.5.12. Tuber Specific Gravity (g/cm<sup>3</sup>).** 5 kg of tubers was randomly taken per plot for the estimation of tuber specific gravity. Tuber specific gravity was measured by using the tuber weight in air and in the water method.

$$\text{Tuber - specific gravity} \left( \frac{\text{g}}{\text{cm}^3} \right) = \frac{\text{weight of tuber in air}}{\text{weight in air} - \text{weight in water}} \quad (1)$$

**2.5.13. Dry Matter Content (%).** Tubers were randomly selected per plot and washed, chopped, and mixed, and then, about 200 g of sample was taken and predry at a temperature of 60°C for 15 hrs and further dried for 3 hrs at 105°C in a drying oven. Finally, the amount was calculated by using the formula below.

$$\text{Dry matter content} (\%) = \frac{\text{dry weight}}{\text{fresh weight}} \times 100. \quad (2)$$

**2.6. Data Analysis.** The data were checked for all ANOVA assumptions. Analysis of variance (ANOVA) was done using SAS version 9.2 statistical software [21]. Mean separations were done using Tukey's test at 5% probability level.

### 3. Results and Discussion

#### 3.1. Crop Phenology

**3.1.1. Days to 50% Emergence.** The analysis of variance indicated that the two-way interaction of seed tuber size with intra-row spacing and variety of tuber size was significantly ( $P < 0.05$ ) influenced the number of days on 50% emergence; however, no significant ( $P < 0.05$ ) interaction effect was observed by the three-way interaction. The results revealed that treatment combination of variety Jalenie with tuber size 81–95 g took significantly earlier days to 50% emergence (13.60). However, statistically the same day with 50% emergence (13.67) recorded from variety Jalenie with a tuber size of 66–80 g. On the other hand, the treatment combination from variety Gudenie with tuber size 36–50 g took longer days to 50% emergence (17.13), which was statistically similar to results with (16.87) and (16.73) obtained with treatment combination of variety Gudenie with tuber size 66–80 g and 81–95 g, respectively (Table 2). Tuber size of 66–80 g planted at 40 cm intra-row spacing numerically emerged earlier (14.17) compared to others (Table 3). Traits

TABLE 2: Interaction effect of variety and tuber size on days to 50% emergence of potato in 2013/2014 at Nono Benja.

Tuber size (g)	Variety	
	Jalenie	Gudenie
20–35	14.47 <sup>c</sup>	16.67 <sup>b</sup>
36–50	14.27 <sup>dc</sup>	17.13 <sup>a</sup>
51–65	14.27 <sup>dc</sup>	16.27 <sup>b</sup>
66–80	13.67 <sup>de</sup>	16.87 <sup>ab</sup>
81–95	13.60 <sup>e</sup>	16.73 <sup>ab</sup>
SEM	0.23	
CV (%)	5.9	
LSD (5%)	0.65	

Means with the same letter (s) within columns and rows of a variable were not significantly different at  $P < 0.05$ . SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

TABLE 3: Interaction effect of intra-row spacing and tuber size on days to 50% emergence of potato in 2013/2014 at Nono Benja.

Intra-row spacing (cm)	Tuber size (g)				
	20–35	36–50	51–65	66–80	81–95
20	16.67 <sup>a</sup>	15.67 <sup>abcd</sup>	15.67 <sup>abcd</sup>	15.17 <sup>cde</sup>	15.33 <sup>cde</sup>
25	16.50 <sup>ab</sup>	15.50 <sup>bcd</sup>	15.67 <sup>abcd</sup>	15.17 <sup>cde</sup>	15.33 <sup>cde</sup>
30	15.67 <sup>abcd</sup>	15.50 <sup>bcd</sup>	15.33 <sup>cde</sup>	14.83 <sup>de</sup>	15.17 <sup>cde</sup>
35	16.00 <sup>abc</sup>	15.33 <sup>cde</sup>	15.17 <sup>cde</sup>	14.83 <sup>de</sup>	15.17 <sup>cde</sup>
40	16.00 <sup>abc</sup>	15.00 <sup>cde</sup>	15.00 <sup>cde</sup>	14.17 <sup>e</sup>	15.00 <sup>cde</sup>
SEM	0.37				
CV (%)	5.4				
LSD (5%)	1.03				

Means with the same letter (s) within a column and row of a variable were not significantly different at  $P < 0.05$ . SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

related to days to 50% emergence, flowering, and maturity are controlled by genetic factors [22]. The earlier emergence of large seed tubers is an indication that the large seed tubers have the advantage of having extra reserves, which promotes earlier emergence. The observed variation across variations reveals the genetic potential of each variety to produce sprouts that emerge either early or later [23].

Days to 50% emergence was relatively increased as tuber size increases. The current result was associated with the fact that larger tuber seeds have superior capacity in providing higher contents of reserve materials, facilitating earlier emergence and crop establishment and in the similar way as the intra-row spacing increases during the days to 50% emergence increase. The result of the present study was similar to the findings of Masarirambi et al. [7] who reported larger tubers emerged earlier due to the high content of stored food. Kumar et al. [24] also reported that large seed tubers showed higher emergence compared to smaller seeds in their study.

**3.1.2. Days to 50% Flowering.** The analysis of variance indicated that there was a significant ( $P < 0.05$ ) interaction effect between variety and intra-row spacing on days to 50% flowering (Table 4). The three-way interaction of tuber size was nonsignificant. The earliest (53.33) days to 50% flowering was recorded from variety Jalenie planted at intra-row spacing of 20 cm followed by variety Jalenie planted at 25 cm

(55.13), whereas the prolonged (72.60) days to 50% flowering was recorded from variety Gudenie planted at intra-row spacing 40 cm (Table 4). As intra-row spacing increases, days to 50% flowering got delayed all over treatment combinations for both varieties. This could be due to the higher competition of plants for resources in the closer intra-row spacing that leads the plants to stress and ultimately the plants flowers early instead of prolonged vegetative growth [25]. The varietal differences can also influence days to 50% flowering as indicated by Ref. [23, 26].

### 3.2. Growth Parameters

**3.2.1. Plant Height.** The three-way interaction of variety, intra-row spacing, and tuber size was significantly ( $P < 0.05$ ) influenced by plant height (Table 5). The maximum plant height (80.38 and 79.75 cm) was recorded from variety Gudenie with tuber size of 66–80 g and 81–95 g planted at intra-row spacing of 35 cm and 25 cm, respectively. Statistically, similar result (79.09 cm) was recorded from variety Gudenie with tuber size 66–80 g planted at 30-cm intra-row spacing, while the shortest plant height (46.54 cm) was recorded from variety Jalenie with tuber size 35–50 g planted at 35 cm (Table 5). The plant height of treatment combination of variety Gudenie was higher by 6.30 cm than treatment combination of variety Jalenie (Table 5). The maximum plant height was obtained from variety Gudenie

TABLE 4: Interaction effect of variety and intra-row spacing on days to 50% flowering of potato in 2013/2014 at Nono Benja.

Intra-row spacing (cm)	Variety	
	Jalenie	Gudenie
20	53.33 <sup>h</sup>	67.60 <sup>d</sup>
25	55.13 <sup>g</sup>	68.33 <sup>dc</sup>
30	56.33 <sup>f</sup>	69.20 <sup>c</sup>
35	57.27 <sup>ef</sup>	70.73 <sup>b</sup>
40	57.48 <sup>e</sup>	72.60 <sup>a</sup>
SEM	0.35	
CV (%)	2.01	
LSD (5%)	0.99	

Means with the same letter (s) in a column of a variable were not significantly different at  $P < 0.05$ . SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

with the widest intra-row spacing indicating the difference in varietal responses [14, 26, 27]. In contrary to the present study, Tesfaye et al. [25] indicated the maximum plant height with closer intra-row spacing of 10 and 20 cm.

On the other hand, the present result indicates the combination of large seed tuber size gave the maximum plant height, which was in line with the findings of Islam et al. [28] who reported the large seed tuber sizes have more food reserve to supply sufficient nutrients to the plant and enhance plant height.

**3.2.2. Number of Main Stems per Plant.** The analysis of variance indicated that the three-way interaction of variety, intra-row spacing, and tuber size was found significant ( $P < 0.05$ ) on the number of main stems per plant. Numerically, the maximum (9.79) number of main stem was recorded from variety Jalenie with a tuber size of 81–95 g planted at intra-row spacing of 40 cm followed by (9.60) obtained from variety Jalenie with tuber sizes of 66–80 g planted at intra-row spacing of 40 cm (Table 5). The lowest (2.17) number of main stems per plant was obtained from variety Gudenie with tuber size 20–35 g planted at intra-row spacing of 35 cm, and this was statistically not significant with the number of main stems produced by variety Jalenie with tuber size of 20–35 g planted at 20 and 25 cm (Table 5). As indicated by the result, the combination of wider intra-row spacing and larger seed tuber sizes produced a higher number of main stems. Production of higher number of main stem per plant by treatment combination from variety Jalenie was probably due to its genetic potential for sprouting capacity [29]. Seed factors such as seed size are by far the most influential as they govern the number of main stems that can emanate from a seed tuber size [30].

The variations in tuber size among treatments in this study might be contributed to the variations in the number of main stems per plant. In agreement with this result, Helen et al. [26] indicated the difference between varieties in the number of main stems could be variations in the number of buds per tuber, which was then influenced by the tuber size. Masarirambi et al. [7] conducted on four levels of seed tuber size and plant population, and reported significant

differences in the number of main stems per plant across four seed sizes.

### 3.3. Yield Parameters

**3.3.1. Tuber Number per Plant.** There was a significant ( $P < 0.05$ ) three-way interaction effect of variety, intra-row spacing, and tuber size on tuber number per plant (Table 6). Numerically, the maximum (8.63) tuber number per plant was recorded from variety Jalenie with a tuber size of 66–80 g planted at intra-row spacing of 25 cm followed by variety Jalenie with a tuber size of 81–95 g planted at intra-row spacing of 20 cm (8.32) (Table 6). The lowest tuber number (4.37) was obtained from variety Gudenie with a tuber size of 20–35 g planted at intra-row spacing of 20 cm (Table 6). Treatment combinations from both varieties gave different results of tuber number per plant. This is due to the varietal differences in producing the tubers. On the other hand, large tubers gave higher number of tubers, while smaller tubers gave lower. This might be indicated by the fact that a large tuber has the potential to have a high number of sprouts, which produces more number of tubers per plant. Large tubers (66–95 g) combined with narrow intra-row spacing (25 cm) produced 8.63 tubers per plant due to more plant population per unit area and high bulking ability of large seed tubers to bear more numbers of tubers than small seed tubers. In addition to this, the maximum number of tubers at closer intra-row spacing is due to the high number of plants per unit area in line with the finding of Harnet et al. [16]. Large seed tubers produced more number of tubers per plant significantly over small seed tubers [28]. Roy et al. [31] reported the maximum tuber numbers per plant from 25 cm intra-row spacing, while the lowest value from 15-cm intra-row spacing. In contrary to the present study, the same authors reported the maximum tuber numbers per plant with tuber size of 30–40 g followed by tuber size 40–50 g. Tuber number per plant and per hectare consistently increased with increasing seed tuber size, which was similar to the findings of Gulluoglu and Arioglu [32]. More tuber numbers per plant were obtained from large seed tuber sizes, and consequently, the bulking period was greater in large seed tuber size across all plant densities [7]. Tibebu et al. [3] conducted a study on tuber sizes and indicated that variety Jalenie scored the maximum, while variety Gudenie scored the lowest tuber number per plant, which might be because of the variety difference.

**3.3.2. Average Tuber Weight.** The analysis of variance results indicated that the three-way interaction of variety, intra-row spacing, and tuber size was significantly ( $P < 0.05$ ) influencing the average tuber weight (Table 6). The maximum average tuber weight (66.05 g) was recorded from variety Jalenie with a tuber size of 66–80 g planted at intra-row spacing of 30 cm, while the lowest average tuber weight (43.67 g) was recorded from variety Gudenie with a tuber size of 20–35 g and planted at intra-row spacing of 20 cm (Table 6). The present study showed the fact that an increase in intra-row spacing and tuber size resulted in an increase in

TABLE 5: Interaction effects of variety, intra-row spacing, and tuber size on growth parameters of potato in 2013/2014 at Nono Benja.

Variety	Treatments		Growth parameters	
	Intra-row spacing (cm)	Tuber size (g)	Number of main stems	Plant height (cm)
Jalenie	20	20-35	2.21 <sup>uv</sup>	47.71 <sup>t</sup>
		36-50	2.69 <sup>st</sup>	47.43 <sup>t</sup>
		51-65	4.84 <sup>mn</sup>	48.90 <sup>t</sup>
		66-80	6.02 <sup>ghij</sup>	57.04 <sup>p-s</sup>
		81-95	6.40 <sup>g</sup>	63.79 <sup>kl</sup>
		20-35	2.31 <sup>tuv</sup>	65.35 <sup>g-k</sup>
	25	36-50	3.33 <sup>pq</sup>	54.02 <sup>n-s</sup>
		51-65	4.79 <sup>mn</sup>	58.48 <sup>n-q</sup>
		66-80	8.38 <sup>c</sup>	74.08 <sup>bc</sup>
		81-95	8.19 <sup>c</sup>	63.44 <sup>ijkl</sup>
		20-35	2.73 <sup>rst</sup>	48.06 <sup>t</sup>
		36-50	3.29 <sup>q</sup>	48.96 <sup>t</sup>
	30	51-65	5.08 <sup>lm</sup>	61.81 <sup>k-n</sup>
		66-80	7.52 <sup>ef</sup>	70.48 <sup>b-f</sup>
		81-95	8.09 <sup>cd</sup>	65.08 <sup>h-l</sup>
		20-35	3.23 <sup>q</sup>	54.63 <sup>qrs</sup>
		36-50	3.52 <sup>pq</sup>	46.54 <sup>t</sup>
		51-65	5.46 <sup>kl</sup>	57.75 <sup>o-r</sup>
	35	66-80	8.35 <sup>c</sup>	65.04 <sup>h-l</sup>
		81-95	9.10 <sup>b</sup>	58.40 <sup>n-q</sup>
		20-35	3.25 <sup>q</sup>	46.67 <sup>t</sup>
		36-50	4.11 <sup>o</sup>	48.21 <sup>t</sup>
		51-65	6.19 <sup>gh</sup>	56.31 <sup>p-s</sup>
		66-80	9.60 <sup>a</sup>	65.02 <sup>h-l</sup>
40	81-95	9.79 <sup>a</sup>	56.94 <sup>p-s</sup>	
	20	20-35	2.27 <sup>tuv</sup>	56.73 <sup>p-s</sup>
		36-50	3.33 <sup>pq</sup>	64.27 <sup>h-l</sup>
		51-65	3.42 <sup>pq</sup>	67.33 <sup>e-j</sup>
		66-80	5.00 <sup>lmn</sup>	74.40 <sup>b</sup>
		81-95	4.60 <sup>n</sup>	71.83 <sup>bcd</sup>
20-35		2.27 <sup>tuv</sup>	59.02 <sup>m-p</sup>	
25	36-50	3.50 <sup>pq</sup>	64.65 <sup>h-l</sup>	
	51-65	3.79 <sup>op</sup>	64.13 <sup>i-l</sup>	
	66-80	6.17 <sup>ghi</sup>	71.21 <sup>b-e</sup>	
	81-95	5.69 <sup>jk</sup>	79.75 <sup>a</sup>	
	20-35	2.64 <sup>stu</sup>	53.56 <sup>s</sup>	
	36-50	3.29 <sup>q</sup>	69.25 <sup>d-g</sup>	
30	51-65	5.65 <sup>jk</sup>	68.23 <sup>d-h</sup>	
	66-80	7.40 <sup>ef</sup>	79.09 <sup>a</sup>	
	81-95	6.10 <sup>ghij</sup>	70.44 <sup>b-f</sup>	
	20-35	2.17 <sup>v</sup>	66.69 <sup>fg</sup>	
	36-50	3.17 <sup>qr</sup>	65.21 <sup>h-k</sup>	
	51-65	5.44 <sup>kl</sup>	67.98 <sup>d-i</sup>	
35	66-80	7.15 <sup>f</sup>	80.38 <sup>a</sup>	
	81-95	5.75 <sup>hijk</sup>	69.30 <sup>d-g</sup>	
	20-35	2.42 <sup>tuv</sup>	62.54 <sup>klm</sup>	
	36-50	3.11 <sup>qrs</sup>	61.17 <sup>l-o</sup>	
	51-65	5.71 <sup>ijk</sup>	62.63 <sup>klm</sup>	
	66-80	7.67 <sup>de</sup>	70.31 <sup>c-f</sup>	
40	81-95	6.06 <sup>ghij</sup>	70.19 <sup>c-f</sup>	
	SEM		0.17	1.47
	CV (%)		5.95	4.17
	LSD (5%)		0.47	4.13

Means with the same letter (s) within a column of a variable were not significantly different at  $P < 0.05$ . SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

the average tuber weight of potatoes. This is due to the reason that large seed tuber size, which can provide sufficiently required substances for growth and development at

the initial growth phase. The decrease in intra-row spacing probably increased the competition between plants, hence, leading to a decrease in the availability of nutrients to each

TABLE 6: Interaction effects of variety, intra-row spacing, and tuber size on yield parameters of potato in 2013/2014 at Nono Benja.

Variety	Treatments		Yield parameters				
	Intra-row spacing (cm)	Tuber size (g)	MTY (t/ha)	UMTY (t/ha)	TTY (t/ha)	TN	ATW (g)
Jalenie	20	20-35	11.64 <sup>i-l</sup>	5.01 <sup>ghi</sup>	16.65 <sup>l-r</sup>	6.46 <sup>i-q</sup>	47.51 <sup>vw</sup>
		36-50	16.55 <sup>b-f</sup>	7.24 <sup>abc</sup>	23.80 <sup>abc</sup>	6.31 <sup>k-r</sup>	49.45 <sup>r-u</sup>
		51-65	16.58 <sup>b-f</sup>	7.46 <sup>ab</sup>	24.05 <sup>abc</sup>	6.67 <sup>g-o</sup>	51.90 <sup>mno</sup>
		66-80	17.04 <sup>a-d</sup>	6.49 <sup>cd</sup>	23.52 <sup>a-d</sup>	7.64 <sup>b-f</sup>	56.72 <sup>efg</sup>
		81-95	16.76 <sup>b-f</sup>	7.52 <sup>a</sup>	24.38 <sup>ab</sup>	8.32 <sup>ab</sup>	56.03 <sup>f-i</sup>
		20-35	14.66 <sup>c-h</sup>	6.43 <sup>cde</sup>	21.09 <sup>a-j</sup>	7.38 <sup>c-h</sup>	55.20 <sup>g-k</sup>
	25	36-50	15.14 <sup>c-g</sup>	6.29 <sup>cdef</sup>	23.40 <sup>a-d</sup>	7.18 <sup>e-k</sup>	56.59 <sup>fgh</sup>
		51-65	17.12 <sup>a-f</sup>	4.76 <sup>f-l</sup>	19.91 <sup>d-m</sup>	6.63 <sup>g-o</sup>	55.74 <sup>g-j</sup>
		66-80	19.93 <sup>a</sup>	4.91 <sup>f-k</sup>	24.84 <sup>a</sup>	8.63 <sup>a</sup>	53.69 <sup>klm</sup>
		81-95	19.48 <sup>ab</sup>	5.06 <sup>ghi</sup>	24.54 <sup>ab</sup>	8.21 <sup>abc</sup>	50.82 <sup>o-s</sup>
		20-35	13.77 <sup>c-j</sup>	3.49 <sup>m-s</sup>	18.08 <sup>h-q</sup>	6.91 <sup>e-m</sup>	51.13 <sup>o-r</sup>
		36-50	14.59 <sup>c-i</sup>	4.63 <sup>h-m</sup>	19.22 <sup>e-o</sup>	7.35 <sup>c-i</sup>	56.80 <sup>efg</sup>
	30	51-65	15.83 <sup>c-f</sup>	3.56 <sup>m-s</sup>	19.39 <sup>e-n</sup>	6.83 <sup>f-n</sup>	57.76 <sup>def</sup>
		66-80	17.00 <sup>a-f</sup>	2.22 <sup>uv</sup>	19.22 <sup>e-o</sup>	7.53 <sup>b-g</sup>	66.05 <sup>a</sup>
		81-95	19.57 <sup>ab</sup>	2.15 <sup>v</sup>	21.82 <sup>a-h</sup>	7.16 <sup>e-k</sup>	54.22 <sup>jkl</sup>
		20-35	13.39 <sup>d-j</sup>	3.51 <sup>m-s</sup>	16.90 <sup>l-r</sup>	6.30 <sup>k-r</sup>	52.13 <sup>m-o</sup>
		36-50	17.41 <sup>a-f</sup>	3.63 <sup>m-s</sup>	21.95 <sup>a-g</sup>	6.95 <sup>e-l</sup>	53.03 <sup>l-o</sup>
		51-65	18.32 <sup>a-d</sup>	2.88 <sup>q-v</sup>	20.28 <sup>c-l</sup>	7.38 <sup>c-h</sup>	54.59 <sup>i-l</sup>
	35	66-80	19.43 <sup>ab</sup>	4.22 <sup>l-o</sup>	24.15 <sup>ab</sup>	7.80 <sup>a-e</sup>	56.17 <sup>f-i</sup>
		81-95	14.88 <sup>c-h</sup>	2.82 <sup>r-v</sup>	17.69 <sup>i-r</sup>	7.24 <sup>d-j</sup>	58.99 <sup>d</sup>
		20-35	13.08 <sup>e-k</sup>	4.44 <sup>h-n</sup>	22.35 <sup>a-f</sup>	5.87 <sup>o-t</sup>	48.76 <sup>tuv</sup>
		36-50	13.50 <sup>c-j</sup>	2.46 <sup>h-m</sup>	15.54 <sup>o-r</sup>	6.30 <sup>k-r</sup>	49.92 <sup>p-t</sup>
		51-65	13.74 <sup>c-j</sup>	2.70 <sup>s-v</sup>	16.19 <sup>m-r</sup>	6.24 <sup>k-r</sup>	50.15 <sup>p-t</sup>
		66-80	17.91 <sup>a-e</sup>	3.97 <sup>k-p</sup>	22.55 <sup>a-e</sup>	8.23 <sup>abc</sup>	50.74 <sup>o-s</sup>
40	81-95	18.58 <sup>abc</sup>	2.82 <sup>r-v</sup>	21.40 <sup>a-i</sup>	6.81 <sup>f-n</sup>	51.24 <sup>opq</sup>	
	20	20-35	8.58 <sup>l</sup>	5.60 <sup>c-g</sup>	14.18 <sup>r</sup>	4.37 <sup>v</sup>	43.67 <sup>z</sup>
		36-50	12.39 <sup>f-k</sup>	5.42 <sup>fgh</sup>	17.81 <sup>l-r</sup>	6.17 <sup>l-r</sup>	43.73 <sup>z</sup>
		51-65	12.88 <sup>e-k</sup>	5.19 <sup>gh</sup>	18.07 <sup>h-q</sup>	5.84 <sup>o-t</sup>	43.75 <sup>z</sup>
		66-80	12.17 <sup>f-k</sup>	4.38 <sup>h-n</sup>	16.55 <sup>l-r</sup>	6.43 <sup>j-q</sup>	43.81 <sup>z</sup>
		81-95	10.98 <sup>i-l</sup>	4.33 <sup>h-o</sup>	15.31 <sup>pqr</sup>	6.00 <sup>m-s</sup>	44.77 <sup>yz</sup>
20-35		10.23 <sup>kl</sup>	4.97 <sup>f-j</sup>	15.20 <sup>pqr</sup>	5.43 <sup>r-u</sup>	43.73 <sup>z</sup>	
25	36-50	11.68 <sup>h-l</sup>	4.38 <sup>h-n</sup>	16.06 <sup>n-r</sup>	5.18 <sup>s-v</sup>	43.71 <sup>z</sup>	
	51-65	12.00 <sup>f-k</sup>	5.41 <sup>efg</sup>	17.41 <sup>j-r</sup>	6.48 <sup>h-q</sup>	43.52 <sup>z</sup>	
	66-80	14.63 <sup>c-h</sup>	4.18 <sup>i-o</sup>	18.81 <sup>e-p</sup>	8.16 <sup>a-d</sup>	43.71 <sup>z</sup>	
	81-95	16.44 <sup>b-f</sup>	4.36 <sup>h-n</sup>	20.80 <sup>n-s</sup>	5.71 <sup>p-u</sup>	44.58 <sup>yz</sup>	
	20-35	11.10 <sup>i-l</sup>	4.41 <sup>h-n</sup>	15.51 <sup>o-r</sup>	6.14 <sup>l-r</sup>	47.73 <sup>uvw</sup>	
	36-50	12.41 <sup>f-k</sup>	4.24 <sup>h-o</sup>	16.65 <sup>l-r</sup>	7.17 <sup>e-k</sup>	50.85 <sup>o-s</sup>	
30	51-65	15.08 <sup>c-g</sup>	3.56 <sup>m-s</sup>	18.64 <sup>f-q</sup>	7.76 <sup>a-e</sup>	52.00 <sup>mno</sup>	
	66-80	15.13 <sup>c-g</sup>	2.86 <sup>q-v</sup>	17.99 <sup>l-q</sup>	6.63 <sup>g-o</sup>	54.92 <sup>h-k</sup>	
	81-95	12.88 <sup>e-k</sup>	3.81 <sup>k-q</sup>	16.69 <sup>l-r</sup>	6.61 <sup>h-p</sup>	62.94 <sup>b</sup>	
	20-35	11.81 <sup>h-k</sup>	4.61 <sup>h-m</sup>	16.42 <sup>m-r</sup>	5.86 <sup>o-t</sup>	45.90 <sup>xy</sup>	
	36-50	12.12 <sup>f-k</sup>	4.01 <sup>j-p</sup>	16.14 <sup>m-r</sup>	5.68 <sup>q-u</sup>	49.15 <sup>s-v</sup>	
	51-65	12.30 <sup>f-k</sup>	3.76 <sup>m-r</sup>	16.06 <sup>n-r</sup>	5.23 <sup>s-v</sup>	49.52 <sup>q-t</sup>	
35	66-80	14.79 <sup>c-h</sup>	3.55 <sup>m-s</sup>	18.34 <sup>g-q</sup>	7.60 <sup>b-f</sup>	58.46 <sup>de</sup>	
	81-95	11.78 <sup>h-l</sup>	3.15 <sup>p-u</sup>	14.92 <sup>qr</sup>	5.77 <sup>o-t</sup>	60.83 <sup>c</sup>	
	20-35	12.23 <sup>f-k</sup>	3.64 <sup>m-s</sup>	15.87 <sup>n-r</sup>	4.83 <sup>uv</sup>	46.71 <sup>wx</sup>	
	36-50	12.39 <sup>f-k</sup>	3.51 <sup>m-s</sup>	15.90 <sup>n-r</sup>	5.03 <sup>tuv</sup>	49.61 <sup>q-t</sup>	
	51-65	13.76 <sup>c-j</sup>	3.39 <sup>o-u</sup>	17.15 <sup>k-r</sup>	6.00 <sup>n-s</sup>	51.42 <sup>nop</sup>	
	66-80	15.72 <sup>c-f</sup>	2.73 <sup>s-v</sup>	18.49 <sup>g-q</sup>	6.49 <sup>h-q</sup>	51.61 <sup>mno</sup>	
40	81-95	14.70 <sup>c-h</sup>	3.47 <sup>n-s</sup>	18.17 <sup>h-q</sup>	6.50 <sup>h-q</sup>	52.19 <sup>mno</sup>	
	SEM		1.12	0.34	1.35	0.33	0.63
	CV (%)		13.2	13.7	12.2	8.5	2.1
	LSD (5%)		3.15	0.96	3.78	0.91	1.77

Means with the same letter (s) in a column of a variable were not significantly different at  $P < 0.05$ . MTY = marketable tuber yield, UMTY = unmarketable tuber yield, TTY = total tuber yield, TN = tuber number per plant, ATW = average tuber weight, SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

plant and, consequently, resulted in a decline of mean tuber weight. The wider intra-row spacing permits free growth without any competition for minerals and other requirements. On the other hand, there might be differences in variety to produce different sizes of tubers. In this case, genetically, performances of the varieties in producing more amounts of large or small tubers might be different [26].

The increase in plant population probably increased competition between and within plants, and, hence, led to a decrease in the availability of nutrients to each plant and, consequently, resulted in a decline of average tuber weight [16]. Closer intra-row spacing and large seed tubers gave less tuber weight [32].

**3.3.3. Marketable Tuber Yield.** The three-way interaction of variety, intra-row spacing, and tuber size significantly ( $P < 0.05$ ) influenced the marketable tuber yield (Table 6). Numerically, the maximum (19.93 t/ha) marketable tuber yield was obtained from variety Jalenie with a tuber size of 66–80 g planted at intra-row spacing of 25 cm. This is statistically at par with variety Jalenie with tuber size of 81–95 g and 66–80 g and planted at intra-row spacing of 30 and 35 cm (19.57 t/ha and 19.43 t/ha), respectively. The lowest marketable tuber yield (8.58 t/ha) was obtained from variety Gudenie with tuber size of 20–35 g planted at an intra-row spacing of 20 cm. The present study indicates that larger seed tuber size produced high marketable tuber yields. Large seed tubers combined with all intra-row spacing produced statistically similar marketable tuber yields. This is due to the fact that large seed tubers can withstand even the effects of population because of the high performance to provide stored food at the early growth phase, which supports in producing high marketable tuber yield. The present result is in agreement with the finding of Harnet et al. [16], who reported that large seed tubers had more food reserves to supply sufficient nutrients to the plant and enhance the production of marketable tuber yield. Mangani et al. [27] also reported that plants were able to efficiently use the available growth requirements and had a direct effect on yield. The difference among varieties was also observed clearly in which variety Jalenie resulted in higher production of marketable tuber yield than variety Gudenie. In contrary to the present result, Roy et al. [31] indicated high marketable tuber yield from small seed tubers of 30–40 g. The present result was also similar to the finding of Ayupov et al. [33] who reported in case of increasing plant population, the marketability (tuber size) of the tubers declines.

**3.3.4. Unmarketable Tuber Yield.** The analysis of variance indicated that unmarketable tuber yield was significantly ( $P < 0.05$ ) affected by the three-way interaction of variety, intra-row spacing, and tuber size (Table 6). The two-way interactions of variety by intra-row spacing, variety by tuber size, and intra-row spacing by tuber size were also significantly ( $P > 0.05$ ) influenced the unmarketable tuber yield. The maximum unmarketable tuber yield (7.52 t/ha) was recorded from variety Jalenie with a tuber size of 81–95 g planted at intra-row spacing of 20 cm followed by (7.46 t/ha)

and (7.24 t/ha) by variety Jalenie with tuber sizes of 51–65 g and 36–50 g planted at intra-row spacing of 20 cm. The smallest (2.15 t/ha) unmarketable tuber yield was obtained from variety Jalenie with a tuber size of 81–95 g planted at intra-row spacing of 30 cm (Table 6).

The smaller seed tuber and the same size tuber yield can expect since the production of tuber yield depends on the performance of seed tubers at planting. In the present study, large seed tubers planted at narrow intra-row spacing resulted in the production of higher unmarketable tuber yield. This is actually described the fact that large seed tubers when planted at narrow intra-row spacing produced high yield of small tubers. Therefore, the present study was similar to the work of Tesfaye et al. [25] who reported that as the decrease intra-row spacing, the production of unmarketable tuber yield increased. Additionally, Gulluoglu and Arioglu [32] reported that planting of large seed tubers at closer intra-row spacing resulted in lower tuber yield because of high production of smaller and unmarketable tuber yield due to increasing intra-plant competition.

In all cases, as an increment of intra-row spacing, there was a decrease in the production of unmarketable tuber yield, which was in line with the findings of Ayupov et al. [33] who indicated that with an increasing of intra-row spacing, the production of unmarketable tuber yield declines. It is interesting to note that the smaller size seed tubers when used for planting produced more number of smaller tubers, which become unmarketable tubers [24].

**3.3.5. Total Tuber Yield.** The analysis of variance indicated that the three-way ( $P < 0.05$ ) interaction had a significant effect (variety, intra-row spacing, and tuber size) on total tuber yield (Table 6). Numerically, the maximum total tuber yield (24.84 t/ha) was recorded from variety Jalenie with a tuber size of 66–80 g planted at intra-row spacing of 25 cm followed by variety Jalenie with a tuber size of 81–95 g planted at intra-row spacing of 25 and 20 cm, respectively. The lowest total tuber yield (13.97 t/ha) was obtained from variety Gudenie with a tuber size of 66–80 g planted at intra-row spacing of 30 cm (Table 6).

The total tuber yield in the present study indicates that at high plant population, there was high production of total tuber yield (Table 6). This shows that at higher plant population, there might be a production of high number of tubers per plant, which results in high tuber yield. When there was a high completion due to plant population, many small size tubers produced per unit area. On the other hand, the production of total tuber yield in the present study also indicated varietal differences. Hence, the ability to produce tubers depends on the potential of each variety to bear sprouts and stems. Tibebu et al. [3] also reported similar results that the total potato tuber yield of variety Jalenie was significantly higher than variety Gudenie. In contrary to the present study, the maximum total tuber yield was observed in variety Gudenie than variety Jalenie [23]. Patel et al. [34] conducted a study on seed tuber sizes and indicated that larger size tubers of 51–70 g resulted in higher tuber yield, which might be due to rapid seedling emergence and better



plant growth. The yield increase could be attributed primarily to the increased weight of seed tubers [35].

The result of the present study was also similar with the findings of Masarirambi et al. [7] who indicated that reducing the intra-row spacing from 45 to 30 cm significantly increased plant population and subsequently increased the total tuber yield. The total tuber yield was important, but the proportion of different tuber sizes has great significance [24]. In contrary to the present study, Roy et al. [31] reported that the maximum total tuber yield was observed in the intra-row spacing of 20 cm.

### 3.4. Quality Parameters

**3.4.1. Fresh Tuber Size Category.** (1) *Large Tuber (>75 g)*. The three-way interaction was significantly affected the mean yield of large tuber size (>75 g). The two-way interactions of variety by intra-row spacing, variety by tuber size, and intra-row spacing by tuber size were also significant (Table 7). The maximum (10.18 t/ha) mean yield of large tuber was recorded from variety Gudenie with a tuber size of 66–80 g planted at 25 cm followed by variety Jalenie with a tuber size of 66–80 g planted at intra-row spacing of 30 cm (10.14 t/ha). The least (4.77 t/ha) mean yield of large tubers was recorded from variety Jalenie with a tuber size of 20–35 g planted at intra-row spacing of 20 cm. The result indicated the small seed tubers planted at closer intra-row spacing produced lower mean yield of large tubers than the large seed tubers planted at wider intra-row spacing in both varieties. Large tuber yield obtained from the large seed tuber in this study indicated that the large seed tubers had the potential to produce large tuber yield due to its high content of carbohydrate to feed plants. In other ways, the large tubers may also affected by soil fertility and nutrients supplement [36]. The emerged plants with large seed tubers can sufficiently compete for resources with other neighboring plants. On the other hand, small seed tubers as discussed in the previous portions had no capability of equal competition with other plants for resources and had also little amount of carbohydrate source to support the plant at an earlier growth period. The variety might be the observed difference in the production of large tubers; Gudenie has larger tuber sizes than Jalenie [37]. Variety Gudenie produced high mean yield of large tubers, while variety Jalenie was less in mean yield of large tubers in line with the finding of Helen et al. [26] who reported the genetic ability of varieties to sprout and produce tubers. In a similar way, plant population affects the production of large tubers as observed in this study. In this case, the increment of intra-row spacing from 30 to 40 cm might decrease the mean yield of large tubers, but intra-row spacing ranges from 20 to 30 cm, with the yield relatively increasing. Gulluoglu and Arioglu [32] also indicated that the tuber size was significantly affected the yield of large tubers and the ratio of large tubers, which significantly affected by in-row spacing treatment. Large seed tubers also produced more number of large size tubers and tuber yield per plant [24].

(2) *Medium Tuber (50–75 g)*. The three-way interaction of variety, intra-row spacing, and tuber size had significantly affected the mean yield of medium tuber sized. Numerically, variety Jalenie with tuber size of 66–80 g planted at 25 cm produced the maximum (8.04 t/ha) mean yield of medium-sized tubers followed by variety Jalenie with tuber size of 66–80 g planted at intra-row spacing of 40 cm (7.58 t/ha) (Table 7). The result indicated that variety Jalenie produced higher mean yield of medium-sized tubers. Therefore, this is actually recognized with the fact that there were genetic differences among varieties in the production of medium size tubers as well. As indicated by Helen et al. [26], there were differences in the yields of medium tuber size for different varieties. Average tuber size decreased with increasing stem or tuber density [38].

(3) *Small Tuber Size (20–49 g)*. The three-way interaction of variety, intra-row spacing, and tuber size had significantly affected the small tuber size. The maximum mean yield of small tuber (8.59 t/ha) was recorded from variety Jalenie with larger tuber size 81–95 g planted at intra-row spacing of 20 cm (Table 7). The result confirmed the findings of Akbari et al. [39], who indicated that different smaller tuber yields of different varieties might be different. Mangani et al. [27] also suggested a similar result.

**3.4.2. Dry Matter Content.** The analysis of variance indicated that dry matter content was significantly ( $P < 0.05$ ) affected by two-way interaction of variety with tuber size as well as the variety with intra-row spacing (Tables 8 and 9). The three-way interaction and two-way interaction of intra-row spacing by tuber size had no significant on tuber dry matter content. Variety Gudenie planted at intra-row spacing of 40 cm gave the maximum dry matter content (19.98%) followed by variety Gudenie planted at intra-row spacing of 30 cm (19.96%), while the lowest (17.03%) was recorded from variety Jalenie planted at 35-cm intra-row spacing (Table 8). The results indicated that variety Gudenie produced more dry matter content than variety Jalenie. The dry matter content observed in the present study revealed the fact that late maturing varieties of potato had high dry matter content, which is indicated by the variety Gudenie [18]. This is due to the reason that as the growing period of potato increased, the dry matter of tubers also increased. The dry matter content was affected differently for the different varieties [25, 27, 40]. Tibebu et al. [3] reported higher dry matter content of variety Gudenie than variety Jalenie. On the other hand, dry matter content is also governed by plant population. The dry matter content of potato variety might be higher in maximum light harvesting resulting in enhanced whole-plant photosynthetic capacity [15].

The interaction effects between variety and tuber size may also indicated the maximum (20.61%) dry matter content was recorded from variety Gudenie having a tuber size of 66–80 g followed by variety Gudenie with a tuber size of 81–95 g (19.61%), while the lowest (17.35%) value was recorded from variety Jalenie having tuber size of 51–65 g (Table 9). The tuber size from which potato tubers emerged might be influenced by the production of dry matter content.

TABLE 7: Interaction effects of variety, intra-row spacing, and tuber size on quality-related parameters of potato in 2013/2014 at Nono Benja.

Variety	Treatments		Quality parameters		
	Intra-row spacing (cm)	Tuber size (g)	LT (t/ha)	MT (t/ha)	ST (t/ha)
Jalenie	20	20-35	4.77 <sup>q</sup>	3.06 <sup>n-u</sup>	3.82 <sup>h-k</sup>
		36-50	6.48 <sup>g-o</sup>	5.07 <sup>g-k</sup>	5.00 <sup>c-f</sup>
		51-65	6.40 <sup>h-p</sup>	5.22 <sup>e-j</sup>	4.96 <sup>c-g</sup>
		66-80	6.25 <sup>h-p</sup>	6.20 <sup>b-h</sup>	4.58 <sup>d-i</sup>
		81-95	7.32 <sup>e-j</sup>	4.24 <sup>j-o</sup>	8.59 <sup>a</sup>
		20-35	6.16 <sup>i-q</sup>	3.33 <sup>n-t</sup>	5.16 <sup>b-e</sup>
	25	36-50	6.40 <sup>h-p</sup>	5.80 <sup>d-i</sup>	4.91 <sup>c-g</sup>
		51-65	6.06 <sup>l-q</sup>	6.97 <sup>a-d</sup>	5.42 <sup>bcd</sup>
		66-80	7.04 <sup>f-m</sup>	8.04 <sup>a</sup>	4.83 <sup>c-g</sup>
		81-95	7.35 <sup>e-j</sup>	6.25 <sup>b-g</sup>	5.88 <sup>b</sup>
		20-35	5.56 <sup>m-q</sup>	4.82 <sup>g-m</sup>	4.21 <sup>f-j</sup>
		36-50	5.68 <sup>k-q</sup>	6.62 <sup>a-e</sup>	4.41 <sup>e-j</sup>
	30	51-65	5.97 <sup>l-q</sup>	6.66 <sup>a-d</sup>	5.61 <sup>bc</sup>
		66-80	10.14 <sup>a</sup>	6.03 <sup>c-h</sup>	4.12 <sup>g-j</sup>
		81-95	5.13 <sup>opq</sup>	4.95 <sup>g-l</sup>	3.69 <sup>jk</sup>
		20-35	5.41 <sup>n-q</sup>	3.70 <sup>k-q</sup>	4.28 <sup>f-j</sup>
		36-50	6.40 <sup>h-p</sup>	7.24 <sup>abc</sup>	4.68 <sup>d-h</sup>
		51-65	6.25 <sup>h-p</sup>	6.52 <sup>b-f</sup>	4.64 <sup>d-h</sup>
	35	66-80	7.42 <sup>e-j</sup>	6.90 <sup>a-d</sup>	5.61 <sup>bc</sup>
		81-95	5.59 <sup>l-q</sup>	5.15 <sup>f-j</sup>	4.12 <sup>g-j</sup>
		20-35	6.24 <sup>h-q</sup>	7.04 <sup>a-d</sup>	4.62 <sup>bc</sup>
		36-50	4.96 <sup>pq</sup>	4.41 <sup>i-n</sup>	3.71 <sup>ijk</sup>
		51-65	5.03 <sup>opq</sup>	4.78 <sup>h-m</sup>	3.69 <sup>jk</sup>
		66-80	6.34 <sup>h-p</sup>	7.58 <sup>ab</sup>	4.65 <sup>d-h</sup>
40	81-95	5.14 <sup>opq</sup>	4.80 <sup>h-m</sup>	3.81 <sup>h-k</sup>	
	20-35	4.99 <sup>pq</sup>	1.49 <sup>v</sup>	2.11 <sup>l</sup>	
	36-50	7.32 <sup>e-j</sup>	2.12 <sup>s-v</sup>	2.94 <sup>kl</sup>	
	51-65	7.70 <sup>d-h</sup>	2.39 <sup>p-v</sup>	2.79 <sup>l</sup>	
	66-80	7.07 <sup>f-l</sup>	2.29 <sup>q-v</sup>	2.80 <sup>l</sup>	
	81-95	6.77 <sup>g-n</sup>	1.91 <sup>tuv</sup>	2.31 <sup>l</sup>	
Gudenie	20	20-35	7.27 <sup>e-j</sup>	2.23 <sup>r-v</sup>	2.49 <sup>l</sup>
		36-50	6.23 <sup>h-q</sup>	1.69 <sup>uv</sup>	2.31 <sup>l</sup>
		51-65	9.51 <sup>abc</sup>	3.62 <sup>l-r</sup>	2.65 <sup>l</sup>
		66-80	10.18 <sup>a</sup>	2.62 <sup>p-v</sup>	2.51 <sup>l</sup>
		81-95	7.00 <sup>f-m</sup>	2.23 <sup>r-v</sup>	2.45 <sup>l</sup>
		20-35	7.27 <sup>e-j</sup>	2.38 <sup>q-v</sup>	2.76 <sup>l</sup>
	25	36-50	9.61 <sup>abc</sup>	3.13 <sup>n-t</sup>	2.38 <sup>l</sup>
		51-65	10.00 <sup>ab</sup>	2.92 <sup>o-v</sup>	2.16 <sup>l</sup>
		66-80	6.90 <sup>f-m</sup>	2.03 <sup>s-v</sup>	2.18 <sup>l</sup>
		81-95	7.95 <sup>d-g</sup>	2.62 <sup>p-v</sup>	2.31 <sup>l</sup>
		20-35	7.44 <sup>e-j</sup>	2.31 <sup>q-v</sup>	2.55 <sup>l</sup>
		36-50	7.58 <sup>e-j</sup>	2.31 <sup>q-v</sup>	2.23 <sup>l</sup>
30	51-65	7.31 <sup>e-j</sup>	2.35 <sup>q-v</sup>	2.16 <sup>l</sup>	
	66-80	9.10 <sup>a-d</sup>	3.02 <sup>n-u</sup>	2.66 <sup>l</sup>	
	81-95	7.09 <sup>f-k</sup>	2.35 <sup>q-v</sup>	2.34 <sup>l</sup>	
	20-35	6.70 <sup>g-n</sup>	2.83 <sup>o-v</sup>	2.69 <sup>l</sup>	
	36-50	7.18 <sup>e-j</sup>	2.81 <sup>o-v</sup>	2.39 <sup>l</sup>	
	51-65	9.47 <sup>abc</sup>	3.82 <sup>j-p</sup>	2.44 <sup>l</sup>	
35	66-80	8.29 <sup>c-f</sup>	3.19 <sup>n-t</sup>	2.27 <sup>l</sup>	
	81-95	8.61 <sup>b-e</sup>	3.39 <sup>p-v</sup>	2.69 <sup>l</sup>	
	SEM		0.53	0.52	0.31
	CV (%)		13.0	22.0	14.9
	LSD (5%)		1.47	1.46	0.87

Means with the same letter (s) in a column of a variable were not significantly different at  $P < 0.05$ . LT = mean yield of large tuber, MT = mean yield of medium tuber, ST = mean yield of small tuber, SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

TABLE 8: Interaction effect of variety and intra-row spacing on quality parameters of potato in 2013/2014 at Nono Benja.

Treatments		Quality parameters	
Variety	Intra-row spacing (cm)	Dry matter content (%)	Tuber specific gravity (g/cm <sup>3</sup> )
Jalenie	20	17.35 <sup>e</sup>	1.059 <sup>f</sup>
	25	18.25 <sup>cd</sup>	1.064 <sup>de</sup>
	30	18.77 <sup>bc</sup>	1.065 <sup>d</sup>
	35	17.03 <sup>e</sup>	1.061 <sup>ef</sup>
	40	17.35 <sup>e</sup>	1.064 <sup>de</sup>
Gudenie	20	18.08 <sup>d</sup>	1.063 <sup>de</sup>
	25	19.05 <sup>b</sup>	1.068 <sup>c</sup>
	30	19.96 <sup>a</sup>	1.073 <sup>b</sup>
	35	19.98 <sup>a</sup>	1.077 <sup>a</sup>
	40	19.77 <sup>a</sup>	1.077 <sup>a</sup>
SEM		0.22	0.001
CV (%)		4.6	0.4
LSD(5%)		0.61	0.0031

Means with the same letter (s) in a column of a variable were not significantly different at  $P < 0.05$ . SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

TABLE 9: Interaction effects of variety and tuber size on quality parameters of potato in 2013/2014 at Nono Benja.

Treatments		Quality parameters	
Variety	Tuber size (g)	Dry matter content (%)	Tuber specific gravity (g/cm <sup>3</sup> )
Jalenie	20–35	17.74 <sup>ef</sup>	1.062 <sup>c</sup>
	36–50	17.73 <sup>f</sup>	1.062 <sup>c</sup>
	51–65	17.35 <sup>f</sup>	1.062 <sup>c</sup>
	66–80	18.35 <sup>de</sup>	1.063 <sup>c</sup>
	81–95	17.58 <sup>f</sup>	1.064 <sup>c</sup>
Gudenie	20–35	18.70 <sup>cd</sup>	1.068 <sup>b</sup>
	36–50	18.66 <sup>cd</sup>	1.069 <sup>b</sup>
	51–65	19.26 <sup>bc</sup>	1.072 <sup>a</sup>
	66–80	20.62 <sup>a</sup>	1.074 <sup>a</sup>
	81–95	19.61 <sup>b</sup>	1.074 <sup>a</sup>
SEM		0.22	0.001
CV (%)		4.6	0.4
LSD (5%)		0.61	0.0031

Means with the same letter (s) in a column of a variable were not significantly different at  $P < 0.05$ . SEM = standard error mean, CV = coefficient of variation, and LSD = least significance difference.

Large seed tubers of 66–80 g produced relatively high dry matter content than others. This is due to the possibility of large seed tubers could produce much amounts of large tuber yield, which might result in high dry matter content. This was realized by Mwansa [41].

**3.4.3. Tuber Specific Gravity (g/cm<sup>3</sup>).** The interaction effect of variety and intra-row spacing and variety by tuber size was significantly ( $P < 0.05$ ) affecting by specific gravity (Tables 8 and 9). The maximum (1.077) value of tuber specific gravity was obtained with variety Gudenie planted at intra-row spacing of 35 and 40 cm followed by variety Gudenie planted at intra-row spacing of 30 cm (1.073), while the lowest (1.059) tuber specific gravity was obtained with variety Jalenie planted at 20 cm (Table 8). On the other hand, the maximum (1.074) tuber specific gravity was obtained with variety Gudenie having tuber sizes of 66–80 g and 81–95 g followed by variety Gudenie having tuber size 51–65 g

(1.072), while the lowest (1.062) was obtained with variety Jalenie having tuber sizes of 20–35 g, 36–50 g, and 51–65 g (Table 9). The results obtained indicated Gudenie gave higher tuber specific gravity, but the values were increased with increasing intra-row spacing (Table 8). This is because the tuber specific gravity might be different among varieties, which caused by the genetic variability of varieties. Shayanowako et al. [30] suggested that specific gravity of tubers was higher at intermediate stem numbers. Tuber specific gravity of potatoes was significantly influenced by variety, and potato varieties having high specific gravity were acceptable for processing purposes like chips [26, 40].

#### 4. Conclusions and Recommendations

The results of growth parameters and yield parameters were influenced by the interaction effect of variety, intra-row spacing, and tuber size. The result clearly indicated the maximum tuber number per plant was recorded from

variety Jalenie with a tuber size of 66–80 g planted at intra-row spacing of 25 cm followed by variety Jalenie with a tuber size of 81–95 g planted at intra-row spacing of 20 cm. The maximum average tuber weight from variety Jalenie had a tuber size of 66–80 g planted at intra-row spacing of 30 cm followed by variety Gudenie having a tuber size of 66–80 g planted intra-row spacing of 30 cm. Variety Jalenie planted at intra-row spacing 25 cm with a tuber size of 66–80 g gave the maximum total tuber yield and marketable tuber yield. Gudenie having tuber sizes of 66–80 g and 81–95 g gave higher tuber specific gravity. On the other hand, the interaction effects of variety, intra-row spacing, and tuber size significantly influenced the mean yields of large, medium, and small tubers. Variety Gudenie having a tuber size of 66–80 g planted at 25 cm gave higher mean yield of large tubers. The interaction effects of variety Jalenie, intra-row spacing 25 cm, and tuber size 66–80 g gave higher performance in marketable and total tuber yield of potato at Nono Benja area.

The overall result of the study showed that the interaction effects of variety, intra-row spacing, and tuber size significantly influenced the yield and quality of potato at Nono Benja area. The three- and two-way interactions have showed superior performance in most growth, yield, and quality parameters. According to the present study, higher marketable tuber yield per hectare was recorded by variety Jalenie with intra-row spacing of 25 cm and tuber size of 66–80 g. In conclusion, the study was conducted at a single season, and on a single location with two varieties, it needs in-depth investigation of the study by repeating in multi-locations with more seasons, varieties, processing quality, and other agronomic practices of the crop to reach a conclusive recommendation.

## Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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## References

- [1] FAOSTAT, "FAO statistical databases FAOSTAT," 2019, <https://faostat3.fao.org>.
- [2] A. Tewodros, C. S. Paul, and H. Adane, "Characterization of seed potato (*solanum tuberosum* L.) storage, pre-planting treatment and marketing systems in Ethiopia: the case of West-Arsi zone," *African Journal of Agricultural Research*, vol. 9, no. 15, pp. 1218–1226, 2014.
- [3] S. Tibebe, T. Abrham, and T. Helen, "Participatory evaluation of potato (*solanum tuberosum* L.) varieties, and tuber size effect on yield and yield traits in wolaita zone, southern Ethiopia," *Journal of Biology, Agriculture and Healthcare*, vol. 4, no. 13, 2014.
- [4] CSA (Central statistical agency), *Agricultural Sample Survey, Report on Area, Production and Farm Management Practice of Belg Season Crops for Private Peasant Holdings*, Statistical Bulletin 578, Addis Ababa, Ethiopia, 2017.
- [5] K. Habtamu, C. Alemayehu, K. Bekele, and K. T. Pananjay, "Evaluation of different potato variety and fungicide combinations for the management of potato late blight (*phytophthora infestans*) in southern Ethiopia," *International Journal of Life Sciences*, vol. 1, no. 1, pp. 8–15, 2012.
- [6] B. Berihun and G. Woldegiorgis, "Potato research and development in Ethiopia: achievements and trends," in *Proceedings of the National Workshop on Seed Potato Tuber Production and Dissemination*, EIAR and ARARI, Bahir Dar, Ethiopia, March 2012.
- [7] M. T. Masarirambi, F. C. Mandisodza, A. B. Mashingaidze, and E. Bhebhe, "Influence of plant population and seed tuber size on growth and yield components of potato (*solanum tuberosum* L.)," *International Journal of Agriculture and Biology*, vol. 14, pp. 545–549, 2012.
- [8] MOARD, *Animal and Plant Health Regulatory Directorate, Crop Variety Register*, Addis Ababa, Ethiopia, 2009.
- [9] A. Badoni and J. S. Chauhan, "Some of cheaper alternatives to ms media for in vitro culture of potato," *Libyan Agriculture Research Center Journal International*, vol. 2, no. 4, pp. 161–167, 2011.
- [10] S. Singh and A. K. Sharma, "Multiple desprouting of seed tubers and its effect on potato production and productivity in hilly regions," *Potato Journal*, vol. 35, no. 1-2, pp. 61–65, 2008.
- [11] D. D. Tarkalson, B. A. King, D. L. Bjorneberg, and J. P. Taberna Jr., "Evaluation of in-row plant spacing and planting configuration for three irrigated potato cultivars," *American Journal of Potato Research*, vol. 88, no. 3, pp. 207–217, 2011.
- [12] C. M. Ayyub, M. W. Haider, M. A. Pervez, M. A. Baloch, and Y. Masih, "Growth and yield of potato (*solanum tuberosum* L.) grown from whole and cut tubers," *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences*, vol. 28, no. 1, pp. 15–19, 2012.
- [13] P. R. Gildemacher, W. Kaguongo, O. Ortiz et al., "Improving potato production in Kenya, Uganda and Ethiopia: a system diagnosis," *Potato Research*, vol. 52, no. 2, pp. 173–205, 2009.
- [14] B. Akassa, D. Belew, and A. Debela, "Effect of inter and intra row spacing on potato (*solanum tuberosum* L.) seed and ware tuber seedling emergence and establishment at bako, western Ethiopia," *Journal of Agronomy*, vol. 13, no. 3, pp. 127–130, 2014.
- [15] A. Tesfaye, A. Anteneh, and J. Eshetu, "The effect of seed tuber size, inter-row spacing and ridging frequency on the yield of potato (*solanum tuberosum* L.)," in *Proceeding of the 8th Annual Conference of the Crop Science Society of Ethiopia*, Addis Ababa, Ethiopia, February 1997.
- [16] A. Harnet, B. Derbew, and W. Gebremedhin, "Effect of inter and intra row spacing on seed tuber yield and yield components of potato (*solanum tuberosum* L.) at Ofra Woreda, northern Ethiopia," *African Journal of Plant Science*, vol. 8, no. 6, pp. 285–290, 2014.

- [17] CSA (Central Statistical Authority), *Agriculture sample Survey 2014/2015 (2007 E.C). Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Seasons)*, pp. 01–578, The FDRE Statistical Bulletin, Addis Ababa, Ethiopia, 2015.
- [18] G. Woldegiorgis, G. Endale, and B. Lemaga, “Potato agronomy,” in *Root and Tuber Crops: The Untapped Resources*, G. Woldegiorgis, G. Endale, and B. Lemaga, Eds., pp. 33–36, Ethiopian Institute of Agricultural Research, Addis Abeba, 2008.
- [19] EIARO (Ethiopian Institute of Agricultural Research Organization), *Directory of Released Crop Varieties and Their Recommended Cultural Practices: A Guide*, EIARO, Addis Ababa, Ethiopia, 2004.
- [20] G. Abbas, I. A. Hafiz, N. A. Abbasi, and A. Hussain, “Determination of processing and nutritional quality attributes of potato genotypes in Pakistan,” *Pakistan Journal of Botany*, vol. 44, no. 1, pp. 201–208, 2012.
- [21] SAS, *SAS Software Version 9.2*, SAS Institute INC, Cary, NC, USA, 2008.
- [22] R. Dhakal, B. Joshi, S. Bharati, S. C. Dhakal, and K. R. Joshi, “Effects of planting configuration and row spacing on growth and production of potato under mulched condition in Dadeldhura, Nepal,” *Journal of Agriculture and Natural Resources*, vol. 2, no. 1, pp. 282–300, 2019.
- [23] F. Addisu, P. Yohannes, and Z. Habtamu, “Genetic variability and association between agronomic characters in some potato (*Solanum tuberosum* L.) genotypes in SNNPR, Ethiopia,” *Academic Journals*, vol. 5, no. 8, pp. 523–528, 2013.
- [24] V. Kumar, B. S. Vyakarnahal, and N. Basavaraj, “Effect of seed tuber size and dates of haulm killing on growth and yield of seed potato crop,” *Potato Journal*, vol. 36, no. 1-2, pp. 45–50, 2009.
- [25] G. Tesfaye, D. Belew, and S. Tulu, “Yield and growth parameters of potato (*Solanum tuberosum* L.) as influenced by intra row spacing and time of earthing up: in boneya degem district, central highlands of Ethiopia,” *International Journal of Agricultural Research*, vol. 7, no. 5, pp. 255–265, 2012.
- [26] T. Helen, D. Nigussie, and T. Tekalign, “Tuber size distribution of potato (*Solanum tuberosum* L.) as influenced by local and improved cultivars grown in eastern Ethiopia,” *Journal of Biology, Agriculture and Healthcare*, vol. 4, no. 17, pp. 138–142, 2014.
- [27] R. Mangani, U. Mazarura, T. A. Mtaita, and A. Shayanowako, “Growth, yield and quality responses to plant spacing in potato (*Solanum tuberosum* L.) varieties. Mutare, Zimbabwe,” *Academic Journals*, vol. 10, no. 6, pp. 571–578, 2015.
- [28] M. S. Islam, S. Moonmoon, M. Z. Islam, H. Waliullah, and M. S. Hossain, *Studies on Seed Size and Spacing for Optimum Yield of Potato in Northern Region of Bangladesh*, Bangladesh Agricultural Research Institute, Rangpur, Bangladesh, 2012.
- [29] H. Bewuketu, “Effect of planting date on tuber yield and quality of potato (*Solanum tuberosum* L.) varieties at Anderacha district, south western Ethiopia,” M.Sc Thesis, Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia, 2012.
- [30] A. Shayanowako, R. Mangani, T. Mtaita, and U. Mazarura, “Influence of main stem density on Irish potato growth and yield: a review annual research and review in biology,” *Science Domain International*, vol. 4, no. 19, 2014.
- [31] T. S. Roy, M. A. Baque, R. Chakraborty, M. N. Haque, and P. Suter, “Yield and economic return of seedling tuber derived from true potato seed as influenced by tuber size and plant spacing,” *Universal Journal of Agricultural Research*, vol. 3, no. 1, pp. 23–30, 2015.
- [32] L. Gulluoglu and H. Arioglu, “Effects of seed size and in-row spacing on growth and yield of early potato in a mediterranean-type environment in Turkey,” *African Journal of Agricultural Research*, vol. 4, no. 5, pp. 535–541, 2009.
- [33] Y. Ayupov, A. Apushev, F. F. Zamalieva, and M. Gabdulov, “The effect of planting density on the crop yield, the structure and the quality of middle-early variety of potato in the west Kazakhstan,” *Life Science Journal*, vol. 11, no. 8, pp. 545–548, 2014.
- [34] C. K. Patel, P. T. Patel, and S. M. Chaudhari, “Effect of physiological age and seed size on seed production of potato in North Gujarat,” *Potato Journal*, vol. 35, no. 1-2, pp. 85–87, 2008.
- [35] A. Mahmoudpour, “Effects of different sizes of mini-tuber on yield and yield components of potato variety agria. PhD student of agronomy, agricultural university of Tajikistan,” *International Journal of Advanced Biological and Biomedical Research*, vol. 2, no. 4, pp. 1099–1104, 2014.
- [36] Y. Gelaye, M. Alemayehu, and D. Ademe, “Potato (*Solanum tuberosum* L.) growth and quality as influenced by inorganic fertilizer rates in northwestern Ethiopia,” *International Journal of Agronomy*, vol. 2022, Article ID 9476021, 9 pages, 2022.
- [37] MOA (Ministry of Agriculture), *Crop Variety Release, Protection and Seed Quality Control Directorate*, MOA, Addis Ababa, Ethiopia, 2016.
- [38] A. J. Bussan, P. D. Mitchell, M. E. Copas, and M. J. Drilias, *Evaluation of the Effect of Density on Potato Yield and Tuber Size Distribution*, Crop Science Society of America, Madison, WI, USA, 2007.
- [39] N. Akbari, M. Barani, J. Daneshian, and R. Mahmoudi, “Potato (*Solanum tuberosum* L.) seed tuber size and production under application of gibberellic acid (GA<sub>3</sub>) hormone,” *Technical Journal of Engineering and Applied Sciences*, vol. 3, no. 2, pp. 105–109, 2013.
- [40] F. Elfinesh, T. Tekalign, and W. Solomon, “Processing quality of improved potato (*Solanum tuberosum* L.) cultivars as influenced by growing environment and blanching,” *African Journal of Food Science*, vol. 5, no. 6, pp. 324–332, 2011.
- [41] N. N. Mwansa, *The Effects of Seed Tuber Size and Spacing on the Yield, Dry Matter Content and Daughtier Tuber Size in Three Potato (Solanum tuberosum L.) Varieties*, University of Zambia Library, Lusaka, Zambia, 2002.