

Potato (*Solanum tuberosum* L.) growth and yield response to inflorescence removal and seed tuber size in Girar Jarso District, Central Ethiopia

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ABSTRACT

Potato (*Solanum tuberosum* L.) is an important food security crop in Ethiopia. The low yield is caused in part by farmers using non-essential seed tuber size and poor agronomic management. This study aimed to examine the effects of seed tuber size and inflorescence removal on yield components and potato yield. A field experiment was carried out at the experimental site of General Tadesse Biru Campus, Salale University. Three levels of inflorescence removal and seed tuber sizes each comprised the treatments. The RCBD with a 3x3 factorial arrangement and 3 replications was used for the study. The R software version 4.03 was used to experiment with data. The experimental results showed that the interaction of big seed tuber size and flower bud removal led to the highest total tuber yield (34.64 t ha⁻¹). Large seed tuber size (46-55 mm) and inflorescence removal led to the highest marketable tuber yield (28.59 t ha⁻¹). Marketable tuber yield correlated positively with steam number, plant height, tuber number, tuber yield, tuber weight, tuber diameter, tuber length, and total tuber, but negatively with days to emergence. As a result, big seed tuber size and inflorescence removal were preferable in terms of all yield-contributing characteristics and tuber yield, and medium seed tuber size was beneficial to the economic and agronomical feasibility of potato production. Because the study was limited to a single season and location, more research is needed to make viable recommendations.

Keywords: Gudenie cultivar, flower, source-sink, assimilate partitioning, tuber yield

INTRODUCTION

Potatoes originated in the Andean region of South America, specifically Peru, Bolivia, and Northern Argentina (Fuentes *et al.*, 2022). Potatoes are the world's third most consumed food crop, behind rice and wheat (FAOSTAT, 2019; Salim *et al.*, 2023). Potatoes are farmed extensively in more than 164 countries and are used by over a billion people almost daily, either raw or prepared (Eid *et al.*, 2020). It is Ethiopia's primary food crop, particularly in high and middle-altitude areas, and one of the most widely planted vegetables (Yazie *et al.*, 2017). Ethiopia has tremendous potential because 70% of its arable land is suitable for potato production, primarily in highland regions above 1500 meters of elevation (Gebregwergis *et al.*, 2019). Over a total area of approximately 85,988.43 hectares, 1,141,871.725 tons were harvested (CSA 2020/21). Global potato production is estimated by FAOSTAT (2019) to be 388.19 million tons annually. Production grew to 29 million tons from 3.65 million tons overall (CSA, 2016). Among all the horticultural crops farmed in Ethiopia, potatoes are the second most cultivated crop with the current area coverage, after red peppers (CSA, 2020).

Ethiopia's national potato output of 13.27 tons per hectare is still low when compared to the average global productivity of 21.77 tons per hectare (FAOSTAT, 2019). Potato productivity remains low in Ethiopia despite its wide cultivation, due to insects and disease pressure, poor soil fertility, climate variability, shortage of water, and weak postharvest practices (Adem *et al.*, 2021; Hailu *et al.*, 2017). Selection of seed tuber size and inflorescence removal also the constraints of yield (Gebregwergis *et al.*, 2019; Habtie, 2022). Because flowers and fruits act as strong sinks, they divert minerals, sugars, and amino acids away from other plant parts (Engels *et al.*, 2012), creating competition among developing parts under assimilate limited conditions (Hassen *et al.*, 2013). Removing reproductive organs can redirect assimilates toward vegetative growth and tuber development (Hasani *et al.*, 2022). Although flowers serve as assimilate sinks, and they have limited economic relevance in potato production (Gebregwergis *et al.*, 2019). The yield of potatoes is also limited by the size of the seed tuber. Ebrahim *et al.* (2018) reported that seed tubers of the improved varieties (*Jalene* and *Gudenie*) that were between 46 and 55 mm (big) or 35 and 45 mm (medium) in diameter produced the maximum total tuber. As many parts of the country, seed tuber size similarly constrains potato productivity in the study area. Moreover, there is no information on potato production trends in the study area. The effects of seed tuber size and inflorescence removal on potato yield and yield components have not been previously investigated in the study area. Therefore, the present study evaluated the combined influences of inflorescence removal and seed tuber size on tuber yield and yield components potato.

MATERIALS AND METHODOLOGY

Description of the study area

The study was conducted in the Girar Jarso districts of the north Shewa zone of Oromia regional state (Fig. 1). The administrative towns of the districts, Fitcha, are located 112 kilometers north of Addis Abeba. From 9°37'0" N to 38°5'0" E and 2,738 m.a.s.l., the districts are distinguished by their longitudinal, latitudinal, and altitudinal locations. The mean annual temperature and rainfall of Girar Jarso are 15°C and 1,200 mm and 18°C and 1,400 mm.

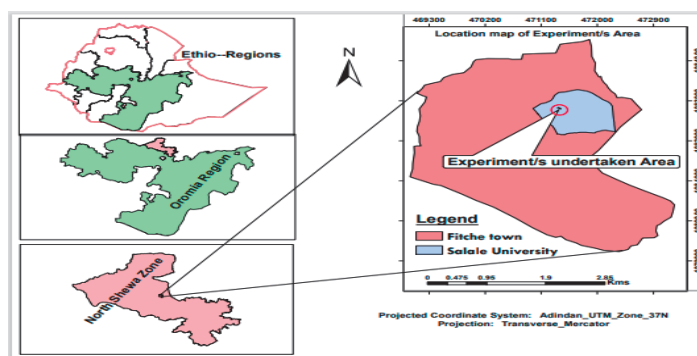


Figure 4. Map of the study area

The field experiment was implemented at the experimental site of General Tadesse Biru Campus, Salale University, during the main cropping season of 2022 under rain-fed conditions. Average landholding per household is approximately 3.2 ha. Mixed farming is the major livelihood activity, with crops such as barley, wheat, maize, teff, sorghum, pulses (beans, peas, lentils), and horticultural crops (apple, cabbage, kale, onion, potato). The soils are clay (Vertisols) with a pH of 6.4 (Abera *et al.*, 2013). According to soil laboratory analysis results at Ethiopian Agricultural Research Institute, Fitcha Agricultural Research Center (EARI FARC (2022), the soil has a sandy clay texture (50.36% sand, 42.36% clay, 7.28% silt), pH 6.60, EC 0.01 dS m⁻¹, organic carbon 9.71%, total nitrogen 0.49%, and C: N ratio 11.48.

Experimental Treatments and Design

The experiment was designed to evaluate the effect of tuber size and inflorescence removal on potato (*Solanum tuberosum* L.) growth and yield. The improved potato variety *Gudenie* (released by Holeta Agricultural Research Center in 2006) was used due to its high yield potential, adaptability, and tolerance to late blight. Treatments consisted of three tuber size categories (25–34 mm, 35–45 mm, and 46–55 mm) Ebrahim *et al.*, 2018 and three inflorescence management methods: Normal growth – plants allowed to flower and set fruits, Flower bud removal – buds removed before opening, Flower removal – flowers removed at full bloom (Gebregwergis *et al.*, 2019). The experiment followed a Randomized Complete Block Design (RCBD) with a factorial arrangement (3×3) and three replications. Each plot measured 3×3 m (9 m^2), consisting of four rows with 10 plants per row. Row and plant spacing were 75 cm and 30 cm, respectively; 1 m between blocks and 0.5 m between plots. Data were collected from the middle two rows (five sample plants). Plots were manually plowed and leveled to 15–20 cm. Uniformly sprouted tubers were selected and treated before planting. Fertilizer was applied at 195 kg ha^{-1} NPS and 111 kg ha^{-1} urea (Fayera, 2017; Alemayehu *et al.*, 2018). Routine field operations (weeding, earthing-up, ridging) followed standard agronomic practices (Desalegn, 2016). Mancozeb fungicide was applied at 3 kg ha^{-1} to control late blight (EARO, 2004). Flower and bud clusters were removed at 3-day intervals for the respective treatments (Bartholdi, 1942).

Data Collection. Data were collected from five representative plants per plot. Phenological traits included days to 50% emergence (DE) and days to 90% maturity (DM). Growth parameters recorded were plant height (cm), number of main stems per hill, and leaf number per plant. Yield and yield components measured included number of tubers per hill, average tuber weight (g), tuber yield per hill (kg), total tuber yield (t ha^{-1}), tuber length and diameter (cm), underground fresh and dry biomass (t ha^{-1}), marketable yield (t ha^{-1}), and unmarketable yield (t ha^{-1}). Experimental data were subjected to analysis of variance (ANOVA) using the R software version 4.03. The mean separations were tested using the LSD test at the 5% level of probability. When there was a significant ANOVA effect and Pearson correlation coefficients were used to determine the relationship of parameters.

RESULTS AND DISCUSSION

Impacts of Inflorescence Removal and Seed Tuber Size on Potato Phenological Parameters

Days to 50% emergence.

The number of days before 50% emergence was significantly influenced by the main effect of seed tuber size (Table 1). The average number of days to reach 50% emergence for all of the studied sizes ranged from 10.33 to 16.89 days. As a result, the large seed tuber emerged from the soil faster (10.33 days) than the other two seed tuber sizes, small seed (16.89 days) and medium seed (12.33 days), (Table 1).

This might be because large tubers can store significantly more food than small seed tubers, which enables them to give the growing seedling the proper quantity of glucose. Similar findings were reported by Ebrahim *et al.* (2018), where larger seed tuber sizes had significantly fewer days to 50% to emergence.

Doboch *et al.* (2022) and Asnake *et al.* (2023) also indicated that smaller seed tubers required the longest days to emerge, whereas larger seed tubers gave early emergence and maximum crop coverage and growth.

Days to 90% maturity

The seed tuber size and the removal of the inflorescence significantly ($p < 0.001$) impacted the days to maturity. The interaction between seed tuber size and inflorescence removal had

no impact on the days to maturity. The average number of days to 90% maturity for flower removal ranged from 92.33 to 105.67 days for all sizes that were tested.

The results showed that the shortest days to 90% maturity (96.89 days) were recorded at medium Size (35-45 mm), which was statistically similar to large seed tuber size (97.11 days), while the longest days (103.56 days) were recorded at small size (25-34 mm). The ANOVA of the results shown in Table 1 revealed that the use of medium seed tubers resulted in a shorter maturation time. Smaller seed tuber diameters (25-34 mm) required the longest maturation period. The results of this study indicated that plants with early sprouting and flowering were more developed than those with later sprouting and flowering. According to Masarirambi *et al.* (2012), larger seed potato tubers showed improved overall resource usage efficiency and allocation of a metabolite, which caused sprouts to emerge earlier, grow and develop more quickly, and reach maturity earlier than small-sized seeds.

The removal of an inflorescence after a bud had been removed was reported to have taken 105.67 days to reach physiological maturity, while normal growth required 92.33 days. According to this study, cutting off flower buds may help to extend canopy life and enable the plant to continue making photo assimilates for a longer period of time. The results supported Gebregwergis *et al.* (2019) evidence that flowerless potato plants matured later than flowering potato plants. In addition to this, the results are in line with Moges (2022), who indicated that very large seed tuber size required the quickest maturity period, whilst smaller seed tubers required the longest maturation period.

Table 4. Interaction effect of tuber size and inflorescence removal on days to emergence and days to maturity of potato (*Solanum tuberosum* L.)

Tuber size (mm)	Inflorescence removal	Days to emergence (days)	Days to maturity (days)
Large (46–55)	Bud removal	10.11 ^d	100.22 ^c
	Flower removal	10.33 ^d	96.55 ^d
	Control (flowers intact)	10.56 ^d	94.55 ^d
Medium (35–45)	Bud removal	12.22 ^c	102.33 ^b
	Flower removal	12.33 ^c	97.89 ^c
	Control	12.45 ^c	95.45 ^d
Small (25–34)	Bud removal	16.45 ^a	108.56 ^a
	Flower removal	16.67 ^a	104.33 ^b
	Control	17.00 ^a	101.11 ^b
Least significant difference (0.05)		1.64	3.12
Coefficient of variation (%)		7.88	2.95

Means within a column that are followed by the same letter do not differ significantly at the 5% level of significance

The Interaction Effects of Seed Tuber Size and Inflorescence Removal on Yield and Yield Components of Potato

Tuber length (cm)

The results of the analysis of variance revealed that the tuber length was affected by the two components' interaction ($p < 0.05$), Table 2. The average tuber length varied from 8.00 cm to 12.06 cm for all of the tuber sizes and inflorescence removal.

The analysis showed that the largest tuber length (12.60 cm) was obtained from the interaction effect of large size (45–55 mm) and flower removal, while the smallest tuber length (8.00 cm) was obtained from the interaction effect of small size (25–34 mm) and flower unremoval (normal growth). The results indicated that using large seed tuber sizes and flower removals resulted in the greatest tuber length. This occurs as a result of the large seed tubers, which are stuffed with food that has been stored, as well as the potato plants' lack of competition for nutrient intake. This result was supported by observations made by Gebregwergis *et al.* (2019),

who noted that the lowest tuber length (7.18 cm) was recorded during normal potato growth and the largest tuber length (17.48 cm) was recorded after the flower bud was removed.

Average tuber weight (gm)

According to the analysis of variance, the interaction of the two components had a substantial effect on the tuber weight ($p < 0.001$). For all of the studied tuber sizes and inflorescence removal, the average tuber weight ranged from 41.63 to 59.00 gm. According to the analysis, the interaction effect of large size (46–55 mm) and bud removal produced the highest tuber weight (59.67 g) statistically similar with interaction of large tuber size with flower removal (58.00 g), while the interaction effect of small size (25–34 mm) and flower removal (normal growth) produced the lowest tuber weight (41.63 g), as shown in Table 2. The results showed that using large seed tuber sizes and blossom bud removals led to the highest average tuber weight. This result is align with Moges (2022), who reported that seed tuber sizes can give the necessary nutrients for growth and developments at the beginning of the growth phase which increase tuber weight.

Total tuber yield ($t\ ha^{-1}$)

According to the analysis of variance, the total tuber production per hectare was also affected by the interaction effects of the two variables. For all of the studied plant sizes and inflorescence removal, the typical quantity of tubers per plant ranged from 29.46 to 34.78 tons ha^{-1} . According to the analysis of the variance, the interaction effect of large size (46–55 mm) and flower removal resulted in the highest total tuber yield per hectare (34.63 tons ha^{-1}) statistically similar with large size with flower bud removal (33.78 tons ha^{-1} , while the interaction effect of small size (25–34 mm) and flower unremoval (normal growth) resulted in the lowest total tuber yield (29.46 tons ha^{-1}) that was statistically no difference interaction of small size flower removal (29.54 tons ha^{-1}) Table 2. The outcome showed that employing large seed tuber size and blossom bud removal led to the maximum overall tuber yield. This may be because, in contrast to small and medium seed tuber sizes in normal growth, an ideal number of stems are produced, leading to less resource rivalry amongst assimilation organs (Tubers and inflorescences). This is align with Sorsa *et al.* (2025) reports indicated that the combination of flower bud removal and larger seed tuber size significantly increased total tuber yield. Ebrahim *et al.* (2018) indicated that larger seed tuber sizes (46–55 mm) produced higher total tuber yields compared with smaller seed sizes (25–34 mm). this result also consistent with findings of Moges (2022) and Zebeay *et al.* (2018), who reported that larger seed tuber sizes produced higher total tuber yields compared to smaller seed tubers.

Marketable tuber yield ($t\ ha^{-1}$)

The analysis of variance revealed that marketable tuber yields (ton ha^{-1}) were significantly affected by the combined effects of seed tuber size and inflorescence removal ($P < 0.01$). According to the analysis of variance, the interaction between large size (46–55 mm) and flower bud removal produced the highest marketable tuber yield (28.59 tons ha^{-1}) statistically no difference between interaction of large tuber size with flower removal (28.47), while the interaction between small size (25–34 mm) and flower removal produced the lowest marketable tuber yield (20.84 tons ha^{-1}), which was statistically similar to the interaction between small seed size (25–34 mm) and normal growth (21.00), as shown in Table 2. The results demonstrated that the largest commercial tuber yield was achieved by using large seed tuber sizes and removing flower buds.

Unmarketable tuber yield (t ha⁻¹)

According to the analysis of variance, the interaction of the two variables significantly affected the yield of unmarketable tubers ($P<0.01$). For all of the tested sizes and Inflorescence removal, the average unmarketable tuber yield ranged from 6.10 to 8.47.

Accordingly, the results of analysis of variance showed that the interaction effect of small tuber Size (25-34 mm) and flower unremove were recorded as the highest unmarketable tuber yield (8.47 tons ha⁻¹), while the interaction effect of medium Size (35-45 mm) and flower bud remove was obtained with the lowest unmarketable tuber yield (6.10 tons ha⁻¹) Table 2. This consequence could be the result of the small seed tubers' low food storage capacity, which causes plant growth failure and flower retention and puts growing tubers and flowers in competition for scarce resources. Hanász *et al.* (2024) also demonstrate that small seed tubers may have lower food storage capacity and are more sensitive to stresses, which supports your reasoning about small seed tuber size leading to greater competition and poorer bulking.

Table 5. Interaction effects of seed tuber size and inflorescence removal on tuber length, average tuber weight, total tuber, marketable yield and unmarketable yield

Seed tuber size	Inflorescence removal	Tuber length	Average tuber weight	Total tuber yield	Marketable yield	Unmarketable yield
Large size (45-55)	Bud removal	9.40 ^{cd}	59.67 ^a	33.78 ^a	28.59 ^a	6.19 ^c
	Flower Remove	12.60 ^a	58.00 ^a	34.63 ^a	28.47 ^a	6.16 ^c
	Flower Unremove	11.18 ^{ab}	54.00 ^a	31.07 ^{cde}	24.00 ^{cd}	7.07 ^b
Medium size (35-45)	Bud removal	9.82 ^{bc}	58.13 ^a	32.91 ^{abc}	26.80 ^{ab}	6.10 ^c
	Flower Remove	9.77 ^{bc}	56.63 ^a	33.18 ^{ab}	26.43 ^b	6.76 ^{bc}
	Flower Unremove	9.79 ^{bc}	46.00 ^b	30.09 ^{de}	23.43 ^d	6.68 ^{bc}
Small Size (25-34)	Bud removal	9.83 ^{bc}	57.47 ^a	31.64 ^{bcd}	25.52 ^{bc}	6.11 ^c
	Flower Remove	9.81 ^{bc}	59.00 ^a	29.54 ^e	20.84 ^e	6.37 ^{bc}
	Flower Unremove	8.00 ^d	41.63 ^b	29.46 ^e	21.00 ^e	8.47 ^a
Least significant difference (0.05)		0.99	3.4	1.13	1.12	0.42
Coefficient of variation (%)		9.94	6.2	3.57	2.12	6.33

Means followed by the same letter within a column are not significantly different at the 5% level of significance

The Relationship between Parameters Influenced by Tuber Size and Inflorescence Removal

The results of the correlation study revealed that the total tuber yield was significantly and positively correlated with the tuber length and marketable tuber yield, but considerably and negatively correlated with the number of days to an emergency (Table 3). The outcome showed that parameters with favorable correlations aid in increasing potato tuber production overall. The total tuber yield was reduced as a result of the potato's days to emergence being prolonged. This showed that the small seed tuber size, which is smaller in stored food and tends to emerge after a specific number of days, produces fewer stems and tubers, which leads to a lower overall tuber production. The Marketable tuber yield had positive ($r=0.493^{**}$, 0.438^{*} and 0.956^{**}) correlations with the following variables: tuber weight, tuber length and total tuber. However, it was significantly and negatively correlated ($r=-0.550^{**}$) with days to emergency. This showed that when the positively linked factors increased, the marketable tuber yield declined while the negatively correlated parameters grew. Gebreselassie and Ajema (2022), negatively correlated parameters revealed that yield increased as parameters declined, whereas positively correlated parameters suggested that yield increased as yield-related parameters increased.

Table 6. Correlation between phenology, growth, and yield parameters of potato, which are affected by seed tuber size and Inflorescence removal

	Days to Emergency	Days to maturity	Tuber weight	Tuber length	Total tuber yield	Marketable tuber yield	Unmarketable tuber yield
Days to Emergency	1	0.419*	-0.21 ^{ns}	-0.458**	-0.543**	-0.550**	0.182 ^{ns}
Days to maturity		1	0.451**	-0.101 ^{ns}	0.117 ^{ns}	0.245	-0.423*
Tuber weight			1	0.443*	0.31 ^{ns}	0.493**	-0.646**
Tuber length				1	0.378*	0.438*	-0.370*
Total tuber yield					1	.956**	-0.115 ^{ns}
Marketable tuber yield						1	-0.367*
Unmarketable tuber yield							1

ns= non-significant, *= significant ($p<0.05$), **= Highly significant ($p<0.01$)

CONCLUSIONS

Seed tuber size and inflorescence removal were found to significantly influence potato yield and yield components. Large seed tuber size (46-55 mm) combined with flower removal produced the highest total yield (34.63 t. ha⁻¹) and marketable yield (28.59 t. ha⁻¹), while smaller seed tuber size (25-34 mm) and without flower removal resulted in the lowest yields. Marketable tuber yield showed a negative correlation with days to emergence but a positive correlation with tuber weight, tuber length, and total tuber yield. Overall, large tuber size with flower removal proved superior in all yield contributing traits, while medium tuber size (34-45 mm) with flower removal was recommended as the most economically viable option for the study area and similar agro-ecological conditions.

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