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# Studying the Effects of Tuber Size and Spacing between Plants on Growth and Yield of Potato (*Solanum tuberosum* L.)

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**ABSTRACT**

**A field experiment was carried out to investigate the impact of different plant spacings and tuber sizes on the growth and yield of potatoes (*Solanum tuberosum* L.). Four tuber sizes (10-20 g, 20-30 g, 30-40 g, and 40-50 g) and three plant spacings (60 x 15 cm, 60 x 30 cm, and 60 x 45 cm) were examined. The study found significant effects of both plant spacing and tuber size on various growth and yield parameters. Increasing plant spacing generally led to increased shoot growth and tuber weight per plant but decreased plant height and overall tuber yield. Similarly, larger tuber sizes were associated with higher emergence rates and yields. The 'Desiree' potato variety showed the highest total tuber yield (62.363 t/ha) when planted with 40–50 g tubers at a spacing of 60 x 15 cm, followed by a yield of 41.136 t/ha with 30–40 g tubers at a spacing of 60 x 30 cm. Optimal production was achieved with a spacing of 60 x 15 cm, and using 40–50 g tubers resulted in the highest yield.**

***Keywords***- Potato growth, Plant spacing, Tuber size, Yield parameters, Desiree variety.

## I. INTRODUCTION

The potato, a widely cultivated tuberous crop, plays a crucial role in global food security and nutrition (Miguel, 1985; Steven, 1999; Karim, 2010). It holds significance as a nourishing fundamental food and is grown in 148 countries worldwide, shaping historical events and addressing hunger and malnutrition in less developed nations (Kumar et al., 2009; Guenthner, 2010; Thiele, 2010). Particularly in Asian nations, such as Afghanistan where it ranks second after wheat in staple food crops, potatoes are gaining prominence (Scott and Suarez, 2011; 2012; FAOSTAT, 2012). Various factors such as nitrogen levels, cultivars, seed spacing, climate, and location influence potato yield (Barry, 1990; Arsenault, 2001). Higher plant densities often lead to reduced plant size and yield per plant due to intensified competition for water, light, and nutrients (Paul, 1985). Optimising crop density is crucial for maximising yields, especially considering the increasing global population and food insecurity in many regions (Kabir et al., 2004). Achieving optimal yield and economic returns requires careful consideration of seed size and spacing levels (Verma et al., 2007). Despite its importance, research on the impact of spacing and tuber size on potato growth and yield remains scarce, particularly in regions like Khost, Afghanistan. Therefore, this study aims to investigate the influence of tuber size and spacing on potato growth and yield. Specifically, it seeks to assess the effects of tuber size and spacing on growth parameters and yield outcomes.

## II. MATERIALS AND METHODS

The research was conducted at the Agricultural Faculty research farm of Shaikh Zayed University in Khost province, Afghanistan, during the potato growing season of 2021. Positioned geographically between

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33°59' and 33°46' North latitudes and 69°19' and 70°21' East longitudes, the experimental site in Khost Province is situated at an altitude of approximately 1,180 meters above sea level. Khost exhibits a semi-arid climate, categorized as either Köppen semi-arid cold (BSk) or semi-arid hot (BSh) (Wali, 2016). The soil composition primarily comprised sandy loam, and the Desiree potato variety seeds were utilized for the study. The experiment aimed to evaluate four tuber sizes (10-20 g, 20-30 g, 30-40 g, and 40-50 g) and three plant spacings (15 x 60 cm, 30 x 60 cm, and 45 x 60 cm). Adopting a factorial randomized complete block design with three replications, the field experiment incorporated two variables: plant spacing and tuber size. Statistical analysis was performed on the gathered data to evaluate various parameters.

## III. RESULTS

The development of plants was notably influenced by the dimensions of tubers. The greatest emergence rate (95.558%) was observed with tubers weighing 30–40 g, while the lowest rate (91.238%) occurred with tubers weighing 20–30 g during planting. Plant spacing did not exert a significant impact on plant emergence (Table 1). Plant height was notably affected by both plant spacing and tuber size at three growth stages (30 days after planting, 60 days after planting, and at dehaulming time) for potatoes (Table 1). The tallest plants were observed with a plant spacing of 60 x 15 cm (33.390, 45.833, and 52.374 cm) and tubers weighing 40–50 g (33.24, 47.02, and 53.36 cm at 30 days after planting, 60 days after planting, and at dehaulming time, respectively). Conversely, the shortest plants were associated with a plant spacing of 45 x 60 cm (27.652, 42.945, and 47.895 cm at 30 days after planting, 60 days after planting, and at dehaulming time, respectively). Additionally, tubers weighing 10–20 g (27.47 cm) at 30 days after planting and 20–30 g had the shortest plant heights at two growth stages (42.21 and 47.21 cm at 60 days after planting and at dehaulming time, respectively). Both the fresh and dry weight of shoots per plant were significantly influenced by plant spacing and tuber size (Table 1). The greatest fresh weight (294.58 g) and dry weight (42.541g) of shoots per plant were recorded with a plant spacing of 60 x 45 cm, while the lowest fresh weight (156.19 g) and dry weight (23.354 g) were observed with a plant spacing of 60 x 15 cm. Tuber size did not significantly impact the fresh and dry weight of shoots per plant. The number of tubers per plant was statistically affected by both plant spacing and tuber size (Table 1). The maximum number of tubers (5.34) per plant occurred with a plant spacing of 60 x 15 cm, while the minimum (4.57) was observed with a plant spacing of 60 x 45 cm. Similarly, the maximum number of tubers (5.40) per plant was recorded with tubers weighing 40–50 g, while the minimum (4.45) was observed with tubers weighing 10–20 g. Both plant spacing and tuber size significantly influenced the total tuber yield per hectare (Table 1). The highest total tuber yield (56.885 t) per hectare was achieved with a plant spacing of 60 x 15 cm, while the significantly lowest yield (29.826 t) occurred with a plant spacing of 60 x 45 cm. Likewise, the maximum total tuber yield (46.13 t) per hectare was obtained with tubers weighing 40–50 g, while the significantly lowest yield (36.33 t) occurred with tubers weighing 10–20 g. Marketable tuber yield per hectare was also significantly affected by both plant spacing and tuber size (Table 1). The highest marketable yield (56.883 t) per hectare was achieved with a plant spacing of 60 x 15 cm, while the significantly lowest yield (29.826 t) occurred with a plant spacing of 60 x 45 cm. Similarly, the maximum marketable yield (46.135 t) per hectare was obtained with tubers weighing 40–50 g, while the significantly lowest yield (36.331 t) occurred with tubers weighing 10–20 g.

**Table 1: Effect of plant spacing and tuber size on plant height (cm), fresh and dry weight/plant (gr) and plant emergence %, number of tubers per plant, total and marketable tuber yield per hectare (t/ha) of potato**

| Tuber Size (g) | Plant height (cm) | | | Fresh weight | Dry weight | Plant emergence | Number of tubers/plant | total tuber yield/ hectare | Marketable yield/ hectare |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAP | 60 DAP | Dehaulming time | | | | | | |
| **10-20** | 27.472 | 42.574 | 47.683 | 225.91 | 34.527 | 92.036 | 4.45 | 36.331 | 36.331 |
| **20-30** | 28.852 | 42.213 | 47.212 | 248.44 | 35.000 | 91.238 | 4.56 | 40.220 | 40.217 |
| **30-40** | 31.963 | 45.574 | 52.628 | 218.34 | 31.388 | 95.558 | 5.31 | 42.961 | 42.958 |
| **40-50** | 33.241 | 47.028 | 53.368 | 233.78 | 33.027 | 95.390 | 5.40 | 46.137 | 46.135 |
| **CD at 5%** | **3.878** | **2.593** | **3.754** | **NS** | **NS** | **3.567** | **0.684** | **5.226** | **5.206** |
| **SED** | **1.87** | **1.25** | **1.81** | **NS** | **NS** | **1.72** | **0.33** | **2.52** | **2.51** |
| **Plant spacing (cm)** | | | | | | | | | |
| **60 x 15** | 33.390 | 45.833 | 52.374 | 156.19 | 23.354 | 93.630 | 5.34 | 56.885 | 56.883 |
| **60 x 30** | 30.104 | 44.265 | 50.400 | 244.08 | 34.562 | 93.520 | 4.88 | 37.525 | 37.522 |

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| **60 x 45** | 27.652 | 42.945 | 47.895 | 294.58 | 42.541 | 93.518 | 4.57 | 29.826 | 29.826 |
| **CD at 5%** | **3.360** | **2.261** | **3.256** | **59.150** | **7.53** | **NS** | **0.593** | **4.521** | **4.521** |
| **SED** | **1.62** | **1.09** | **1.57** | **28.52** | **3.63** | **NS** | **0.286** | **2.18** | **2.18** |

CD: critical difference, NS: non-significant, DAP: days after planting, SED: Standard Error of Difference

## IV. DISCUSSION

The sprouting of plants was notably affected by the magnitude of tubers, whereas plant spacing exhibited no significant influence on sprouting percentage. The investigation unveiled that sprouting percentage rose with increasing tuber size (Table 1). These results coincide with Divis and Barta (2001), who observed that larger seed tubers resulted in higher planting percentages across various tuber size categories. Rashid (1987) also documented enhanced plant sprouting with larger seed tubers compared to smaller ones. Plant stature was significantly impacted by both plant spacing and tuber size at three growth stages (30 days post-planting, 60 days post-planting, and during dehaulming) for potatoes (Table 1). The findings indicated that plant height escalated as plant spacing decreased throughout all growth stages. This heightened growth with closer spacing may be attributed to heightened competition among plants for sunlight, as noted by Kushwah and Singh (2008). Similar patterns were observed by Kumar et al. (2011). Additionally, plant height increased with larger tuber sizes, likely owing to the substantial stored nutrients in larger tubers, fostering increased vegetative growth. This observation aligns with findings by several researchers (Garg et al., 2000; Khalafalla, 2001; Reust, 2002; Cornwall, 2004). Nandekar et al. (1992) also reported significant enhancements in vegetative growth, particularly in plant height, with larger seed tubers in potato cv. Kufri Jyoti. Both the fresh and dry weight of shoots per plant were significantly influenced by plant spacing (Table 1), with increments observed as plant spacing widened. This outcome echoes the findings of Lal et al. (1981), who observed that greater plant spacing correlated with increased leaf count and plant weight. The impact of plant spacing and tuber size on the number of tubers per plant was statistically notable (Table 1), with a decline in the number of tubers per plant as plant spacing widened. This contrasts with findings by Yenagi et al. (2002), who noted a positive association between plant spacing and tuber count per plant. Conversely, the number of tubers per plant increased with larger tuber sizes, likely due to more robust stem development. This trend is supported by multiple researchers (Rashid, 1987; Garg et al., 2000; Khalafalla, 2001; BongKyoon et al., 2001; Verma et al., 2007). Both plant spacing and tuber sizes significantly influenced total tuber yield per hectare (Table 1), with larger tuber sizes leading to a noteworthy increase in yield per hectare. This surge in yield with larger tuber sizes was attributed to their favorable impact on tuber yield per plant, consistent with findings by Malik et al. (2002). Furthermore, total tuber yield per hectare escalated with narrower plant spacing, likely due to the higher tuber count per hectare. This observation aligns with prior studies in potato farming (Ghosh et al., 2002; Yenagi et al., 2002; Cornwall, 2004; Kushwah and Singh, 2008). The effect of plant spacing and tuber size on marketable yield per hectare was statistically significant (Table 1), possibly resulting from efficient soil nutrient utilization and a higher tuber count per hectare at narrower plant spacings. This finding resonates with the work of Tesfa (2012), who observed higher marketable tuber yields with closer plant spacings. Similarly, Khalafalla (2001) noted increased marketable yields at narrower spacings compared to wider ones. Marketable tuber yield per hectare increased with larger tuber sizes, primarily due to the substantial food reserves and larger tuber size, fostering increased plant growth and accelerated tuber development. Conversely, smaller tubers yielded lower marketable tuber yields due to their lighter weight per plant, consistent with findings by various researchers (Malik et al., 2002; Verma et al., 2007; Gulluoglu and Aroglu, 2009).

## V. SUMMARY AND CONCLUSION

Optimizing plant spacing and selecting suitable tuber sizes are essential practices for maximizing potato (*Solanum tuberosum* L.) yields. The primary aim of this study is to determine the optimal combination of plant spacing and tuber size to achieve maximum potato tuber yield. It can be inferred that both plant spacing and tuber size positively influenced the growth and yield attributes of potatoes. The findings demonstrate that a plant spacing of 60 cm × 15 cm resulted in higher yields of marketable tubers compared to other spacing configurations. Similarly, larger tuber sizes (40–50 g) consistently yielded the highest marketable tuber yields compared to smaller sizes (30–40 g, 20–30 g, and 10–20 g). Therefore, a tuber size of 40–50 g, paired with a plant spacing of 60 cm x 15 cm, appears to be the most effective combination for achieving optimal tuber yield.

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