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# Effect of variety and irrigation on tuber growth rate of potato

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**The experiment was carried out in the field using a three replicate strip plot design. In the experiment, four potato varieties were used, namely Diamant, Cardinal, Asterix, and Lady Rosetta, and four irrigations were used as treatments. Four varieties and four irrigations were assigned randomly to plots. There were seven rows in each plot at 60cm distance and fourteen plants in each row at 25cm distance. The total area of each plot was 14.7 m² (4.2 m x 3.5 m). BARI Alu-25 (Asterix) and BARI Alu-8 (Cardinal) also produced higher tuber fresh weight (g) and tuber fresh yield (t/ha) under water stress and well-watered conditions. Experiments revealed that the varieties BARI Alu-25 (Asterix) and BARI Alu-8 (Cardinal) demonstrated greater yield stability and yield contributing characteristics under water stress conditions and could be considered water stress tolerant varieties.**

***Key words:*** *tuber growth rate, irrigation, potato, water stress, irrigation*

## INTRODUCTION

Potato (*Solanum tuberosum* L.) is the fourth most important agricultural tuber crop in the world after winter wheat, maize, and rice; with overall world potato production of 388 million tons in 2017 (FAOSTA, 2019). Potato is the second largest agricultural crop in Bangladesh after rice and currently occupies a vital position inside the list of major crops in Bangladesh (Ali & Haque, 2011). In fact, the fast cycle of the potato lets in land to be set aside for growing some other plant (Hoque et al., 2012). Because the fourth most important food crop inside the world, the potato plays an increasingly vital role in worldwide food security (Vreugdenhil, 2007). Potatoes are grown to some extent in all districts of Bangladesh, but are most commonly grown in Munshiganj, Bogra, Rangpur, Dinajpur and parts of Greater Kumira (Anon, 2014). Potatoes are a versatile food crop and are used worldwide as a source of starch and alcohol production and are also consumed by humans and animals (Hassanpanah et al., 2006).

At some stages of the early levels of potato growth, light use in the potato canopy is nearly 100% (Begum et al., 2015). Some potato cultivars have also been discovered to be high in carotenoids (antioxidants), which have been linked to a decreased risk of heart disease, cancer, and muscle degeneration (Singh et al., 2005). Furthermore, it is a staple diet in European nations, and its use in processed and edible form is expanding quicker in Asian countries. Numerous high yielding potato varieties (HYV) were introduced to Bangladesh in recent decades and tested there in an experimental setting before being suggested for widespread planting (Khalil et al., 2013). Finally, the BARI Tuber Crop Research Center presented more than 66 HYVs for cultivation in our country. These include such notable varieties as Diamant, Cardinal, Granola, Patrone, Asterix, Lady Rosetta, Binella, Murta, Provent, Heera, Deira, Courage, Ailsa, and Alinda. The functions of irrigation are to offer all or part of the water needed for crops, to reduce soil and plant temperatures, to leach extra salts, to increase groundwater components, to facilitate row crop cultivation, and apply fertilizer. The quality of water used is appropriate for irrigation because the land is porous and well drained (this interpretation is based on the USDA irrigation water classification) (Bauder et al., 2011).

Direct reduction of water stress, increased inputs such as fertilizers and improved varieties affected by unpredictable yields in wet weather are also benefits of irrigation (Zotarelli et al., 2009). Khan et al. (2011) strongly supports this issue, observing that unfavorable weather conditions for tuber growth delayed planting and reduced marketable yields. Water stress typically causes premature leaf senescence, shortening the growing season and reducing tuber production (Shiri-e-Janagard et al., 2009), whereas the average yield in 2014-15 was 19.64 t/ha and overall production increased from 0.471 million hectares to 9.254 million tons (Anon, 2015). Estimates for 1989–1990 and 2008–2009, indicate annual growth rates of were 7.14%, 9.90%, and 2.76%, for area, production, and yield of potatoes, respectively (Miah et al., 2011). More than 80 different potato cultivars have been released by the BARI's Tuber Crops Research Center, although most of them have not gained popularity for a variety of reasons. The capacity of the kinds to adapt to the altered environment is a significant barrier. To identify variations that are adaptive, it is necessary to study the physiological changes of BARI-released potato types under the altered climate, such as water stress. In Bangladesh, information on this topic is hard to come by. As a result, the aim of this research was to determine the effects of irrigation and variety on tuber growth rate and productivity in potato cultivation.

## MATERIALS AND METHODS

During the winter of 2015-16, the experiment was conducted at the Horticultural Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. The study was conducted in the Agro-Ecological Zone 28 (The Madhupur tract), which has a height of approximately 8.5 meters above sea level and is located between latitudes of $24^0 05'$N and $90^0 25'$E. (Anon., 1995). This soil of land is part of Madhupur tract (AEZ-28). The soil at the BSMRAU research farm is Salna Red-Brown Terrace soil, with silty clay on top and silty clay loam beneath (Haider et al., 1991). The experimental site's climate was subtropical in nature, with three distinct seasons.

**Climatological data**

The monsoon and pre-moonson season last from March to April, while the winter season lasts from November to February. Rainfall is abundant from April to September and scarce the rest of the year. Table 1 shows details of Meterological data collected during the study period. The oven dry method (at 105 °C for 24 hours) was used to determine field capacity (FC) (Aschonitis et al., 2013).

**Table 1. Climatological data of the 2015-2016 crop season**

| Month | Air Temp. (°C) | | | Soil Temp. (°C), Depth | | | Humidity | *Rainfall | *Evaporation |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Ave. | 10 cm. | 20 cm. | 30 cm. | (%) | (mm) | (mm) |
| November | 29.85 | 17.6 | 23.72 | 25.78 | 24.08 | 23.64 | 81.2 | 0.00 | 62.77 |
| December | 24.63 | 11.53 | 18.08 | 21.5 | 20.6 | 19.95 | 86.4 | 0.00 | 18.74 |
| January | 24.70 | 12.15 | 18.88 | 19.47 | 18.74 | 18.14 | 89.41 | 0.00 | 44.44 |
| February | 29.75 | 17.10 | 23.43 | 21.92 | 21.33 | 20.89 | 84.58 | 0.00 | 67.07 |
| March | 3.16 | 20.93 | 27.04 | 25.41 | 24.82 | 24.38 | 78.45 | 99.99 | 96.09 |

*Data not recorded, Source: Meteorological Station, BSMRAU, Salna, Gazipur.

**Design and field layout**

The experiment was laid out in the field according to a three replicate strip plot design. Four potato varieties were used in the experiment, and four irrigations were used as treatments. There were seven rows in each plot at 60cm distance and fourteen plants in each row at 25cm distance. The total area of each plot was 14.7 $m^2$ (4.2 m x 3.5 m).

**Plant materials**

In this experiment, four potato varieties were used: Diamant, Cardinal, Asterix, and Lady Rosetta. The planting material for the experiment was disease-free, uniformly sized tubers (28-55mm).

**Irrigation scheduling**

Four types of irrigation were applied in this experiment viz. $D_1$= 1/4$^{th}$ Irrigation cut i.e., 3 irrigations at 10, 30 and 45 DAP ($I_3$), $D_2$= ½ Irrigation cut i.e., 2 Irrigation at 10 and 30 DAP ($I_2$), $D_3$= ¾ Irrigation cut i.e., 1 irrigation at 10 DAP ($I_1$), $D_4$= Control i.e., 4 Irrigation at 10, 30, 45 and 60 DAP ($I_4$).

**Preparation of planting material and land**

To obtain healthy shoots before planting, tubers of different varieties were stored in an airy room and germinated under diffused light.

**Land preparation**

By using a power tiller and laddering to create a good tilth, the plots were well-prepared. The plots were cleared of weeds and stubble, and big clods were broken up into smaller pieces. For the experiment, the soil was evenly leveled and ground into small pieces.

**Fertilizer application**

Manures and fertilizers were applied as follows (Abdullah *et al*., 2010).

| Manures/Fertilizers | Dose/ha |
|---|---|
| Cowdung | 10 ton |
| Urea | 350 kg |
| TSP | 220 kg |
| MoP | 260 kg |
| Gypsum | 120 kg |
| $ZnSO_4$ | 14 kg |
| Boric acid | 6 kg |

The final land preparation involved applying cow dung. To keep the tubers from coming into contact with the fertilizer, all of the following materials were applied in the furrows at planting: TSP, MoP, Gypsum, ZnSO4, Boric acid, and half of the urea. At 35 days after planting (DAP), the other half of the urea was used as a topdress.

**Planting method and Intercultural operations**

Whole tubers were planted following the ridge method. The soil on the sides was earthing up and ridged. Weeding plowing and other intercultural operations were done by hand. Weeds were removed after the soil between the rows was plowed. During the growing season, earthing up took place twice. Once at 35 DAP, when the plants were 15 to 20 cm above ground, and once 20 days later. The remaining Urea was applied prior to the first emergence of the ears. Furadan 5G @ 10 kg/ha was applied at the end of field preparation to control ants, mites, cutworms, aphids, and other soil-borne insects. Malathion (0.2%) was applied twice at 45 DAP and 60 DAP to control insect pests. Dithane-M 45 (0.2%) was applied 05 times (at 28, 40, 50, 65, and 75 DAP) alternately to manage potato late blight and other diseases.

**Harvesting**

Haulm pulling was done seven (07) days prior to harvest. Tubers were harvested on March 27, 2016, as curing of the tubers and installation of the skins took place 8 days under the soil. The tubers were carefully collected without injury with the help of a plow.

**Data recorded from destructive sampling**

Five plants from each plot were randomly harvested at 30, 40, 50, 60 and, 70 days Day After planting (DAP). Plants in the outer rows were excluded in this sampling to avoid edge effects. The five plants were given the following information. Plant height, number of leaves per plant, number of tubers per plant, dry matter weight per plant, and tuber weight per plant are all factors to consider.

**Sequential harvest (to get response)**

Potato variety response was determined by destructively sampling of plants at 10-day intervals and measuring dry matter accumulation and distribution; five plants were harvested from each plot at 30, 40, 50, 60, and 70 DAP. All plant biomass were separated into leaves, stems, roots and tubers. To estimate the dry matter content of each biomass group, excluding tubers, fresh total weight was measured on an electric balance and stored in an oven. The oven temperature was set to 80° C. and the samples were dried for at least 48 hours or until the weight remained constant. An electric balance was used to calculate the final weight of the dried samples. The dry matter (%) was then calculated using the standard formula. For tubers, 100 g of fresh tubers were measured, and the dry weight was calculated at 30, 40, 50, 60, and 70 DAP using the above-mentioned method.

**Data of dry matter distribution**

Five samples (30, 40, 50, 60, and 60 DAP) were considered to determine the percentage of total dry matter or assimilate per plant distributed in different parts of the plant (leaves, stems, roots, and tubers) determined (Geremew *et al.,* 2007 and Tekalign and Hammes, 2005).

**Tuber weight per plant (g)**

The numbers of plants were counted before harvest. Tubers were harvested and weight was measured in groups by an electric balance.

$$\text{Tuber fresh weight per plant (g)} = \frac{\text{Total weight of the harvested tubers (g)}}{\text{Number of plants harvested}} \text{ x } 100$$

**Tuber growth rate (TGR)**

The following formula was used to calculate the Tuber growth rate (TGR) (Sen et al., 2013).

$$\text{Tuber Growth Rate} = \frac{1}{\text{GA}} \text{ x } \frac{\text{W2} - \text{W1}}{\text{T2} - \text{T1}} \text{gm}^{-2}\text{day}^{-1}$$

Where, $W_1$ = dry weight (g) of tuber at time $T_1$, $W_2$ = dry weight (g) of tuber at time $T_2$, GA = ground area or land area ($m^2$).

**Tuber yield per hectare (t/ha)**

The total tuber per plot was calculated by taking the weight in kg of harvested tubers from all plants on the plot and converting it to tons per hectare using the following formula:

$$\text{Yield (t/ha)} = \text{Tuberyield per plot (kg) x } \frac{10}{\text{Area (m2)}}$$

**Statistical analysis**

The statistics amassed for the diverse parameters were statistically analyzed the use of the MSTAT-C program. The Duncan's multiple tests (DMRT) (Gomez and Gomez, 1984) changed into used to split the means at 1% and 5% level of probability.

**RESULTS AND DISCUSSION**

**Effect of varieties on Tuber growth rate (TGR) of potato**

Difference in tuber growth rate ($gm^{-2}day^{-1}$) was found significant due to the effect of variety at 30-40 DAP (Figure 1). The maximum tuber growth rate ($7.92gm^{-2}day^{-1}$) at 30-40 DAP was found in $V_4$ which was statistically alike with $V_1$ and$V_2$ and unlike with other treatments. The minimum tuber growth rate ($7.63gm^{-2}day^{-1}$) was found in $V_3$.

Difference in tuber growth rate ($gm^{-2}day^{-1}$) was found significant due to the influence of variety at 50-60 DAP (Figure 1). The best tuber growth rate ($17.25gm^{-2}day^{-1}$) at 50-60 DAP was found in $V_4$ which was statistically alike with $V_1$ and $V_3$ and unlike with other treatments (Figure 1). The lowest tuber growth rate ($14.81gm^{-2}day^{-1}$) was found in $V_2$ which was statistically similar with $V_1$. Dissimilarity in tuber growth rate ($gm^{-2}day^{-1}$) was found significant due to the influence of variety at 60-70 DAP (Figure 1). The maximum tuber growth rate ($17.11gm^{-2}day^{-1}$) at 60-70 DAP was found in $V_4$ which was statistically identical with $V_3$. The lowest tuber growth rate ($14.97gm^{-2}day^{-1}$) was found in $V_1$ which was statistically different from the other treatments. Similar results were obtained by Sen e*t al*. (2014) who found the highest TGR at 45-60 DAP. (Mahmud, 2012) recorded the highest TGR for Asterix at 50-60 DAP.

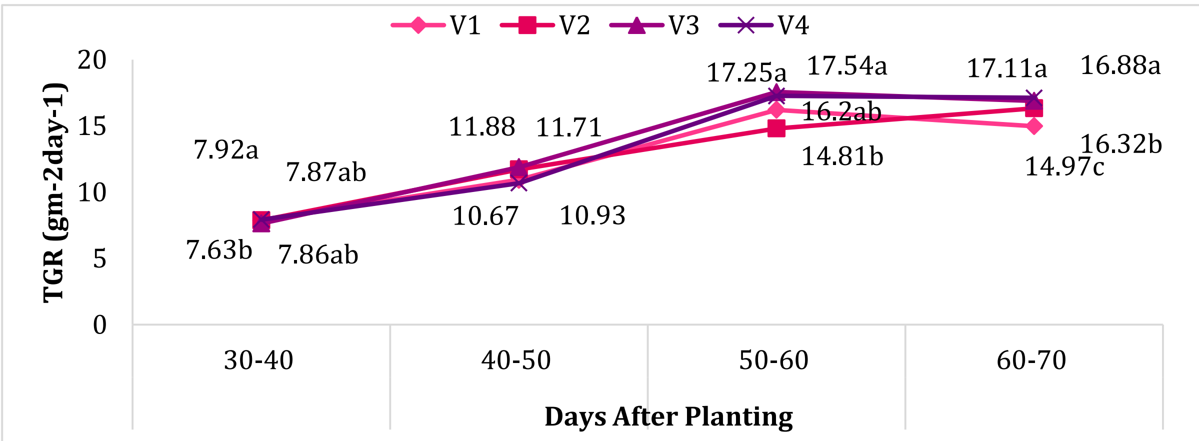


**Figure 1. Effect of varieties on TGR of potato at different days after planting.**
$V_1$= Diamant, $V_2$=Cardinal, $V_3$=Lady Rosetta and $V_4$=Asterix

**Effect of irrigations on Tuber growth rate (TGR) of potato**

Various levels of irrigation cause variation on tuber growth rate $gm^{-2}day^{-1}$ per plant significantly (Figure 2). Imparity in tuber growth rate ($gm^{-2}day^{-1}$) was found significant due to the influence of irrigation at 30-40 DAP. The maximum tuber growth rate ($8.33gm^{-2}day$-1) at 30-40 DAP was found in $I_4$ which was statistically alike with $I_2$ and$I_3$ and unlike with other treatments. The minimum tuber growth rate ($6.50gm^{-2}day^{-1}$) at 30-40 DAP was found in $I_1$. The maximum tuber growth rate ($13.07gm^{-2}day^{-1}$) at 40-50 DAP was maximum in $I_3$ and was statistically different from the other treatments (Figure 2). The minimum net assimilation rate ($9.36gm^{-2}day^{-1}$) at 40-50 DAP was found in $I_1$. The best tuber growth rate ($18.74gm^{-2}day^{-1}$) at 50-60 DAP was found in $I_3$ which was statistically similar with $I_4$ and different with other treatments (Figure 2). The minimum tuber growth rate ($13.13gm^{-2}day^{-1}$) at 50-60 DAP was found in $I_1$. The maximum tuber growth rate ($18.53gm^{-2}day^{-1}$) at 60-70 DAP was found in $I_4$ which was statistically similar with $I_3$ and dissimilar with other treatments (Figure 2). The minimum net assimilation rate ($12.68gm^{-2}day^{-1}$) at 60-70 DAP was found in $I_1$. An extra 55mm of irrigation can growth potato yield with the aid of as much as 50.8% (Tang *et al.,* 2018). Water stress reduces nitrogen uptake due to reduced water uptake and transpiration charges (Koch *et al.,* 2020). WUE increases with nitrogen content material however decreases with improved irrigation water (Tolessa, 2019).

### Interaction effect of varieties and irrigations on tuber growth rate (TGR) of potato

The combination of variety and irrigation treatment was observed to have a significant effect on tuber growth rate ($gm^{-2}day^{-1}$) at 30-40 DAP (Table 2). At 30-40 DAP, the highest tuber growth rate ($8.72gm^{-2}day^{-1}$) was found in $V_2I_4$ which was statistically similar with $V_1I_2$, $V_1I_4$, $V_2I_3$, $V_3I_2$, $V_3I_4$ and $V_4I_2$ and dissimilar with other treatment combinations (Table 2). The lowest tuber growth rate ($5.82gm^{-2}day^{-1}$) was seen with $V_3I_1$ and statistically equal to $V_2I_1$. At 40-50 DAP, the maximum tuber growth rate ($15.90gm^{-2}day^{-1}$) was seen with $V_2I_3$. This is statistically different from other treatment combinations (Table 2). The lowest tuber growth rate ($8.60gm^{-2}day^{-1}$) was found in $V_4I_1$ which was statistically similar with $V_1I_1$, $V_1I_2$, $V_2I_1$ and $V_2I_4$ and dissimilar with other treatment combinations. At 50-60 DAP, the topmost tuber growth rate ($19.99gm^{-2}day^{-1}$) was found in $V_4I_3$ which was statistically alike with $V_1I_3$, $V_1I_4$, $V_3I_3$ and $V_3I_4$ and unlike with other treatment combinations (Table 2). The lowest tuber growth rate ($11.38gm^{-2}day^{-1}$) was found in $V_2I_1$ which was statistically parallel with $V_1I_1$. At 60-70 DAP, the maximum tuber growth rate ($19.66gm^{-2}day^{-1}$) was found in $V_3I_4$ which was statistically similar with $V_4I_4$ and different with other treatment combinations (Table 2). The lowest tuber growth rate ($12.07gm^{-2}day^{-1}$) was found in $V_1I_1$, which was statistically alike with $V_2I_1$ and $V_4I_1$. From the above findings it was clear that water stress reduced the TGR. Significant variations in TGR were observed at stages 50–60 DAP and 60–70 DAP under severe drought conditions. Previous studies have yielded comparable results (Tolessa et al., 2017; Setu and Mitiku, 2020). In a previous study, irrigated potatoes produced more tubers per plant and more marketable potatoes than rain-fed potatoes (Djaman et al., 2021). Djaman et al. (2021) also proposed that his FI acquired the maximum number of tubers per plant. Tang *et al.* (2018) said that a further 55 mm of irrigation accelerated potato yield by up to 50.8% compared to rainfed irrigation.

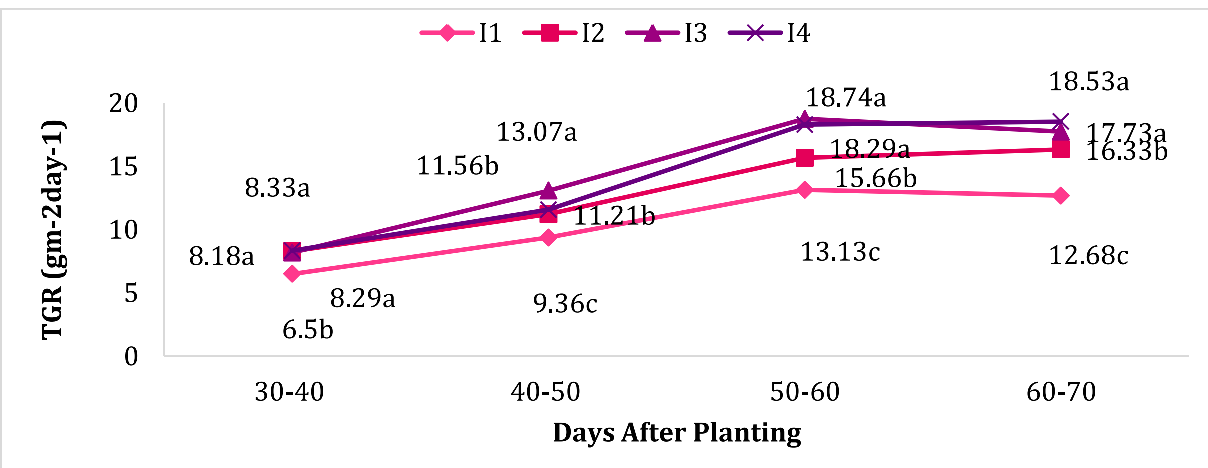


**Figure 2. Effect of irrigations on TGR of potato at different days after planting.**

### Interaction effect of varieties and irrigations on tuber growth rate (TGR) of potato

The combination of variety and irrigation treatment was observed to have a significant effect on tuber growth rate ($gm^{-2}day^{-1}$) at 30-40 DAP (Table 2). At 30-40 DAP, the highest tuber growth rate ($8.72gm^{-2}day^{-1}$) was found in $V_2I_4$ which was statistically similar with $V_1I_2$, $V_1I_4$, $V_2I_3$, $V_3I_2$, $V_3I_4$ and $V_4I_2$ and dissimilar with other treatment combinations (Table 2). The lowest tuber growth rate ($5.82gm^{-2}day^{-1}$) was seen with

$V_3I_1$ and statistically equal to $V_2I_1$. At 40-50 DAP, the maximum tuber growth rate (15.90gm$^{-2}$day$^{-1}$) was seen with $V_2I_3$. This is statistically different from other treatment combinations (Table 2). The lowest tuber growth rate (8.60gm$^{-2}$day$^{-1}$) was found in $V_4I_1$ which was statistically similar with $V_1I_1$, $V_1I_2$, $V_2I_1$ and $V_2I_4$ and dissimilar with other treatment combinations. At 50-60 DAP, the topmost tuber growth rate (19.99gm$^{-2}$day$^{-1}$) was found in $V_4I_3$ which was statistically alike with $V_1I_3$, $V_1I_4$, $V_3I_3$ and$V_3I_4$ and unlike with other treatment combinations (Table 2).

**Table 2. Interaction effects of variety and irrigation on potato tuber growth rate (TGR) at different days after planting**

| Variety x Irrigation | Tuber growth rate (gm$^{-2}$day$^{-1}$) | | | |
|---|---|---|---|---|
| | 30-40 DAP | 40-50 DAP | 50-60 DAP | 60-70 DAP |
| $V_1$ $I_1$ | 6.79d | 8.93g | 12.31ij | 12.07g |
| $V_1$ $I_2$ | 8.35ab | 10.20fg | 15.29fgh | 14.77d |
| $V_1$ $I_3$ | 8.01b | 12.06b-e | 18.48a-d | 16.27c |
| $V_1$ $I_4$ | 8.31ab | 12.53bcd | 18.71a-d | 16.76c |
| $V_2$ $I_1$ | 6.08e | 9.11g | 11.38j | 12.42fg |
| $V_2$ $I_2$ | 8.05b | 12.87bc | 13.70hi | 16.77c |
| $V_2$ $I_3$ | 8.65a | 15.90a | 17.15c-g | 17.85b |
| $V_2$ $I_4$ | 8.72a | 8.97g | 17.04d-g | 18.26b |
| $V_3$ $I_1$ | 5.82e | 10.78ef | 13.80hi | 13.29e |
| $V_3$ $I_2$ | 8.31ab | 11.07def | 17.40c-f | 16.09c |
| $V_3$ $I_3$ | 8.05b | 12.29b-e | 19.32abc | 18.46b |
| $V_3$ $I_4$ | 8.37ab | 13.38b | 19.62ab | 19.66a |
| $V_4$ $I_1$ | 7.30c | 8.60g | 15.02gh | 12.94f |
| $V_4$ $I_2$ | 8.47ab | 10.69ef | 16.24efg | 17.70b |
| $V_4$ $I_3$ | 8.00b | 12.03b-e | 19.99a | 18.36b |
| $V_4$ $I_4$ | 7.91b | 11.37c-f | 17.77b-e | 19.43a |
| Level of significance | ** | ** | * | ** |
| CV (%) | 3.67 | 7.59 | 7.05 | 2.60 |

Means for the same letter are not significantly different at DMRT probability levels 1 or 5%.
**= Significant at 1% level of probability; *= Significant at 5% level of probability
$V_1$= Diamant, $V_2$=Cardinal, $V_3$=Lady Rosetta and $V_4$=Asterix
$I_1$= one irrigation at 10 DAP, $I_2$=two irrigations at 10 & 30 DAP, $I_3$=three irrigation 10, 30 & 45 DAP and $I_4$= four Irrigations at 10, 30, 45 & 60 DAP

The lowest tuber growth rate (11.38gm$^{-2}$day$^{-1}$) was found in $V_2I_1$ which was statistically parallel with $V_1I_1$. At 60-70 DAP, the maximum tuber growth rate (19.66gm$^{-2}$day$^{-1}$) was found in $V_3I_4$ which was statistically similar with $V_4I_4$ and different with other treatment combinations (Table 2). The lowest tuber growth rate (12.07gm$^{-2}$day$^{-1}$) was found in $V_1I_1$, which was statistically alike with $V_2I_1$ and $V_4I_1$. From the above findings it was clear that water stress reduced the TGR. Significant variations in TGR were observed at stages 50–60 DAP and 60–70 DAP under severe drought conditions. Previous studies have yielded comparable results (Tolessa et al., 2017; Setu & Mitiku, 2020). In a previous study, irrigated potatoes produced more tubers per plant and more marketable potatoes than rain-fed potatoes (Djaman et al., 2021). Djaman et al. (2021) also proposed that his FI acquired the maximum number of tubers per plant. Tang et al., (2018) said that a further 55 mm of irrigation accelerated potato yield by up to 50.8% compared to rainfed irrigation.

## CONCLUSION

Among the varieties, BARI Alu-25 (Asterix) and BARI Alu-8 (Cardinal) may be considered water stress tolerant varieties as they showed better stability in yield and yield contributing characters under water stress conditions. A further experiment should be carried out to explain the qualitative changes in the plant and tuber under water stress conditions in relation to yield in water stress conditions for getting good yield and bringing the drought-prone area under potato cultivation. BARI Alu-25 (Asterix) and BARI Alu-8 (Cardinal) may be considered in water stress tolerant varieties as for getting better stability in yield and to bring the drought-prone area under potato cultivation.

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## AUTHOR CONTRIBUTIONS

Md. Salim participated in the development of the proposal, field research to design the experiment, data collection, data analysis and interpretation, and manuscript writing. Md. Omar Faruq and Md. Mahbubur Rahman assisted in the development of the proposal, field research for the design of the experiment, data collection, data analysis and interpretation, and the writing of the manuscript. The final manuscript become read and approved by way of all authors.

## COMPETING INTERESTS

The authors declare they have no conflict of interest. The manuscript has not been submitted for publication in other journal.

## ETHICS APPROVAL

Not applicable

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