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# Optimization of Urea Super Granule Boost up for the Efficiency of N and Improved the Potato Quality, Growth and Yield

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Potato is the third most important food crop after wheat and rice in Bangladesh. To determine the suitable nitrogen source by observing the growth performance with a view to increasing the yield of potato, a research work was carried out at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2018 to March, 2019. The experiment consisted of eight treatments. The experiment was laid out with Randomized Complete Block Design with three replications. Experimental results showed that nitrogen sources had significant effect on plant height, number of effective stem hill$^{-1}$, wt. of tuber (g hill$^{-1}$), yield of tubers (kg plot$^{-1}$), yield of tubers (t ha$^{-1)}$, tuber fleshy dry matter content, specific gravity, grading of tubers (% by

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number). Potato production increased significantly due to the application of Urea Super Granule (USG). The highest production was observed in $T_3$ treatment. The application of $T_3$ treatment showed the highest wt. of tuber hill$^{-1}$ (57.53g hill$^{-1}$), highest tuber yield (25.77 kg plot$^{-1}$), highest tuber yield (29.45 t ha$^{-1}$) than any other sources of nitrogen treatments. The mean apparent recovery of Nitrogen by tested variety BARI Alu 7 (Diamant) was obtained with the application of USG in other treatment (except control) but the nitrogen use efficiency was highest in $T_3$ treatment. Findings revealed that application of USG showed the superiority over other sources of nitrogen to produce highest tuber yield of potato and for all cases lowest results were found in $T_1$ treatment receiving no fertilizer (control).

*Keywords: USG; nitrogen; growth; yield; quality; potato.*

## 1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is the 3rd largest food and vegetable crop in Bangladesh after rice and wheat. It is also a world leading vegetable crop that furnishes appreciable amount of vitamin B and vitamin C as well as minerals. As an industrial crop, potato is a raw material of various foods and confectionaries. It produces more calories and protein per unit land with minimum time and water than most of the major food crops Upadhya [1]. Potato can be used in numerous ways, such as, boiled, baked and fried potatoes, dehydrated potatoes, canned potatoes and as starch for culinary purposes Hoque [2]. Because of its high yield potential and food value, compared to rice and wheat, potato is considered as a promising candidate crop for feeding the hungry people of the world. In 2018-19, the area, production and average yield of potato in Bangladesh were 0.46 million hectare, 9.65 million tons and 20.61 tons per hectare, respectively [3]. The yield level of this crop in Bangladesh is low compared to other potato growing countries of the world [4]. Nitrogen requirement of potato is very high. It is an essential plant nutrient element and is the most limiting due to its high mobility and different types of losses like leaching, volatilization and mobilization [5].

Farmers of Bangladesh grow potato in different regions through prilled urea with other fertilizers. Nitrogen is the most deficit nutrient element in Bangladesh soil. In general farmers traditionally apply at least nitrogenous fertilizer to their crops for better yield. It is said that urea super granule (USG) is more efficient than that of prilled urea. USG minimizes N leaching and volatilization loss to a greater extent. Where large amount of urea fertilizer application are made, especially if they are not well incorporated, substantial losses (20 to 40%) of added N might be accepted. Application of USG in potato field improve efficiency more than 60% with an increase of about 15-20% potato yield over conventional urea application. Now, USG has been considered as a proven technology in potato production [6]. During the last couple of years, farmers are applying USG. Some research report on different crops especially vegetables revealed that by using of USG substantial amount of urea fertilizer can be saved [7]. Urea currently consists of more than 70% of the fertilizer being consumed in Bangladesh. Again, to meet the demand of urea-N fertilizer in country, often Bangladesh has to import urea fertilizer [6]. USG more efficiently in upland vegetable and fruit crops like brinjal, cabbage, cauliflower, tomato and on quick growing fruits like papaya, banana etc. [8]. USG requirement is less than prilled urea in cabbage, cauliflower, brinjal and tomato. USG also increases yield of these crops. However, there is no recommendation of USG for upland crops and research findings in this regard are very scanty. Efficiency of USG on upland crops is yet to be ascertained. Various factors are responsible for high yield in Bangladesh. There is a vast scope of increasing the yield per hectare through the introduction of high yielding potato and good keeping quality. The local variety are in existence in Bangladesh have become degenerated on account of various reasons and give extremely low yield. On the other hand, the yields of high yielding variety are much better than the local ones under the identical conditions and cultural practices. Therefore, with a view to stepping up the degeneration gap and getting high yield, Bangladesh has to import seed-tubers of good quality from abroad at the cost of foreign exchange. Hence, the present study was undertaken to evaluate the efficiency of USG on the yield of potato and find out the optimum dose of USG for maximum potato production.

## 2. MATERIALS AND METHODS

Field trail was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Sher-e-

Bangla Nagar, Dhaka, Bangladesh during the Robi season of November 2018 to March 2019. Crop season weather data is shown in Table 1 and the physicochemical properties of the soil are presented in Table 2.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of the unit plot was 5 m ×1.75m. Distances between block to block and plot to plot were 1.0 m and 0.50 m, respectively. The plots were raised up to 10 cm. There were 8 treatments and three replications. The treatments are $T_1$ = Control (0 kg N $ha^{-1}$); $T_2$ = Recommended fertilizer dose ($N_{150}$ $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha; $T_3$ = 2.7 g size USG (2 granule at both side) with $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha; $T_4$ = 1.8 g size USG (2 granule at both side) with $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha; $T_5$ = 1 USG (2.7g) + 1 USG (1.8g) with $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha; $T_6$ = 1 USG (2.7g) + 2 USG (1.8g) with $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha; $T_7$ = 1 USG (2.7g) + 1 time top dress 1/4th dose of N (tuber bulk stage) with $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha; $T_8$ = 1 USG (1.8g)+ 1 time top dress 1/4th dose of N (tuber bulk stage) with $P_{30}$ $K_{140}$ $S_{15}$ $Zn_3$ Kg/ha.

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), Gypsum, Zinc oxide were used as sources of nitrogen, phosphorus, potassium, sulphur, zinc respectively and the doses of fertilizers were N 150 kg $ha^{-1}$, P 30 kg $ha^{-1}$, K 140 kg $ha^{-1}$, S 15 kg $ha^{-1}$, Zn 3 kg $ha^{-1}$ respectively. Total amount of TSP, Gypsum, ZnO and 50 % MoP were applied as basal doses during final land preparation. The remaining 50% MoP were side dressed in two equal splits at 25 and 45 days after planting (DAP) during first and second earthing up. Diamant (BARI Alu 7) variety was the test crop collected from Bangladesh Agricultural Development Corporation, Nalitabari, Sherpur. The tubers were graded according to the size of 40 g, 10 g and kept under diffuse light conditions to have healthy and good sprouts. After sprouting 40gm sized were cut by sharp knife into two pieces with good sprouting. Cut pieces were kept on ash to protect it from fungus. Planting was done on November 26, 2018. The well sprouted tubers were planted at a depth of 5-7 cm in furrow made 60 cm apart. Hill to hill distance was 75 cm. After planting, the seed tubers were covered with soil.

**Table 1. Crop season weather data of the experimental site during the period from November, 2018 to February, 2019**

| Months | Air temperature ($^0$C) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| November | 29.74 | 19.15 | 67.21 | 66 |
| December | 23.92 | 14.50 | 75.58 | 5 |
| January | 24.55 | 12.20 | 64.39 | 12 |
| February | 28.60 | 17.5 | 48.16 | 30 |

*Source: Bangladesh Meteorological Dept. (Climate & weather division), Agargoan, Dhaka-1207*

**Table 2. Physiochemical characteristics of the experimental field**

| Physiochemical characteristics | Values |
|---|---|
| Textural class | Clay loam |
| Sand (%) | 25 |
| Silt (%) | 47 |
| Clay (%) | 28 |
| pH | 5.4 |
| Organic matter (%) | 1.28 |
| Organic carbon (%) | 0.743 |
| Total N (%) | 0.05(Very low) |
| Available phosphorous (ppm) | 20 |
| Exchangeable K (meq/100 g soil) | 0.15 |
| Total S (microgram/g soil) | 16 |

Furadan 5G @ 10 kg $ha^{-1}$ was applied in soil at the time of final land preparation to control cut worm. Dithane M-45 was sprayed in 2 installments at an interval of 15 days from 50 DAP as preventive measure against late blight disease. Haulm cutting was done on 19 February, 2019 when 40-50% plants showed senescence and the tops started drying. After haulm cutting the tubers were kept under the soil for 7 days for skin hardening. Harvesting of potato was done on 26 February 2019 at 7 days after haulm cutting. Potatoes of each treatment were separately harvested, bagged, tagged and brought to the laboratory. Harvesting was done manually by hand. The parameters i.e. plant height at haulm cutting (cm), number of stem $hill^{-1}$, number of tubers $hill^{-1}$, average weight of tubers $hill^{-1}$(g), yield of tubers kg $plot^{-1}$, yield of tubers t $ha^{-1}$, tuber flesh dry and grading of tubers (% by number) were recorded and their mean values were calculated from the sample plants.

## 3. RESULTS AND DISCUSSION

The experiment was conducted to study the indicative performance of urea super granules while used in potato cultivation. Data on different crop growth characters, yield contributing characters and yield of potato were recorded and significant differences were found among the recorded characters. The results have been discussed with the help of table and graphs and possible interpretations given under the following headings.

### 3.1 Effect of Urea Super Granule on Plant Height at Haulm Cutting (cm), Number of Stem $Hill^{-1}$, Number of Tuber $Hill^{-1}$ and Average Weight of Tuber G $Hill^{-1}$

Plant height due to application of different levels of urea super granules was significantly influenced at haulm cutting. The maximum plant height (65 cm) was recorded from $T_3$ treatment whereas the minimum (39 cm) was recorded from control treatment ($T_1$). But $T_2$ and $T_4$ treatments are statistically similar in recording in plant height as show in Table 3. Plant height was increased due to application of different levels of urea super granules. Zohra et al*.* [9] set an experiment with 3 different potato varieties and highest plant height was recorded when 3 pellets of USG applied in 4 adjacent hills. Razib [10] showed the highest plant height (55 cm) of potato when 120 kg N $ha^{-1}$was applied. Nitrogen level significantly influenced plant height of potato. Increasing levels of nitrogen increased the plant height significantly up to 150 kg N $ha^{-1}$. Plants receiving no nitrogenous fertilizer as significantly shorter than other treatments. They also stated that nitrogen influences cell division and cell enlargement and ultimately increases plant height.

**Table 3. Effect of Urea super granule on Plant height at haulm cutting (cm), Number of stem $hill^{-1}$, Number of tuber $hill^{-1}$ and average weight of tuber g $hill^{-1}$**

| Treatment | Plant height (cm) | Number of stem per hill | Number of tuber per hill | Average weight of tuber g $hill^{-1}$ |
|---|---|---|---|---|
| $T_1$ | 39 g | 4 d | 5 c | 40.667 e |
| $T_2$ | 51 d | 5 c | 6 bc | 51.233 d |
| $T_3$ | 65 a | 7 a | 8 a | 57.533 a |
| $T_4$ | 52 d | 5 c | 6 bc | 52.367 cd |
| $T_5$ | 55 c | 4 d | 7 ab | 54.200 bc |
| $T_6$ | 48 e | 5 c | 6 bc | 54.320 bc |
| $T_7$ | 58 b | 6 b | 7 ab | 55.900 ab |
| $T_8$ | 44 f | 5 c | 6 bc | 51.333 d |
| CV(%) | 2.33 | 9.34 | 10.62 | 2.17 |
| LSD | 2.099 | 0.838 | 1.185 | 1.980 |

*In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability*

The number of stems per hill significantly varied due to application of the different levels of urea super granules. The maximum numbers of stem hill$^{-1}$(7) was obtained from $T_3$ treatment and minimum (4) was obtained from control treatment. The study referred that USG produced maximum number of stem hill$^{-1}$ in Table 3. $T_2$, $T_4$, $T_6$ and $T_8$ treatments are statistically similar stem shows in Table 3. Zohra et al. [9] stated that the number of stem hill$^{-1}$ was varied significantly due to different level of USG. There was no appreciable change in stem hill$^{-1}$due to higher dose of N above 150 kg ha$^{-1}$. They also showed an appreciable reduction in stem hill$^{-1}$at 250 kg N ha$^{-1}$. Length of stem was highly related with the application of increased level of nitrogen. Tuber formation and elongation was directly related with the contribution of nitrogen.

Number of tubers per hill significantly influenced by application of different treatment. The maximum number of tubers hill$^{-1}$(8) was recorded from $T_3$ treatment which was statistically similar to $T_5$ and $T_7$, whereas the minimum (5) number of tubers hill$^{-1}$ was recorded from $T_1$ (control) treatment which was very close with $T_2$, $T_4$, $T_6$ and $T_8$ treatments in Table 3. Hasan [11] conducted an experiment during the robi season of 2006 and recorded the increased number of tuber hill$^{-1}$ with increased nitrogen level using USG. Effective tuber hill$^{-1}$ was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tuber hill$^{-1}$. Idris and Matin [12] reported that the maximum number of tuber hill$^{-1}$ was produced with 140 kg N ha$^{-1}$ and the minimum number of tuber hill$^{-1}$ was obtained from the control treatment (0 kg N ha$^{-1}$).

The variation in weight of tuber per hill due to application of different fertilizer management practices was observed to be statistically significant. The maximum tuber average weight g hill$^{-1}$ (57.533g) was recorded, $T_3$ treatment which was statistically similar to $T_7$ and the minimum (40.667g) average weight of tubers g hill$^{-1}$ was recorded from $T_1$ (control) treatment. $T_5$ and $T_6$ treatments were statistically similar in recording average weight of tuber g hill$^{-1}$ and very close to $T_2$ and $T_8$ treatments in Table 3. Garcia and Azevedo [13] conducted an experiment with 5 doses of nitrogen fertilizer (0, 50, 100, 150 and 200 kg N ha$^1$) and concluded that weight of tuber increased with increase in nitrogen fertilizer up to 150 kg N ha$^{-1}$. Naseem et al. [14] reported lower tuber weight in control treatment when the plots received low nitrogen fertilizer.

### 3.2 Effect of Urea Super Granule on Yield of Tuber (kg plot$^{-1}$) and Yield of Tuber (t ha$^{-1}$)

Application of urea super granule had significant effect on the yield of tuber kg plot$^{-1}$. The highest tuber yield (25.77) kg plot$^{-1}$was obtained from $T_3$ treatment and the lowest tuber yield (13.8) kg plot$^{-1}$was obtained from $T_1$ (control) treatment. $T_5$, and $T_6$ treatment were statistically similar and very close to $T_2$, $T_7$ treatments (Table 4). Application of nitrogen significantly increased the components of tuber yield and plant yield as well as 150 kg N ha$^{-1}$.

Application of urea super granules had significant effect on the yield of tuber (t ha$^{-1}$). The highest tuber yield 29.45 (t ha$^{-1}$) was obtained from $T_3$ treatment and the lowest tuber yield 15.7(t ha$^{-1}$) was obtained from $T_1$ (control) treatment as shown in Table 4. $T_6$, and $T_7$ treatment are statistically similar and very close to $T_2$ and $T_5$ treatments.

**Table 4. Effect of urea super granule on Yield of tuber kg plot$^{-1}$and on yield of tuber t ha$^{-1}$**

| Treatment | Yield of tuber (kg plot$^{-1}$) | Yield of tuber (t ha$^{-1}$) |
|---|---|---|
| T1 | 13.80 f | 15.77 f |
| T2 | 20.80 de | 23.76 de |
| T3 | 25.77 a | 29.45 a |
| T4 | 23.70 b | 27.08 b |
| T5 | 21.63 cd | 24.72 cd |
| T6 | 21.97 cd | 25.10 bcd |
| T7 | 22.73 bc | 26.40 bc |
| $T_8$ | 19.56 e | 22.35 e |
| CV (%) | 3.86 | 4.75 |
| LSD | 1.438 | 2.026 |

*In a column, it means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability*

### 3.3 Dry Matter Content (%)

Above ground stem dry matter content significantly influenced different levels of urea super granules application. Higher stem dry matter content (23.10 %) in $T_3$ treatment whereas, the minimum (15.95 %) was recorded from the control ($T_1$) treatment. $T_6$, $T_8$ treatment are statistically similar and very close to $T_2$, $T_5$ treatments (Fig. 1).

### 3.4 Specific Gravity of Tuber

Specific gravity of tuber varied significantly with different urea super granules application. The highest specific gravity of tuber was recorded (1.076) while the minimum was found from control (1.034). Treatments $T_3$, $T_2$, $T_6$ and $T_7$ were statistically similar (Fig. 2).

### 3.5 Grading

On the basis of weight, tubers have been graded into marketable tuber greater than 20g and non-marketable tuber less than 20g. The results indicate that there was significant difference in the varietal effect in respect to production of different grades of tubers. Among USG application from 2.7 g sized 2 USG in both side produced the maximum (67.32%) marketable tuber greater than 20g while the minimum (32.68%) in non-marketable tuber less than 20g (Table 5). On the basis of size in diameter tubers have been graded into seed tuber greater than 55 mm, non- seed tuber less than 28 mm, tuber yield for chips (45-55 mm) and tuber yield for french fry greater than 75 mm. The results indicate that there was significant difference in the varietal effect in respect to production of

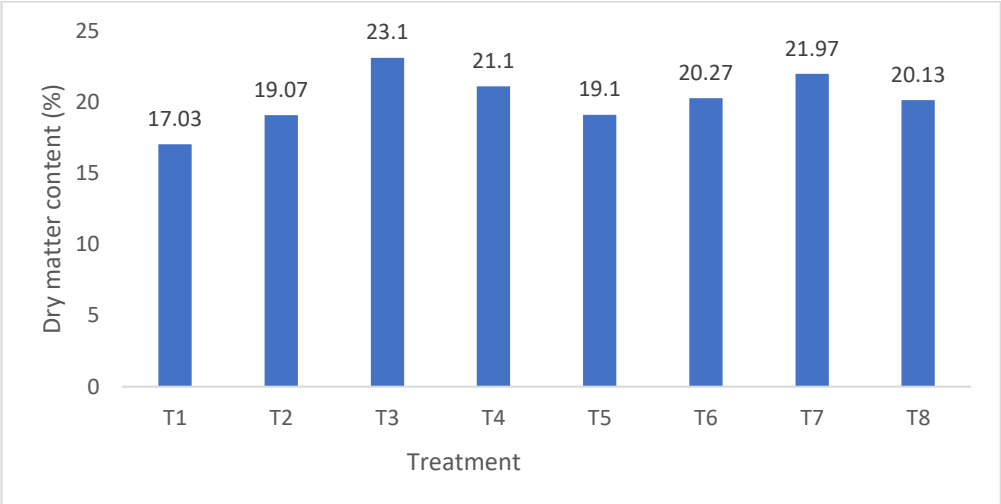


**Fig. 1. Effect of urea super granule on dry matter content (%)**

**Table 5. Effect of urea super granule on grading of potato tuber**

| Treatment | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ |
|---|---|---|---|---|---|---|
| T1 | 32.68 c | 52.54 b | 9.96 c | 12.78 b | 13.667 c | 5 b |
| T2 | 35.79 c | 64.21 ab | 9.99 c | 17.92 a | 20.667 ab | 7 ab |
| $T_3$ | 47.46 a | 67.32 a | 16.96 a | 19.95 a | 23.33 a | 12 a |
| $T_4$ | 37.36 ab | 62.64 ab | 14.04 ab | 18.47 a | 21.33 ab | 10 a |
| $T_5$ | 40.83 abc | 59.17 b | 13.35 ab | 16.23 ab | 17.33 abc | 6 ab |
| $T_6$ | 46.57 a | 53.43 b | 12.21 bc | 16.76 ab | 22.333 a | 7 ab |
| $T_7$ | 41.41 abc | 58.59 b | 11.56 bc | 16.80 ab | 16.333 bc | 9 ab |
| $T_8$ | 36.25 bc | 63.75 ab | 10.64 bc | 16.42 ab | 17.33 abc | 8 ab |
| CV(%) | 8.80 | 12.30 | 16.78 | 13.65 | 16.68 | 13.45 |
| LSD | 6.31 | 6.52 | 3.62 | 6.52 | 3.52 | 6.02 |

*In a column, it means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability*

*[$X_1$: % no. of non-marketable tuber < 20 g, $X_2$: % no. of marketable tuber >20 g, $X_3$: % no. of non- seed tuber <28 mm, $X_4$ : % no. of seed tuber >55 mm , $X_5$ : % no. of tuber yield for chips 45-55 mm , $X_6$ : % no. of tuber yield for french fry >75 mm.]*

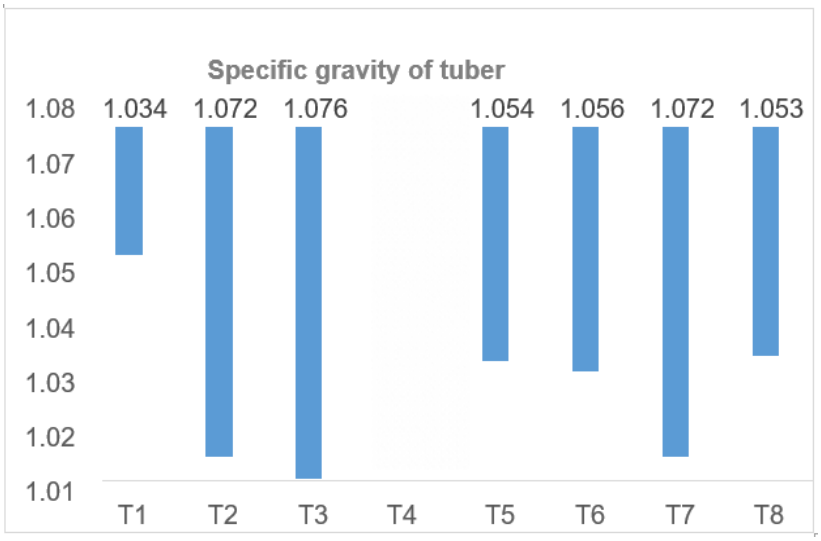


**Fig. 2. Effect of urea super granule on specific gravity of tuber**

different grades of tubers. 2.7 g sized 2 USG in both side produced the highest percentage of seed tuber, non-seed tuber, tuber yield for chips and tuber yield for french fry grades that was 19.95%, 16.96%, 23.33% and 12% respectively. While the lowest percentage was found in control for seed tuber, non-seed tuber, tuber yield for chips and tuber yield for french fry that was 12.78%, 9.96%, 13.667%, 5% respectively (Table 5).

## 4. CONCLUSION

Results revealed that nitrogen sources, variety had significant effect on plant height at different days after planting. The highest number of stem hill$^{-1}$ and tallest plant were recorded from $T_3$ treatment compared to the lower levels of nitrogen at harvest. Length of stem was highly related with the application of increased level of nitrogen. Tuber formation and elongation were directly related with the contribution of nitrogen. The maximum number of tubers hill$^{-1}$ was recorded from $T_3$ treatment. Effective tuber hill$^{-1}$ was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tuber hill$^{-1}$. The weight of tuber increased with increase in nitrogen fertilizer up to 150 kg N ha$^{-1}$. The $T_3$ treatment produced highest tuber yield, higher stem dry matter content and highest specific gravity of tuber. The maximum values of tuber yield, total N uptake and apparent N recovery were obtained with the application of $T_3$ treatment (150 Kg N ha$^{-1}$as USG). Nitrogen use efficiency represents the response of potato plant in terms of tuber yield to N fertilizer. Reviewing above the results of the present study, it might be concluded that 150 kg N ha$^{-1}$as USG showed the superiority over other sources and application methods of nitrogen to produce higher tuber yield of potato. Sources and application methods of nitrogen as USG showed the superiority over prilled urea.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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