Influence of Bed Size and Irrigation Methods on Potato (*Solanum tuberosum*)

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**ABSTRACT**

**Background:** Potato (*Solanum tuberosum*) popularly known as ‘The King of Vegetables’, has emerged as fourth most important food crop in the world after rice, wheat and maize. Indian vegetables basket is incomplete without potato as its, dry matter, edible energy and edible protein makes it nutritionally superior as well as staple food throughout the world.

**Methods:** The experiment during 2016-2018 was laid out in factorial randomized complete block design with three replications to study the effect of bed size on the yield and size of the tuber under different irrigation methods.

**Results:** Maximum yield was obtained in 60cm bed (narrow bed size) whereas in irrigation system drip produced maximum yield. All quality parameters did not influence due to sowing method and irrigation system but chip recovery was more in drip irrigation than furrow system. Maximum yield through interaction was found in drip irrigated 105 cm triple row bed. About 45-50 per cent water was saved through drip irrigation as compared to furrow irrigation. However, maximum benefit cost ratio was obtained in furrow irrigated 60cm bed size.

**Key words:** Drip irrigation, Furrow irrigation, Potato, Water use efficiency.

**INTRODUCTION**

Water is the key input in potato production and the problem of water management vary from region to region. Water is the vital factor for the germination. To initiate the germination process optimum moisture is required. India occupies a unique position where potato can be grown throughout the year in different parts of the country. About 81 per cent of the potato is grown in plains during winter under short day conditions whereas 13 per cent in hills during summer under long day and about 6 per cent in plateau during rainy season under equinox conditions. High frequency water management by drip irrigation minimizes soil as a storage reservoir for water and provides at least daily water to the root zone of each plant and maintains a high soil matric potential the rhizosphere to reduce plant water stress (Phene and Sanders 1976). Optimizing irrigation efficiency through properly designed, maintained and managed irrigation system to derive the maximum crop yield from every increment of water available will generally lead to more economic return than any other change in management (King et al 2003).

The earlier studies have highlighted the importance of economizing irrigation water by micro irrigation is 30 per cent and improvement in crop yield by 15-20 per cent over furrow method of irrigation (Singh and Sood, 2012). Based on experimentation, (Singandhupe and Verma 2002), also gives a significant increase in yield and water saving under micro irrigation compared to furrow irrigation. Potatoes have shallow root zone and a lower tolerance for water stress then most other crops. Low moisture levels can contribute to common scab, early dying, hollow heart, knobby tubers, low dry matter, low tuber set and low tuber yield. Excessive water soil moisture resulting in poor aeration and water logging of the soil reduces the yield and in extreme cases causes the rot and enlarged lenticels. As water application in furrows causes more soil cracking and it also produces more green heads and infested tubers. The effect of tuber worm is more in furrow irrigation (Shelton and Wyman 1997). Therefore, an efficient irrigation systems and water saving techniques such as drip irrigation have been found useful to improve water productivity. Drip irrigation minimizes leaching losses due to which utilization of water and nutrients increases and water losses due to surface runoff and deep percolation is decreases. It also enhances the potato production and keeps productivity at high level. All these factors may play a crucial role in yield and improvement of processable grade tuber.

So, the present investigation is proposed to study the effect of bed size on the yield and size of the tuber and to study the effect of wide raised bed planting pattern under different irrigation methods.

**MATERIALS AND METHODS**

The present experiment was carried out at Student’s Research Farm, Khalsa College Amritsar during rabi season of 2016-17 and 2017-18. The field was laid out in Factorial
Influence of Bed Size and Irrigation Methods on Potato (Solanum tuberosum)

Randomized Complete Block Design with three replications including two factors i.e. method of sowing in factor A and method of irrigation in factor B. Treatments for factor A were B1: 60cm bed, B2: 75cm bed, B3: 90cm bed with single row, B4: 90cm bed with double row, B5: 105cm bed with double row, B6: 105cm bed with triple row and treatments for factor B were I1: drip irrigation and I2: furrow irrigation. The soil of the experimental field had sandy loam texture with neutral pH and electrical conductivity, low in organic carbon and available N, medium in available P and high in available.

The crop was sown manually on 20th October and 14th October during crop season of 2016-17 and 2017-18, respectively. The recommended fertilizers (187 kg N, 62 kg P2O5 and 62 kg K2O per hectare) were applied. First irrigation was given immediately after planting. Further irrigations were applied according to the treatments. In furrow irrigation total 7-9 irrigations were applied throughout the growing period. On the other hand drip irrigation was applied according to the following schedule:-

| Month     | Time of irrigation (min) |
|-----------|--------------------------|
| October   | 20                       |
| November  | 25                       |
| December  | 45                       |
| January   | 20                       |

Water measurement was done for the calculation of Water Use Efficiency.
WUE = Grain yield
Water applied at different levels of requirement

Volumetric method was used for measuring the flow in drip system. In this method flow rate was determined by dividing the volume of the container (liters) by the time (seconds) taken to fill it. V-Notch a triangular thin plate weir was used to measure the flow in furrow irrigation system.

Formula,

\[ Q = 1.38 \times H^{2.50} \]

Where,

\[ Q = \text{discharge in m}^3/\text{sec} \]
\[ H = \text{difference between the crest and water surface at point upstream from the weir at a distance of four times the maximum head on the crest (m).} \]

Reducing sugars (mg/100g fresh weight)

Reducing sugars were estimated by Nelson-Somogi method (Pearson 1976).

**Nelson’s arsenomolybdate reagent**

a) 25 g ammonium molybdate [(NH4)6Mo7O24.4H2O] was dissolved in 450 ml distilled water and then add 21 ml of concentrated sulphuric acid (H2SO4) in to it.
b) Dissolved separately 3g sodium arsenate (Na5HAsO4.8H2O) in 25 ml distilled water. Then this solution (b) was added with continuous stirring to the previously prepared ammonium molybdate solution (a) and stored in an amber coloured corked bottle.

**Procedure**

i. One ml each of extract (sample) and distilled water (as blank) were taken in test tubes.
ii. Add 1 ml of freshly prepared reagent C on each test tube.
iii. Started heating of test tubes in boiling water bath for 20 minutes and then cooled.
iv. After cooling 1 ml of Nelson’s arsenomolybdate reagent was added to each tube.
v. Test tube contents were then diluted to 13 ml with distilled water.
vii. Then the absorbance of extract was recorded at 520 nm with spectromic 20-D spectrophotometer (Milton Roy).

**Calculations**

\[ \text{Concentration of glucose in standard solution} \times \text{OD of sample} \times \frac{T. \text{ vol of sample}}{\text{Vol. of Aliquot}} \times \frac{20}{100} \]

**Sucrose**

Sucrose content in tubers was estimated by a method suggested by Van Handle (1968) as explained below:

i. 0.2 each of sample extract and distilled water (as blank sample) were taken in test tube.
ii. Then add 0.1 ml KOH (30%) to each test tube.
iii. Test tube was heated in water bath for 40 minutes and then immediately chilled in ice cold water.
iv. 3.0 ml of 0.15% anthrone solution in 76% H2SO4 was added to each test tube.
v. Then tubes were brought to room temperature and incubated at 40°C for 40 minutes.
vi. After this, absorbance was recorded at 620 nm.

**Calculations**

\[ \text{Concentration of sucrose in standard solution} \times \text{OD of sample} \times \frac{T. \text{ vol of sample}}{\text{Vol. of Aliquot}} \times \frac{20}{100} \]

**Range of chip color score.**

| Chip color score | Remarks             |
|------------------|---------------------|
| 1 to 3           | Highly acceptable   |
| 3 to 4           | Acceptable          |
| 4 to 5           | Nearly acceptable   |
| 5 to 10          | Highly unacceptable |

**Chip recovery (%)**

A total of 30 chips were weighed immediately before and after frying in cotton seed oil. Per cent recovery was
calculated as follows:

\[ \text{Chip recovery (\%)} = \frac{X \times \text{Peel weight}}{\text{tuber weight}} \times 100 \]

Where,

\[ X = \frac{\text{Weight of 30 fried chips}}{\text{Weight of 30 raw chips}} \]

The benefit:cost (B:C) ratio is computed on the basis of formula given below:-

\[ \text{Net return} = \text{gross return} - \text{total cost} \]

\[ \text{(B:C) ratio} = \frac{\text{gross return}}{\text{total cost}} \]

**Statistical analysis**

Statistical analysis of the data recorded was done as per split plot design using EDA 1.1 software developed by PAU, Ludhiana. The comparisons were made at five per cent level of significance. The analysis of variance (ANOVA) is as in the Table.

**Analysis of variance.**

| Source of variation | Degree of freedom |
|---------------------|------------------|
| Replications        | (r-1) = 2        |
| Treatments          | (ab-1) = 11      |
| Factor A            | (a-1) = 5        |
| Factor B            | (b-1) = 1        |
| A*B                 | (a-1)(b-1) = 5   |
| Error               | (r-1)(ab-1) = 22 |
| Total               | (rab-1) = 35     |

**RESULTS AND DISCUSSION**

**Yield attributes**

The number of tubers per plant is an important yield bearing parameter. The data presented in Table 2 showed that bed size had a significant effect on number of tuber per plant. The data revealed that maximum number of tubers per plant was recorded in treatment B1 followed by treatments B2, B5 and B3. The treatments B1 were B2 were statistically at par with each other during both crop years. The trend in treatments was B1 > B2 > B3 > B4 and B6. This might be due to variation in spacing and bed size. It could be attributed to increase in plant density area leading to more competition and consequent reduction in tuber weight and number of tubers per plant. Above results were in accordance with the findings of Singh and Sood (2016).

Among irrigation treatments, data demonstrated in Table 2 showed that number of tubers per plant were significantly higher under drip irrigation in comparison to furrow irrigation. It might be due to optimum availability of soil moisture and fertilizer nutrients in the plant root zone during entire period of crop growth in drip method of irrigation. Above results were in accordance with the findings of Singh and Sood (2016).

**Tuber weight (g)**

Persual of data in Table 2 showed that average tuber weight significantly influenced by bed size. Maximum tuber weight was achieved in 105cm triple row (B6) bed followed by 90cm double row (B2) and 105cm double row (B3) bed. All these treatments were statistically at par with each other. Whereas minimum average tuber weight was noticed in 75 cm (B2) bed. This might be due to intra row competition.

**Tuber yield**

Yield of a crop is the final output of successful completion of growth and development of its individual plant which in turn depends upon rate of carbon assimilation and converts into harvestable products. Tubers collected from each of the experimental treatment plots were hand graded into processing (40-75mm) and non-processing (<40mm/ >75mm) tuber grades. Bed size and irrigation both factors showed their effect on plant yield. Yield of each grade and total yield are presented in Table 3.

**Table 1:** Temperature (°C) and rainfall (mm) during Potato crop seasons.

| Month    | Maximum Temperature(°C) | Minimum Temperature(°C) | Mean Temperature(°C) | Rainfall (mm) |
|----------|--------------------------|--------------------------|----------------------|---------------|
| **2016-17** |                          |                          |                      |               |
| October  | 33.0                     | 18.7                     | 25.9                 | 0.0           |
| November | 27.5                     | 11.2                     | 19.3                 | 3.0           |
| December | 22.5                     | 7.2                      | 14.9                 | 0.0           |
| January  | 18.4                     | 6.5                      | 12.5                 | 45.6          |
| **2017-18** |                          |                          |                      |               |
| October  | 30.9                     | 17.5                     | 25.1                 | 0.0           |
| November | 24.1                     | 10.3                     | 17.6                 | 0.4           |
| December | 20.7                     | 5.7                      | 13.5                 | 1.6           |
| January  | 18.0                     | 4.4                      | 11.7                 | 2.1           |
Table 2: Effect of improved agronomic practices on number of tubers per plant and weight of tuber of potato.

| Treatments              | 2016-17 No. of tubers/plant | 2017-18 Weight (g) | 2016-17 Weight (g) | 2017-18 Weight (g) |
|-------------------------|-----------------------------|--------------------|--------------------|--------------------|
| **Bed size**            |                             |                    |                    |                    |
| 60cm (B₁)               | 6.3                         | 7.8                | 45.3               | 48.9               |
| 75cm (B₂)               | 4.2                         | 7.1                | 39.6               | 43.8               |
| 90cm single row (B₃)    | -                           | 5.7                | -                  | 46.2               |
| 90cm double row (B₄)    | 4.8                         | 6.0                | 49.6               | 52.3               |
| 105cm double row (B₅)   | 6.2                         | 6.3                | 47.6               | 51.1               |
| 105cm triple row (B₆)   | 6.0                         | 5.6                | 50.8               | 54.4               |
| **CD (p=0.05)**         | 0.90                        | 0.80               | 6.31               | 5.91               |
| **Irrigation**          |                             |                    |                    |                    |
| Drip irrigation (I₁)    |                             |                    |                    |                    |
| Furrow irrigation (I₂)  |                             |                    |                    |                    |
| **CD (p=0.05)**         | 0.57                        | 0.46               | 3.99               | 3.42               |

Table 3: Effect of improved Agronomic practices on tuber yield of potato (qha⁻¹).

| Treatments              | 2016-17 Tuber yield | 2017-18 Tuber yield | 2016-17 Tuber yield | 2017-18 Tuber yield |
|-------------------------|--------------------|--------------------|--------------------|--------------------|
| **Bed size**            |                    |                    |                    |                    |
| 60cm (B₁)               | 172.8              | 178.7              | 66.0               | 67.7               |
| 75cm (B₂)               | 151.9              | 158.1              | 44.6               | 55.7               |
| 90cm single row (B₃)    | -                  | 159.1              | -                  | 56.1               |
| 90cm double row (B₄)    | 156.0              | 162.3              | 66.3               | 68.2               |
| 105cm double row (B₅)   | 152.9              | 158.9              | 67.1               | 68.7               |
| 105cm triple row (B₆)   | 161.3              | 165.7              | 56.6               | 57.5               |
| **CD (p=0.05)**         | 13.4               | 11.8               | 10.2               | 9.6                |
| **Irrigation**          |                    |                    |                    |                    |
| Drip irrigation (I₁)    | 164.2              | 168.2              | 68.8               | 68.1               |
| Furrow irrigation (I₂)  | 153.7              | 159.4              | 53.4               | 55.4               |
| **CD (p=0.05)**         | 8.5                | 6.8                | 6.4                | 5.5                |

Table 3.1: Effect of interaction between irrigation and bed size on processable tuber yield of potato (qha⁻¹).

| Treatments              | 60 cm single row (B₁) | 75 cm single row (B₂) | 90 cm single row (B₃) | 90 cm double row (B₄) | 105 cm double row (B₅) | 105 cm triple row (B₆) |
|-------------------------|-----------------------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|
| 2016-17                 | 165.6                 | 139.8                 | -                     | 157.4                 | 168.1                  | 189.9                  |
| Drip irrigation (I₁)    | 179.8                 | 164.1                 | -                     | 154.7                 | 137.6                  | 132.6                  |
| Furrow irrigation (I₂)  |                       |                       |                       |                       |                        |                        |
| Interaction CD (p=0.05) | 19.1                  |                       |                       |                       |                        |                        |
| 2016-17                 |                       |                       |                       |                       |                        |                        |
| Drip irrigation (I₁)    | 171.8                 | 144.9                 | 157.4                 | 163.2                 | 174.5                  | 197.2                  |
| Furrow irrigation (I₂)  | 185.3                 | 171.2                 | 160.7                 | 161.5                 | 143.3                  | 134.2                  |
| Interaction CD (p=0.05) | 16.6                  |                       |                       |                       |                        |                        |

2016-17 and 2017-18, respectively which were significantly higher than other treatments. The treatments B₅ > B₆ > B₄ > B₃ in the same trend were statistically at par with each other. Similar result was observed by Kumar et al (2011).

Regarding irrigation treatments, the recoded in table 3 showed that during both crop year drip irrigation produced significantly higher processable yield than furrow irrigation. Above results were in accordance with Singh and Sood (2016).

The data presented in the Table 3.1 showed that interaction between irrigation and bed size was significant during both crop years. Maximum yield was obtained in drip irrigated 105cm triple row (I₆B₆) bed followed by 60cm (I₅B₁) which were statistically at par with each other. Minimum yield was obtained in 105cm triple row (I₆B₆) bed with furrow irrigation. It was due to less moisture availability in the central part of the bed. The results are in accordance with the results of Boujelben and M’barek (1997).
The above results might be due to low availability of soil moisture and fertilizer nutrients during active period of crop growth under conventional furrow irrigation as compared to drip irrigation method. It also be due to increase in tuber weight and numbers per m² under double and triple row raised beds with drip irrigation as compared to other patterns.

**Quality parameters**

**Tuber dry matter (per cent)**

Tuber dry matter is an important quality parameter. Tuber dry matter content more than 20 per cent is acceptable for processing (Sandhu et al. 2010). The data presented in the Table 4 showed that tuber dry matter accumulation was not influenced significantly due to bed size. All the treatments of bed size were non-significant.

Among irrigation treatments, perusal of data in Table 4 further revealed that irrigation had a significant effect on the tuber dry matter. Maximum tuber dry matter was obtained in drip irrigation I₁ and minimum was obtained in furrow irrigation I₂. Where I₁ was significantly higher than I₂ in both cropping years. This might be due to the presence of moisture for longer duration in the plant root zone.

**Chip recovery (per cent)**

Chip recovery is good index of final products. Data presented in Table 4 revealed in cropping years 2016-17 and 2017-18 that maximum chip recovery was obtained from followed by I₁, B₁, B₂, B₃ and B₄. It was observed that there was no significant effect on chip recovery per cent due to bed size.

In irrigation treatments, data presented in Table 4 suggested that during both years slightly higher chip recovery was obtained in drip irrigated treatment I₁ then furrow irrigated treatment I₂. However treatment I₁ and I₂ were statistically at par with each other.

**Reducing sugars (mg/100g FW)**

Reducing sugars affects the chipping quality of tuber. Low reducing sugars are preferable for good chipping quality. The data presented in the Table 5 revealed that bed size had a non-significant effect on the reducing sugars in potato. It was observed that B₁ had slightly higher reducing sugars content as compared to other treatment. Similarly data presented in table 5 showed that irrigation treatments also had non-significant effect on the reducing sugars in tubers.

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**Table 3.2:** Effect of interaction between irrigation and bed size on total tuber yield of potato (qha⁻¹).

| Treatments | 60cm single row (B₁) | 75cm single row (B₂) | 90cm single row (B₃) | 90cm double row (B₄) | 105cm double row (B₅) | 105cm triple row (B₆) |
|------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 2016-17    |                     |                     |                     |                     |                     |                     |
| Drip irrigation (I₁) | 235.4              | 198.1              | -                   | 231.4              | 247.1              | 252.1              |
| Furrow irrigation (I₂) | 237.1              | 211.4              | -                   | 214.2              | 191.2              | 181.6              |
| Interaction CD (p=0.05) | 20.5              |                     |                     |                     |                     |                     |
| 2017-18    |                     |                     |                     |                     |                     |                     |
| Drip irrigation (I₁) | 244.7              | 204.3              | 209.1              | 240.5              | 255.6              | 262.2              |
| Furrow irrigation (I₂) | 247.8              | 218.3              | 217.4              | 220.5              | 200.1              | 185.1              |
| Interaction CD (p=0.05) | 19.3              |                     |                     |                     |                     |                     |

**Non-processable yield (<45/>75mm)**

The data presented in Table 3 showed that bed size has its own effect on non-processable tuber yield. Maximum non-processable tuber yield during both crop years was recorded in B₂ (105cm double row) followed by treatments B₁ (90cm double row), B₃ (60cm single row), B₄ (75cm single row), B₅ (90cm single row) and B₆ (60cm single row) which were significantly different at par with each other. Whereas, minimum processable yield was obtained in B₁ (75cm bed) which was significantly different from the treatment B₅, B₄ and B₂. Similar result was observed by Kumar et al (2011).

Data regarding irrigation treatments presented in Table 3 in which maximum non-processable yield drip irrigation and minimum was observed furrow irrigation during both crop years. Above results were in accordance with Singh and Sood (2016).

**Total tuber yield**

Regarding bed size, the data presented in table 3 showed that bed size had a significant effect on total tuber yield. The data revealed that during both cropping years maximum total tuber yield of 236.2qha⁻¹ and 246.3 qha⁻¹ respectively was obtained in treatment B₁ (75cm bed) which was significantly higher than bed size 90 cm (B₂ and B₃) and 105cm (B₄ and B₅) where treatments B₂, B₃ and B₄ were statistically at par with each other. Ridge planting with drip irrigation attributed highest tuber yield. Singh and Sood (2016) reported the same results.

Among irrigation treatments, the given data in table 3 further examined that in both cropping years maximum total tuber yield was recorded drip irrigation and minimum was observed in furrow irrigation. The drip irrigation was significantly different from furrow irrigation. Above results were in accordance with Singh and Sood (2016).

The data presented in the table 3.2 showed that during both crop years interaction among irrigation and bed size was significant. Maximum yield was obtained in drip irrigated 105cm triple row (I₁B₆) bed. It was due to the availability of proper moisture in the center of bed. Minimum yield was obtained in same bed with furrow irrigation (I₂B₆) it due to the less moisture availability in the central part of the bed. This might be due to the availability of proper moisture and nutrients during the active period of growth in drip irrigation system Singh and Sood (2016).
Table 4: Effect of improved agronomic practices on tuber dry matter percentage and chip recovery percentage of potato.

| Treatments               | Tuber dry matter (per cent) | Chip recovery (per cent) |
|--------------------------|-----------------------------|--------------------------|
|                          | 2016-17                     | 2017-18                   | 2016-17 | 2017-18 |
| Bed size                 |                             |                          |         |         |
| 60 cm (B₁)              | 26.9                        | 27.5                     | 34.9    | 36.7    |
| 75 cm (B₂)              | 22.7                        | 24.5                     | 32.7    | 33.7    |
| 90 cm single row (B₃)   | -                           | 24.6                     | -       | 33.9    |
| 90 cm double row (B₄)   | 24.6                        | 25.8                     | 33.1    | 35.1    |
| 105 cm double row (B₅)  | 24.8                        | 25.8                     | 33.9    | 35.1    |
| 105 cm triple row (B₆)  | 23.9                        | 25.6                     | 32.6    | 34.8    |
| CD (p=0.05)             | NS                          | NS                       | NS      | NS      |
| Irrigation               |                             |                          |         |         |
| Drip irrigation (I₁)     | 24.2                        | 26.7                     | 34.6    | 35.9    |
| Furrow irrigation (I₂)   | 22.9                        | 24.5                     | 32.1    | 34.8    |
| CD (p=0.05)             | 0.9                         | 1.2                      | 1.4     | 1.2     |

Table 5: Effect of improved Agronomic practices on Reducing sugars, Sucrose content and Chip colour.

| Treatments               | Symbol | Reducing sugars (mg/100g FW) | Sucrose content (mg/100g FW) | Chip colour score |
|--------------------------|--------|-----------------------------|-----------------------------|------------------|
|                          |        | 2016-17         | 2017-18         | 2016-2017 | 2017-18 | 2016-17 | 2017-18 |         |
| Bed size                 |        |                 |                 |           |         |         |         |         |
| 60 cm                    | B₁     | 23.7            | 23.9            | 130.8     | 130.7   | 1.7     | 1.8     |         |
| 75 cm                    | B₂     | 22.5            | 23.1            | 129.9     | 130.1   | 2.1     | 2.1     |         |
| 90 cm single row         | B₃     | -               | 23.5            | -         | 130.4   | -       | 1.9     |         |
| 90 cm double row         | B₄     | 22.7            | 22.4            | 130.2     | 129.6   | 1.8     | 1.9     |         |
| 105 cm double row        | B₅     | 20.4            | 21.1            | 128.4     | 128.1   | 1.5     | 1.8     |         |
| 105 cm triple row        | B₆     | 23.8            | 23.7            | 130.5     | 130.8   | 1.8     | 1.8     |         |
| CD (p=0.05)             | NS     | NS              | NS              | NS        | NS      | NS      | NS      |
| Irrigation               |        |                 |                 |           |         |         |         |         |
| Drip irrigation (I₁)     |        | 23.2            | 23.1            | 129.9     | 130.1   | 1.7     | 1.9     |         |
| Furrow irrigation (I₂)   |        | 22.4            | 22.1            | 129.5     | 129.8   | 1.8     | 1.9     |         |
| CD (p=0.05)             | NS     | NS              | NS              | NS        | NS      | NS      | NS      |

Sucrose content (mg/100g FW)

Sucrose content in potato tuber is an important quality parameter because it may participate as substrate for reducing sugars after undergoing heat induced hydrolysis during frying and can affect chip colour negatively. Data regarding sucrose content in tubers is presented in table 5 revealed that maximum sucrose content was observed in B₆ followed by treatments B₁, B₃, B₂, B₄ and B₅. It was observed that sucrose content was not influenced due to the bed size.

Among irrigation treatments data presented in table 5 data showed that maximum sucrose content was observed in drip irrigation which was slightly higher than furrow irrigation. Therefore, drip and furrow irrigation had a non-significant effect on sucrose content in potato tubers.

Chip colour score

The colour of fried chips is most important visual character for determining the suitability of potatoes for processing. Chips having dark colour are unacceptable to consumers due to poor aesthetic appeal and bitter taste. Chip colour score up to 3 is considered highly acceptable. The data in Table 5 revealed that there was no significant variation in the chip colour score due to variation in the bed size.

In irrigation treatments data in the table 5 revealed that chip colour score in drip irrigation and furrow irrigation was found in acceptable range (<3). However both the treatments had no significant effect on chip colour score.

Water use efficiency (WUE kg ha⁻¹ mm)

Maximum water use efficiency was recorded in drip irrigated 105 cm double row bed followed by triple row in same bed size. Whereas in furrow irrigation maximum water use efficiency was recorded in 60 cm bed followed by 90 cm double row and 105 cm double row. From given data it was noticed that drip irrigation saved 48% water as compared to furrow irrigation.

Benefit Cost ratio

Data in table 6 depicts that in drip irrigation B₁ gave maximum return followed by B₅ > B₆ > B₁ > B₂ and B₃. Whereas among furrow irrigation B₁ gave maximum returns followed by B₂ > B₃ > B₅ and B₆.
Table 6: Effect of improved agronomic practices on water use efficiency (kg ha\(^{-1}\) mm) of potato.

| Treatments         | Symbols | Water applied (mm) | Total yield (kg ha\(^{-1}\)) | Water use efficiency (kg ha\(^{-1}\)-mm) | B.C. ratio |
|--------------------|---------|--------------------|------------------------------|------------------------------------------|------------|
|                    |         | 2016-17            | 2017-18                      | 2016-17                                  | 2017-18    |
| Drip irrigation    | B\(_1\) | 198.5              | 189.2                        | 23545                                    | 24477      |
| 60cm               | B\(_2\) | 186.2              | 177.4                        | 19805                                    | 20432      |
| 90cm single row    | B\(_3\) | -                  | 165.1                        | -                                        | 20914      |
| 90cm double row    | B\(_4\) | 201.4              | 192.7                        | 23144                                    | 24058      |
| 105cm double row   | B\(_5\) | 182.6              | 177.6                        | 24717                                    | 25562      |
| 105cm triple row   | B\(_6\) | 204.7              | 192.9                        | 25218                                    | 26225      |
| Furrow irrigation  | B\(_1\) | 402.6              | 392.5                        | 23709                                    | 24788      |
| 60cm               | B\(_2\) | 412.5              | 403.7                        | 21149                                    | 21836      |
| 90cm single row    | B\(_3\) | -                  | 394.1                        | -                                        | 21742      |
| 90cm double row    | B\(_4\) | 405.1              | 391.4                        | 21423                                    | 22053      |
| 105cm double row   | B\(_5\) | 418.2              | 405.9                        | 19128                                    | 20004      |
| 105cm triple row   | B\(_6\) | 422.7              | 408.2                        | 18165                                    | 18510      |

CONCLUSION
Drip irrigation (236.1qha\(^{-1}\)) and 60cm bed size (246.3qha\(^{-1}\)) yielded maximum potato as compared to other treatments. Maximum WUE was obtained in drip irrigated broad beds and saves 45-50 per cent water as compared to furrow irrigation during both crop seasons. Furrow irrigated with narrow bed size beneficial than other treatments.

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