RESEARCH ARTICLE

IMPACT OF DIFFERENT IRRIGATION SYSTEMS AND PLANTING DATES ON NUMBERS OF DIFFERENT GRADES OF POTATO (*SOLANUM TUBEROSUM* L.)

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Abstract: Among different irrigation methods, micro-sprinkler irrigation method (I2) was significantly influence on number of tubers per m^2 in different grade i.e. up to 25g (4.37 & 4.09), >25-50g (4.76 & 5.04), >50-75g (6.02 & 4.73) and >75 g (12.84 & 14.46 g) Harvested at 75 DAP and 90 DAP, respectively, of potato over furrow irrigation method, whereas, among different dates of sowing, 15th October (D$_4$) had significant effects on potato growth metrics of potato i.e. up to 25g (5.78 & 5.36), >25-50g (5.41 & 5.43), >50-75g (7.20 & 5.39) and >75 g (18.91 & 20.27) Harvested at 75 DAP and 90 DAP, respectively, over rest of the other planting dates during 2017-19. Number of tubers per m^2 in different grade of potato crop variety (Kufri Lima) sown on 15 October and harvested at 90 DAP by micro-sprinkler irrigation system performed best under Hisar conditions.

Keywords: Potato, Micro-sprinkler, Furrow, Irrigation, Growth parameters

INTRODUCTION

Potato (*Solanum tuberosum* L.) is originally a native of the South American continent, where it used to grow as wild plant right from about 7000 to 9000 years ago. In India, the Portuguese introduced it during the early 17th century; further British took potato to hills in Northern India. It is the single most popular tuber vegetable crop grown in more than 100 countries of the world (Pandey and Sarkar, 2005 and Touseef Hussa, 2016**).** Potato is the largest non-cereal food crop worldwide and ranked as the world's fourth most important food crop after rice, wheat, and maize. (Zhang *et al.,* 2017). Role of potato as food and income security crop for the global poor in general and the residents of developing countries in particulate, was adequately documented by Thiele *et al*., (2010).

Presently, India is the second largest producer of potato in the world after China and the crop occupies 21.84 lakh ha with a production of 525.89 lakh tonnes and productivity 24.08 t/ha during 2017-18. The major seven states growing potato in our country are Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab and Haryana accounting for nearly 90 % of the total production of potato. Potato is an important vegetable crop of Haryana state also. It occupies a premier position in terms of both area and production, whereby ranks first in production and second in area among vegetable crops in the state. During 2017-18, the area and production of potato in Haryana state was 34.72 thousand ha and 897.58 thousand tones, respectively, however, the productivity of this crop is still lower (25.85 t/ha) than the potential yield.

Nutritionally, Potato contributes key nutrients to the diet including vitamin C, potassium, and dietary fiber (Weaver and Marr, 2013). In fact, potatoes have a more favorable overall nutrient to price ratio than many other fruits and vegetables and are an affordable source of nutrition worldwide (Drewnowski and Rhem, 2013). Animal studies and some human research indicate that potatoes and potato nutrients may positively impact risk factors for chronic disease including blood pressure, blood lipids and inflammation (Beals, 2019). Besides the high nutritive value, it has greater yield potential and contributes towards food and nutrition security through the alleviation of poverty and hunger, especially in the developing world.

The potato is a cool-season crop that grows well in certain areas of the Prairie Provinces. The rate of development of sprouts from seed pieces depends on soil temperature. Very little sprout elongation occurs at 6°C, elongation is slow at 9°C and is maximized at about 18°C. The optimum soil temperature for initiating tubers is 16-19°C. Tuber development declines as soil temperatures rise above 20°C and tuber growth practically stops at soil temperatures above 30°C. The number of tubers set plant^{-1} is greater at lower temperatures than at higher temperatures, whereas higher temperature favour development of large tubers. (Pandey *et al.,* 2008). Due to high temperature, potato crop is normally planted after mid of October, as early planting may result in rotting of tubers in the post monsoon season. Among different irrigation methods, micro-sprinkler

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irrigation system is very useful in vegetable production, especially in row crops, but information on the economic viability of this system in potato is lacking.

The optimum level of soil moisture is needed to be maintained in the root zone, which can best be achieved with improved irrigation methods viz., drip and sprinkler (Pawar *et al*., 2002). These techniques add precisely measured quantity of irrigation water to the root zone at the appropriate time and space and hence are very much useful for a sensitive crop like potato. However, their adoption is restricted due to huge initial investment for its installation. Therefore, the economic feasibility for adoption of these improved techniques in short duration crops like potato need to be assessed.

Furthermore, sprinkler irrigation methods provide scope to utilize resources effectively and enhance crop productivity (Singh *et al*., 2001). The better crop performance under the micro-sprinkler could be attributed to minimize the influence of frost, whitefly, nutrient leaching and minimizing fluctuation in soil moisture in the effective root zone, which holds promise for increase in crop yield. It was visually observed that whitefly attack was not so severe under the micro-sprinkler regime as compared to drip and furrow irrigated crop. Frequent irrigation with micro-sprinkler washed the leaf canopy and minimized the whitefly infestation. Apart from this, micro-sprinkler irrigation might have created a better microclimate, which facilitated better photosynthesis, root aeration and plant growth, which resulted in higher yield (Holzapfel *et al*., 2000).

MATERIALS AND METHODS

The present experiment entitled **"Effect of irrigation methods and planting dates on yield of potato (*Solanum tuberosum* L.)"** was conducted at the Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during winter (*rabi*) season of the years 2017-18 and 2018-19. The details of materials used and methods applied in the present study are given below:

Experimental Site, Climate and Weather Conditions

Hisar is situated at latitude of 29º10' N, longitude of 75º 46' E and at the height of 215.2 meters above mean sea level and falls in semi-arid and sub-tropical region with hot and dry summer and severe cold in winter. The mean monthly meteorological data (maximum and minimum temperature, relative humidity, sunshine and rainfall) recorded during the crop-growing season are presented in Fig. 1 and 2 from Department of Agricultural Meteorology, CCS HAU, Hisar.

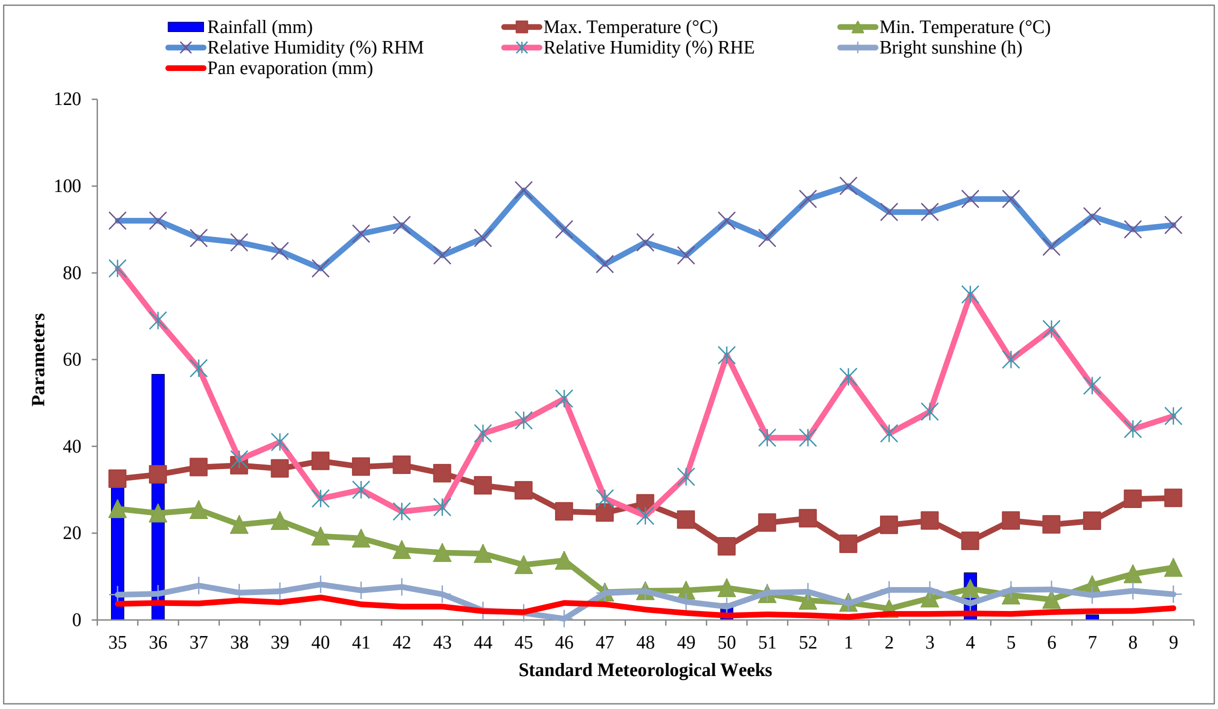

Fig. 1: Mean of weekly meteorological data of Hisar district from August, 2017-March, 2018

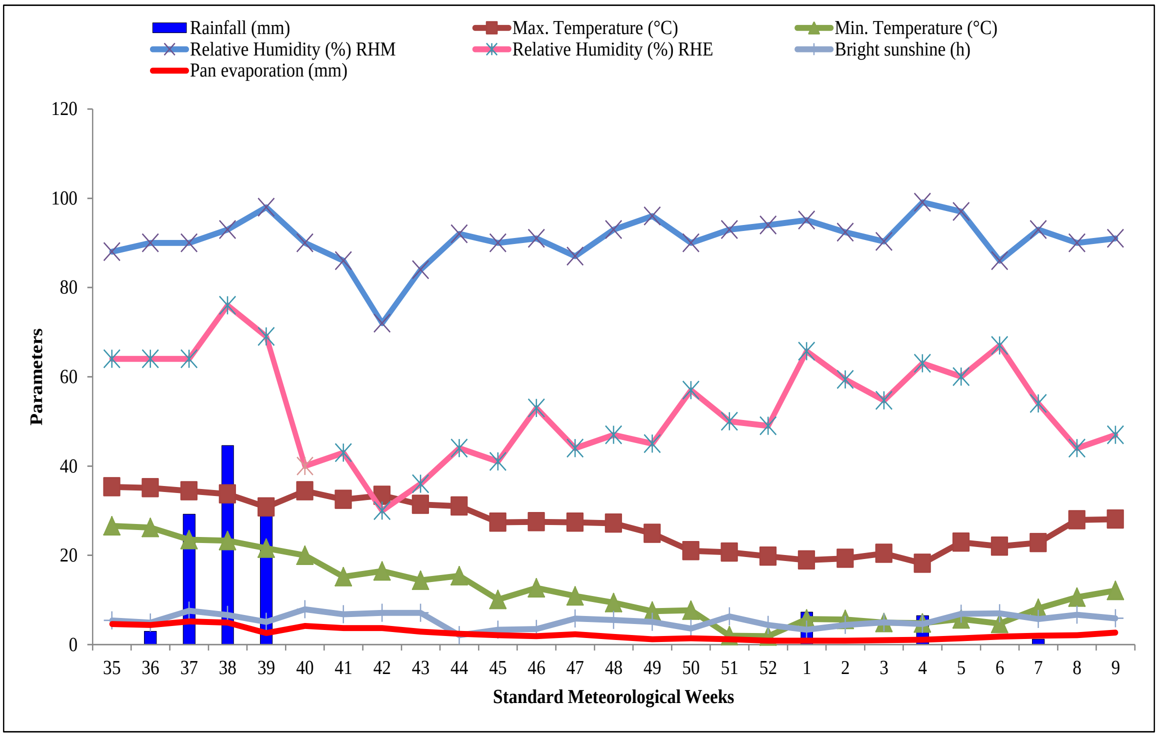

Fig. 2: Mean of weekly meteorological data of Hisar district from August, 2018-March, 2019

Soil Characteristics

Before conducting experiment, the composite soil samples were taken from the experimental field up to a depth of 15 cm. These samples were subjected to analysis to assess the initial status of soil before imposing treatments the samples were analyzed for their Physico-chemical properties.

Experimental Details

The study was carried out at Research Farm of the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Rabi* season of 2017-18 and 2018-19. Two experiments were conducted during the study, the other details of the experimental material, design and treatments are given as under:

Details of the experiment

Experiment 1: Effect of irrigation methods and planting dates on potato yield harvested at 75 days after planting.

Experiment 2: Effect of irrigation methods and planting dates on potato yield harvested at 90 days after planting

Experimental design	:	Split plot design
Variety	:	Kufri Lima
Number of replications	:	Four
Net plot size (m^2)	:	3×2 m (6 m^2)
Row to row spacing	:	60 cm
Plant to plant spacing	:	20 cm

Experiment design and layout

The experiment was laid out in Split-plot Design (SPD) replicated four times. The plan of experiment has been given in Fig. 3. The 8 treatments were randomized with the help of random number table (Fisher, 1958).

Experimental materials

The seed tubers of potato variety Kufri Lima used for the present investigation were procured from the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar (Haryana). The details of the treatment are given as under:

A. Main plot: Irrigation methods - Two

1. I_1: Furrow irrigation (30 mm CPE)
2. I_2: Micro-sprinkler (10 mm CPE)

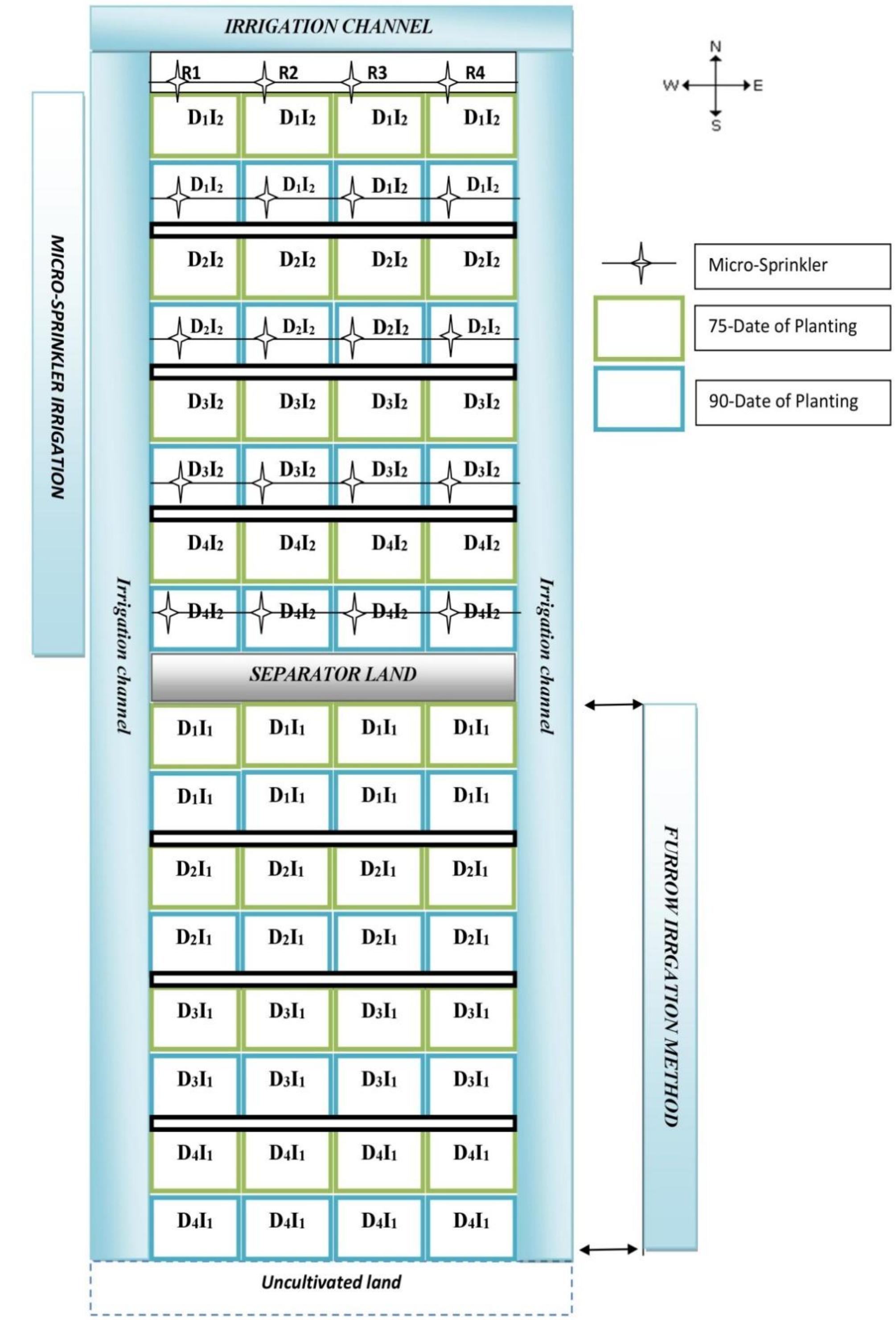

Fig. 3: Layout of experimental field

B. Sub-plot: Planting dates - Four

1. 1st September
2. 15th September
3. 30th September
4. 15th October

Details of the treatments and notations used

S. No.	Notation	Description
1.	$D_1 I_1$	Planted on 1st September under furrow irrigation method
2.	$D_2 I_1$	Planted on 15th September under furrow irrigation method
3.	$D_3 I_1$	Planted on 30th September under furrow irrigation method
4.	$D_4 I_1$	Planted on 15th October under furrow irrigation method
5.	$D_1 I_2$	Planted on 1st September under micro-sprinkler irrigation method
6.	$D_2 I_2$	Planted on 15th September under micro-sprinkler irrigation method
7.	$D_3 I_2$	Planted on 30th September under micro-sprinkler irrigation method
8.	$D_4 I_2$	Planted on 15th October under micro-sprinkler irrigation method

Cultural Operations

The cultural operations practiced in the course of experiment are described below:

Field preparation and application of fertilizer

The experimental field was properly prepared in the last week of August during both the years. The field was ploughed twice with tractor drawn cultivator after harvest of the previous crop to crush clods. The field was ploughed by cross harrowing followed by the cultivator twice and in the last planking to bring the soil to a fine tilth before sowing. **Seed rate and sowing**

On the well - prepared field, by potato planter planted seeds of the potato crop @ 30 qha^{-1} on 1st September, 15th September, 30th September, 15th October in 2017 and 2018.

Details of Collection of Experimental Data

The details of different observations recorded along with the techniques to be used are given as following:

Number of tubers per m^2 in each grade (0-25, >25-50, >50-75 and >75 g)

Tuber plot was harvested and grade wise number of tubers was counted per plot and calculated per m^2. Tubers were divided into four different grades, *i.e.*, A grade (>75 g), B grade (>50-75 g), C grade (>25-50 g), and D grade (up to 25 g) and then the number of tubers of different grade per plot was divided by plot size

$$\text{Number of tubers in different grade } m^2 = \frac{\text{Number of tubers in different grades per plot}}{\text{plot size}}$$

Statistical analysis

The data observed for the various characters during the study were statistically analyzed following the technique of analysis of variance (ANOVA). The significance of difference between mean of two treatments were judge with the critical difference (CD) worked out using following formula:

$$CD = \sqrt{\frac{2 \text{ X Mean square error}}{n}} \text{ X 't'}$$

Where, CD = Critical difference

n = Number of replications of the factor for which C.D. is to be calculated.

t = The value from fisher table for error degree of freedom at 5 per cent level of significance.

RESULTS AND DISCUSSIONS

The results of field experiment entitled **"Impact of different irrigation systems and planting dates on numbers of different grades of potato (*Solanum tuberosum* L.)"** conducted at the Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during winter (*rabi*) season of the years 2017-18 and 2018-19 are being presented in this chapter. The data pertaining to a trend of increase in numbers of different grades of potato was observed in timely planted over early planted potato and under the micro-sprinkler over furrow irrigation method during both the years.

Generally, furrow method of irrigation is recommended for potato. However, up to 38 per cent irrigation water could be saved by applying with water in alternates furrows irrigation turn at the expenses of 10.7 per cent decrease in yield (Bhan and Dharma, 1982). This practice seems promising where irrigation water is a major limiting factor in potato production. Also, in the areas of undulating topography, as in the hills and scarce water supply condition, where other methods of irrigation could not be adopted, sprinkler irrigation is applied which is expected to economic in water by about 40 per cent (Singh *et al*., 1983). Sprinkler irrigation system achieves water, saving up to 30 per cent compared with surface irrigation (Jamal *et al*., 2001).

Methods of irrigation comprehensively manipulated the hydrothermal regimes of the soil. Preferential wetting of the furrow (inter-row) is wasteful because that location is characterized by high leaching and low water uptake rates by plant roots. The soil moisture was nearly at field capacity in sprinkler irrigation, whereas, under furrow irrigation it indicated that the crop is exposed to temporary water stress, which may be detrimental for a sensitive crop like potato. In sprinkler irrigation, water was applied frequently in lower amounts as compared to heavy application under furrow irrigation that resulted in water stress to the crop and temporarily decreases aeration in the soil, which is very detrimental for a sensitive crop like potato. Mean maximum temperatures lower down under sprinkler irrigation, whereas, furrow irrigation recorded comparatively higher temperature that affects the plant processes. Hence, Micro-sprinkler irrigation system can protect the crop from the adverse effect of low temperature as well as of high temperature by sprinkling water droplets on the leaves of the plant, helped in better growth, early maturity (one week early) and higher potato yield as compared to traditional method.

On the other hand, planting dates greatly influence the growth parameters of potato plants as well as the duration of the inter phase periods. Potato planted on optimum time form powerful plants with developed bushes, better leafed stems, the above ground mass increases, as well as the assimilation leaf surface, and the intensity of photosynthesis, which contributes to the accumulation of an early harvest of high-quality tubers.

Tuber yield in short growing season of potato is affected mainly by the intercepted radiation, methods to increase tuber yield need to address reducing the time to emergence, improving haulm growth after emergence and increasing the harvest index. Emergence will be earlier with sufficiently pre-sprouted seed tubers and tubers of advanced physiological age.

During the presentation of experimental results, significant variation noticed due to the experimental treatments has been discussed to establish cause and relationship. In doing so, the relevant findings of other researchers have also been quoted in order to support the results of the present experiment.

Number of tubers per m^2 in grade up to 25g

The data mentioned in Table 1 depicts that significantly highest number of tubers of grade up to 25 g at harvest (5.07 at 75 DAP & 4.99 at 90 DAP during 2017-18 and 2018-19, respectively) were recorded under furrow irrigation method (I_1) over micro-sprinkler irrigation method (I_2). Among different dates of planting, highest number of tubers of grade up to 25 g at harvest (5.78 at 75 DAP & 5.36 at 75 DAP during 2017-18 and 2018-19, respectively) were recorded in potato planted on 15th October (D_4). Lowest number of tubers of grade up to 25 g of potato at harvest were observed in treatment D_1 I_2 (where potato planted on 1st September under micro-sprinkler irrigation) followed by D_1I_1 (where potato planted on 1st September under furrow irrigation).

In the present study, significantly higher number of tubers of grade up to 25g in potato (ranged from 16.07% harvested at 75 DAP and 22% harvested at 90 DAP) was observed under furrow irrigation method over micro-sprinkler irrigation during 2017-18 and 2018-19, respectively. Similar finding of higher number of smaller grades of potato under furrow irrigation method over micro- sprinkler irrigation method was observed by Patel *et al.*, (2011) whereas, significantly higher number of tubers of grade up to 25g in potato (25.11% harvested at 75 DAP and 15.77 harvested at 90 DAP) was observed in potato planted on 15th October over one-month early potato planted on 15th September during 2018-19 and 2017-18, respectively. Similar trend of reduction in number of smaller grade of tubers in timely planted potato.

Number of tubers per m^2 in grade >25-50g

The data mentioned in Table 2 indicates that significantly maximum number of tubers of grade >25-50 g at harvest (4.76 at 75 DAP & 5.04 at 90 DAP during 2017-19) were recorded under micro-sprinkler irrigation method (I_2) than furrow irrigation method (I_1). Among different dates of planting, highest number of tubers of grade >25-50 g at harvest (5.41 at 75 DAP & 5.43 at 90 DAP during 2017-19) were recorded in potato planted on 15th October (D_4). While, comparing the combinations of different dates of planting with different methods of irrigation, significantly maximum number of tubers of grade >25-50 g at harvest (5.81 at 75 DAP

Table 1: Effect of irrigation methods and planting dates on total number of tubers per m2 in grades up to 25g in potato

Irrigation methods / Planting dates	Harvested at 75 DAP			Harvested at 90 DAP		
	2017-19 (Pooled)			2017-19 (Pooled)		
	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean
1st September (D_1)	3.36	2.93	3.14	3.48	3.02	3.25
15th September (D_2)	5.08	4.17	4.62	5.10	4.15	4.63
30th September (D_3)	5.69	4.99	5.34	5.53	4.33	4.93
15th October (D_4)	6.16	5.39	5.78	5.84	4.88	5.36
Mean	5.07	4.37		4.99	4.09	

CD at 5% level of significance	Irrigation (I) : 0.34 Date of planting (D) : 0.43 D at same level of I : N/A I at same level of D : N/A	Irrigation (I) : 0.32 Date of planting (D) : 0.33 D at same level of I : N/A I at same level of D : N/A

Table 2. Effect of irrigation methods and planting dates on total number of tubers per m2 in grades up to 25-50 g in potato

Irrigation methods / Planting dates	Harvested at 75 DAP			Harvested at 90 DAP		
	2017-19 (Pooled)			2017-19 (Pooled)		
	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean
1st September (D_1)	2.25	3.30	2.78	2.46	3.36	2.91
15th September (D_2)	4.25	4.74	4.49	3.98	5.14	4.56
30th September (D_3)	4.69	5.21	4.95	4.33	5.65	4.99
15th October (D_4)	5.00	5.81	5.41	4.83	6.02	5.43
Mean	4.05	4.76		3.90	5.04	
CD at 5% level of significance	Irrigation (I) : 0.31 Date of planting (D) : 0.28 D at same level of I : N/A I at same level of D : N/A			Irrigation (I) : 0.24 Date of planting (D) : 0.30 D at same level of I : N/A I at same level of D : N/A		

& 6.02 at 90 DAP during 2017-19) were recorded in treatment D_4I_2 (where potato planted on 15th October under micro-sprinkler irrigation) than rest of the other interactions. Minimum number of tubers of grade >25-50 g of potato at harvest were reported in treatment D_1I_1 (where potato planted on 1st September under furrow irrigation) followed by D_1 I_2 (where potato planted on 1st September under micro-sprinkler irrigation).

Number of tubers per m^2 in grade >50-75g

The data mentioned in Table 3 indicates that significantly maximum number of tubers of grade >50-75 g at harvest (6.05 at 75 DAP & 4.73 at 90 DAP during 2017-19) were recorded under micro-sprinkler irrigation method (I_2) over furrow irrigation method (I_1). Among different dates of planting, maximum number of tubers of grade >50-75 g at harvest (7.20 at 75 DAP & 5.39 at 90 DAP during 2017-19) were recorded in potato planted on 15th October (D_4) which were statistically at par with D_3 (6.86) at 75 DAP during 2017-19; D_3 (5.01) at 90 DAP during 2017-19. Lowest number of tubers of grade >50-75 g of potato at harvest were recorded in treatment D_1I_1 (where potato planted on1st September under furrow irrigation) followed by D_1I_2 (where potato planted on1st September under micro-sprinkler irrigation).

Number of tubers per m^2 in grade >75 g

The data mentioned in Table 4 shows that significantly highest number of tubers of grade >75 g at harvest (12.84 at 75 DAP & 14.46 at 90 DAP during 2017-19) were recorded under micro-sprinkler irrigation method (I_2) than furrow irrigation method (I_1). Among different dates of planting, significantly highest number of tubers of grade >75 g at harvest (18.91 at 75 DAP & 20.27 at 90 DAP during 2017-19) were recorded in potato planted on 15th October (D_4). While, comparing the combinations of different dates of planting with different methods of irrigation, highest number of tubers of grade >75 g at harvest (19.27 harvested at 75 DAP & 20.92 at 90 DAP during 2017-19) were recorded in treatment D_4I_2 (where potato planted on 15th October under micro-sprinkler irrigation) Lowest number of tubers of grade >75 g of potato at harvest were found in treatment D_1I_1 (where potato planted on 1st September under furrow irrigation) followed by D_1I_2 (where potato planted on1st September under micro-sprinkler irrigation).

On the other hand, a trend of increased in number of tubers per m^2 of grade >25-50g of potato (17.51% harvested at 75 DAP and 54% harvested at 90 DAP); of grade >50-75g of potato (18.97% harvested at 75 DAP and 21.28% harvested at 90 DAP) and of grade >75g of potato (16.94% harvested at 75 DAP and 23.80% harvested at 90 DAP) was observed under micro-sprinkler irrigation method over furrow irrigation method during 2017-19. Similar finding of higher number of bigger grades of potato under micro-sprinkler irrigation method over furrow irrigation method was observed by Patel *et al.*, (2011).

It may be due to uniform availability of water under micro-sprinkler irrigation method that increased the number of bigger tubers. Likewise, Similar trend of increased in number of tubers per m^2 of grade >25-50g of potato (20.19% harvested at 75 DAP and 19.08% harvested at 90 DAP); of grade >50-75g of potato (33.33% harvested at 75 DAP and 33.41% harvested at 90 DAP) and of grade >75g of potato (132% harvested at 75 DAP and 96.03% harvested at 90) was observed in potato planted on 15th October over one-month early potato planted on 15th September during 2017-19. It may be due to the optimization of temperature favorable to increase the number of bigger tubers of potato at timely sown condition in comparison to warmer temperature at one month early planted crop of potato.

Table 3. Effect of irrigation methods and planting dates on total number of tubers per m2 in grades up to 50-75 g in potato.

Irrigation methods / Planting dates	Harvested at 75 DAP			Harvested at 90 DAP		
	2017-19 (Pooled)			2017-19 (Pooled)		
	Furrow (I_1)	**Micro-sprinkler (I_2)**	**Mean**	**Furrow (I_1)**	**Micro-sprinkler (I_2)**	**Mean**
1st September (D_1)	2.42	2.98	2.70	2.31	3.31	2.81
15th September (D_2)	4.25	6.56	5.40	3.50	4.59	4.04
30th September (D_3)	6.62	7.10	6.86	4.71	5.31	5.01
15th October (D_4)	6.96	7.43	7.20	5.07	5.70	5.39
Mean	5.06	6.02		3.90	4.73	
CD at 5% level of significance	Irrigation (I) : 1.03 Date of planting (D) : 1.33 D at same level of I : N/A I at same level of D : N/A			Irrigation (I) : 0.21 Date of planting (D) : 1.29 D at same level of I : N/A I at same level of D : N/A		

Table 4. Effect of irrigation methods and planting dates on total number of tubers per m2 in grades up to >75g in potato

Irrigation methods / Planting dates	Harvested at 75 DAP			Harvested at 90 DAP		
	2017-19 (Pooled)			2017-19 (Pooled)		
	Furrow (I_1)	**Micro-sprinkler (I_2)**	**Mean**	**Furrow (I_1)**	**Micro-sprinkler (I_2)**	**Mean**
1st September (D_1)	2.44	3.67	3.05	2.87	5.06	3.96
15th September (D_2)	6.39	9.85	8.12	7.96	12.73	10.34
30th September (D_3)	16.53	18.59	17.56	16.27	19.14	17.71
15th October (D_4)	18.57	19.27	18.91	19.62	20.92	20.27
Mean	10.98	12.84		11.68	14.46	
CD at 5% level of significance	Irrigation (I) : 0.70 Date of planting (D) : 0.57 D at same level of I : 0.94 I at same level of D : 0.97			Irrigation (I) : 0.79 Date of planting (D) : 1.26 D at same level of I : N/A I at same level of D : N/A		

Total number of tubers per m^2 of potato was affected significantly by method of irrigation. Significantly, higher total number of tubers per m^2 (ranged from 11.72 to 10.80% harvested at 75 The present results are in conformity with the findings of Singh and Sood, (2013) and Mustafa *et al*., (2017) found more total number of tubers/ha of potato through sprinkler irrigation as compared to furrow irrigation. It may be due to less availability of soil moisture under furrow in comparison to micro-sprinkler irrigation method that reduced the total number of tubers per m^2 of potato whereas, significantly higher total number of tubers per m^2 (77.57 to 53.73% harvested at 75 DAP and 60.78 to 47.27% harvested at 90 DAP) was observed in potato planted on 15th October over one-month early potato planted on 15th September during 2017-18 and 2018-19, respectively. Similar trend of increased in total number of tubers per m^2 in timely planted potato was observed by Haile *et al*., (2015) and Dash *et al*., (2018). It may be due to the optimization of temperature favorable to increase total number of tubers at timely sown condition in comparison to warmer temperature at one month early planted crop of potato.

CONCLUSION

Based on the findings of this study, it is concluded that irrigation methods and planting dates had a significantly impact on numbers of different grades of potato. Micro-sprinkler irrigation with Kufri-Lima found superior to increase numbers of different grades of potato significantly i.e. Up to 25-50 g (17.51 & 29.23 %), Up to 50-75 (18.97 & 21.28 %), up to >75g (16.94 & 23.80 %) more were harvested at 75 DAP and 90 DAP, respectively, which was comparatively higher than furrow irrigation method. Likewise, optimum date and duration for planting for good numbers of different grades of potato are 15th October and 90 DAP with micro-sprinkler irrigation method, respectively. Finally, by following the conclusion, it is suggested that potato (Kufri-Lima) planted on 15th October and harvested at 90 under micro-sprinkler irrigation method to be a good for numbers of different grades of potato crop under Hisar conditions.

REFERENCES

Beals, K.A. (2019). Potatoes, Nutrition and Health. American Journal of Potato Research **96**:102–110.
Google Scholar

Bhan, S. and Dharma, C.S. (1982). Effect of frequency and method of irrigation on potato. *Indian Journal of Agronomy*, **27**: 227-30.
Google Scholar

Dash, S.N., Behera, S. and Pushpavathi, Y. (2018). Effect of Planting Dates and Varieties on Potato Yield. *International Journal of Current Microbiology for Applied Sciences*, **7**(3): 1868-1873.
Google Scholar

Drewnowski, A. and Rehm, C.D. (2013). Vegetable cost metrics show that potatoes and beans provide most nutrients per penny. *PloS One*, **8**(5): e63277.
Google Scholar

Haile, B., Mohammed, A. and Woldegiorgis, G. (2015). Effect of Planting Date on Growth and Tuber Yield of Potato (*Solanum tuberosum* L.) Varieties at Anderacha District, Southwestern Ethiopia. *International Journal of Research and Agricultural Sciences*, **2**(6): 2348-3997.
Google Scholar

Holzapfel, E.A., Merino, R., Marino, M.A. and Matta, R. (2000). Water production functions in kiwi. *Irrigation Science*, **19**: 73–79.
Google Scholar

Jamal, A., Ball, M.S. and Samims, T.W. (2001). Comparison of Sprinkler, trickle and furrow irrigation efficiencies for more onion production. *Agricultural Water Management*, **46**(3): 253-266.
Google Scholar

Mustafa, N.F., Sulaiman, S.M., Abdulrahman, A.M., Abdulaziz, B.A. and Khdir, J.H. (2017). Effect of different irrigation systems on irrigation water use efficiency, growth and yield of potato under bazian clay loam soil condition. *Journal of Duhok University*, 736-742.
Google Scholar

Pandey, S.K. and Sarkar, D. (2005). Potato in India: Emerging Trends and Challenges in the New Millennium. *Potato Journal*, **32**: 93-104.
Google Scholar

Pandey, S.K., Singh, J.P. and Gopal, J. (2008). Potato varieties and cropping systems in India. *Potato Journal*, **35**: 103-110.
Google Scholar

Pawar, D.D., Bhoi, P.G. and Shinde, S.H. (2002). Effect of irrigation methods and fertilizer levels on yield of potato (*Solanum tuberosum*). *Indian Journal of Agricultural Sciences*, **72**(2): 80-82.
Google Scholar

Saxena, R. and Mathur, P. (2013). Analysis of potato production performance and yield variability in India. *Potato Journal*, **40**(1): 38-44.
Google Scholar

Singh, B., Khera, K.L. and Sandhu, B.S. (1983). Response of autumn potato to method of irrigation application and planting. Indian J. Ecol. 10: 157-160.
Google Scholar

Singh, N. and Sood, M.C. (2013). Raised bed planting techniques for potato production under furrow and sprinkler irrigation methods. *Annals of Horticulture*, **6**(1): 45-48.
Google Scholar

Singh, R.B., Srivastva, K.K. and Paul, S.M. (2001). Effect on planting dates and temperature on development of potato stem necrosis disease. *Journal of Indian Potato Association*, **28**: 201-206.
Google Scholar

Thiele, G., Theisen, K., Bonierbale, M. and Walker, T. (2010). Targeting the poor and hungry with potato science. *Potato Journal*, **37**(3-4): 75–86.
Google Scholar

Touseef, H. (2016). Potatoes: Ensuring Food for the Future. *Advances in Plants and Agriculture Research*, **3**(6): 00117.
Google Scholar

Weaver, C. and Marr, E.T. (2013). White vegetables: a forgotten source of nutrients: Purdue roundtable executive summary. *Advances in Nutrition*, **4**(3): 318S-326S.
Google Scholar

Zhang, H., Fen, X., Yu, W., Hu, H.H. and Dai, X.F. (2017). Progress of potato staple food research and industry development in China. *Journal of Integrative Agriculture*, **16**(12): 2924-2932.
Google Scholar