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Mukesh Kumar
Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Arun Kumar Bhatia
Scientist, Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Correspondence
Mukesh Kumar
Department of Vegetable Science, CCS HAU, Hisar, Haryana, India

Effect of irrigation methods and planting dates on percent of emergence in potato (*Solanum tuberosum* L.)

Mukesh Kumar and Arun Kumar Bhatia

Abstract
The present investigation entitled "Effect of irrigation methods and planting dates on percent of emergence of potato (*Solanum tuberosum* L.)" was studied at Research farm of Department of Vegetable Science, CCS HAU, Hisar during the year 2017-18 and 2018-19. Among different irrigation methods, micro-sprinkler irrigation method (I_2) significantly enhance percent of emergence of potato (9.89 to 10.6% harvested at 75 DAP and 12.10 to 6.40% harvested at 90 DAP) over furrow irrigation method, whereas, among different dates of planting, 15th October (D_4) gave significantly higher percent of emergence of potato (91.25 and 94.50% harvested at 75 DAP and 94.50 and 93.75% harvested at 90 DAP) over rest of the other planting dates during 2017-18 and 2018-19, respectively. While comparing the interaction between irrigation method and date of planting, high percent of emergence of potato was observed in treatment D_4I_2.

Keywords: Potato, micro-sprinkler, furrow, percent of emergence, date of planting

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, Portuguese introduced it during 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 (Nath *et al.*, 2008, Pandey and Sarkar, 2005 and Touseef Hussa, 2016) [1-3]. 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*., 2016, FAOSTAT, 2017) [4-5]. 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) [6] and Singh and Rana, (2013) [7].

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 million tonnes and productivity 24.08 t/ha during 2017-18 (FAOSTAT, 2019) [8]. 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 percent of the total production of potato. The maximum area and production comes from Uttar Pradesh followed by West Bengal and Bihar, while maximum productivity comes from West Bengal followed by Gujarat (Anonymous, 2018) [9]. At national level during the last decade, the potato productivity and production grew by 1.10 and 5.98 percent per annum, respectively. The maximum growth in the area was observed in Bihar (12.74%) followed by Gujarat (9.53%), however, remarkable production growth was noticed in Bihar, Uttar Pradesh and Gujarat to the extent of 23.64, 15.10 and 12.39 percent, respectively (Saxena and Mathur, 2013) [10]. 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 tonnes, respectively, however, the productivity of this crop is still lower (25.85 t/ha) than the potential yield (Anonymous, 2019) [11].

Nutritionally, Potato contributes key nutrients to the diet including vitamin C, potassium, and dietary fiber (Weaver and Marr, 2013) [12]. 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) [13]. A medium-size potato (150 g) with the skin provides 27 mg of vitamin C, 620 mg of potassium, 0.2 mg of vitamin B_6 and trace amounts of thiamin, riboflavin, folate, niacin, magnesium, phosphorus, iron and zinc.

Potato is known for its carbohydrate content (approximately 26g in a medium-sized potato) represented by starch. A small but significant portion of this starch is resistant to digestion by enzymes in the stomach and small intestine, and reaches the large intestine intact (Cummings *et al.*, 1996) [14]. This resistant starch has physiological effects and health benefits similar to fiber and show promising physiological benefits in humans, which may result in prevention of various diseases. It provides bulk offer protection against colon cancer, improves glucose tolerance and insulin sensitivity, lowers plasma cholesterol and triglyceride concentrations, increases satiety, and possibly reduces fat storage (Hylla *et al.*, 1998, Raben *et al.*, 1994, Holt *et al.*, 1995, Geliebter *et al.*, 2013 and Akilen *et al.*, 2016) [15-19]. Besides the high nutritive value, it has great 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 per plant is greater at lower temperature than at higher temperatures, whereas higher temperature favour development of large tubers. The yield is maximum when the average day time temperature is about 21°C. The cool night is important because they affect the accumulation of carbohydrates and dry matter in the tubers. At lower night temperatures, respiration is slowed, which enhances storage of starch in the tubers (Pandey *et al.*, 2008 and Anonymous, 2013) [20-21]. Among various factors playing important role in deciding the production, productivity and keeping quality of the potato, the irrigation and date of sowing are most dominant ones. The water supply either in both excess or in deficit declines potato yield.

Several high yielding varieties have been developed and several agronomical practices on planting time, spacing, manorial, fertilizer requirements, water management and weed control have been investigated to increase the production of potato. The state has low and erratic rainfall during the winter season when potato is grown, the quality of underground water is also poor with only 39 percent of it is good quality and crops are grown with canal irrigation.

Further, where the underground water is of good quality, it is going down due to indiscriminate use through traditional irrigation method. Improper irrigation management practices not only waste the expensive and scarce water resources, but also decrease crop yield (Singh, 1987 and Imtiyaz *et al*., 2000) [22-23]. It is, therefore, essential to formulate an efficient, reliable and economically viable irrigation management strategy in order to irrigate more land area with the existing water resources to maintain optimum moisture in the effective root zone. It can be achieved best with the use of modern micro-irrigation system under limited water resources, particularly in semi-arid regions. However, drip irrigation has proven its potential to increase yield and water productivity, the climatic condition of this region seems more suitable to micro-sprinkler irrigation, as it protects the crops from adverse climatic conditions and help in better growth and yield (Spieler, 1994) [24]. 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 irrigation system is very useful in vegetable production, especially in row crops but information on 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. The use of drip and sprinkler irrigation can increase the potato yield by 20-40 percent and save up to 39 percent water (Pawar *et al*., 2002) [25]. 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) [26]. The better crop performance under micro-sprinkler could be attributed to minimum influence of frost, whitefly, nutrient leaching and minimizing fluctuation in soil moisture in effective root zone, which holds promise for increase in crop yield. It was visual observed that whitefly attack was not so severe under 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 better microclimate, which facilitated better photosynthesis, root aeration and plant growth, which resulted into higher yield (Holzapfel *et al*., 2000) [27]. Emergence of potato plant relatively positively affects the yield of tubers.

Material and Mathods

The present experiment entitled “Effect of irrigation methods and planting dates on yield of potato (*Solanum tuberosum* L.)” was conducted at 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:

Experiment 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 precipitation) recorded during the crop-growing seasons.

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.

Table 1: Physico-chemical composition of experimental field soil

Soil parameter	Values		Method of estimation
Mechanical composition			
Soil texture	Sandy-loam		Hydrometer method (Piper, 1967)
Sand (%)	55		
Silt (%)	34		
Clay (%)	11		
Chemical properties			
	2017-18	2018-19	
Soil pH (1: 2 soil water suspension)	7.8	7.9	Glass electrode pH meter method (Jackson, 1973)
EC (dSm^{-1} at 25ºC)	0.38	0.40	Conductivity bridge method (Richards, 1954)
Organic carbon (%)	0.48	0.50	Walkley and Black's wet Oxidation method (1934)
Available N (kg /ha)	142	151	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg /ha)	18.7	19.2	Olsen'smethod (Olsen *et al*., 1954)
Available K_2O (kg /ha)	488	492	Flame Photometer method (Richards, 1954)

It revealed from Table 1 that the texture of the soil of experimental field was sandy-loam and it is slightly alkaline in reaction. The fertility status of soil was medium in organic carbon, medium in available nitrogen and phosphorus but high in available potassium.

Previous Cropping History of Experimental Field

The previous history of the crops grown in the experimental field is presented in Table 2.

Table 2: Cropping history of the experimental field for last three years

Year	Season	
	Kharif	***Rabi***
2014-15	Eggplant	Coriander
2015-16	Eggplant	Coriander
2016-17	Eggplant	Coriander
2017-18	Eggplant	Potato*
2018-19	Blank	Potato*

*Experimental crop

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
Duration of crop : 75 days and 90 days

Experiment design and layout

The experimental was laid out in Split-plot Design (SPD) replicated four times. 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)

B. Sub-plot: Planting dates - Four
1. 1st September
2. 15th September
3. 30th September
4. 15th October

Table 3: Details of the treatments and notations used

5	Notation	Description
1.	$D_1 I_1$	Planted on1st September under furrow irrigation method
2.	$D_2 I_1$	Planted on15th September under furrow irrigation method
3.	$D_3 I_1$	Planted on30th September under furrow irrigation method
4.	$D_4 I_1$	Planting at 15th October under furrow irrigation method
5.	$D_1 I_2$	Planted on1st September under micro-sprinkler irrigation method
6.	$D_2 I_2$	Planted on15th September under micro-sprinkler irrigation method
7.	$D_3 I_2$	Planted on30th September under micro-sprinkler irrigation method
8.	$D_4 I_2$	Planted on15th 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. Field was ploughed twice with tractor drawn cultivator after harvest of the previous crop to crush clods. Field was ploughed by cross harrowing followed by 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:

Plant emergence (%) at 15, 20, 25 and 30 DAP
The count of plant emergence in each plot was recorded at 15, 20, 25 and 30 days after planting and was converted into percent.

$$\text{Plant emergence (\%)} = \frac{\text{Number of tubers sprouted per plot}}{\text{Total number of tubers planted per plot}} \text{ x } 100$$

Statistical analysis
The data observed for the various characters during the study were statistically analysed 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 percent level of significance.

Result
The results of field experiment entitled "Effect of irrigation methods and planting dates on yield of potato (*Solanum tuberosum* L.)" conducted at 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 the percent of emergence of potato was observed in timely planted over early planted potato and under the micro-sprinkler over furrow irrigation method harvested at 75 DAP or 90 DAP during both the years.

Plant emergence
Plant emergence (%) at 15 DAP
The perusal data presented in Table 04 shows that significantly highest plant emergence at 15 DAP of potato (13.50 and 20.12% at 75 DAP & 14.37 and 16.50% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded under micro-sprinkler irrigation method (I_2) over furrow irrigation method (I_1). Among different dates of planting, significantly highest plant emergence at 15 DAP (19.50 and 21.50% at 75 DAP & 23.50 and 24.50% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in potato planted on 15th October (D_4). While comparing the combinations of different dates of planting with different methods of irrigation, significantly highest plant emergence at 15 DAP (23.00 and 28.50% at 75 DAP & 26.50 and 24.50% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in treatment D_4I_2 (where potato planted on 15th October under micro-sprinkler irrigation) over rest of the other combinations. Lowest plant emergence of potato at 15 DAP was reported in treatment D_1I_1 (where potato planted on 1st September under furrow irrigation) followed by D_1I_2 (where potato planted on 1st September under micro-sprinkler irrigation).

Plant emergence (%) at 20 DAP
It is evident from Table 05 that significantly highest plant emergence at 20 DAP (41.37 and 61.25% at 75 DAP & 43.25 and 63.00% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded under micro-sprinkler irrigation method (I_2) over furrow irrigation method (I_1). Among different dates of planting, highest plant emergence at 20 DAP (57.50 and 65.00% at 75 DAP & 65.50 and 62.00% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in potato planted on 15th October (D_4), which was significantly higher over the rest of the other planting dates except D_3 (30th September) at 90 DAP during 2018-19. While comparing the combinations of different dates of planting with different methods of irrigation, highest plant emergence at 20 DAP (61.50 and 69.00% at 75 DAP & 69.50 and 67.50% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in treatment D_4I_2 (where potato planted on 15th October under micro-sprinkler irrigation), which was statistically at par with D_3I_2 (57.50%) at same level of irrigation at 75 DAP during 2017-18; D_3I_2 (68.50%) at same level of irrigation and D_4I_1 (61.00%) at same level of date of planting at 75 DAP during 2018-19; D_4I_1 (61.50%) at same level of date of planting at 90 DAP during 2017-18; and D_3I_2 (66.00%) and D_2I_2 (64.50%) at same level of irrigation at 90 DAP during 2018-19. Lowest plant emergence of potato at 20 DAP was reported in treatment D_1I_1 (where potato planted on 1st September under furrow irrigation) followed by D_1I_2 (where potato planted on 1st September under micro-sprinkler irrigation).

Plant emergence (%) at 25 DAP
Data mentioned in Table 06 depicts that significantly highest plant emergence at 25 DAP (69.50 and 79.50% at 75 DAP & 74.75 and 83.75% at 90 DAP during2017-18 and 2018-19, respectively) was recorded under micro-sprinkler irrigation method (I2) over furrow irrigation method (I1), whereas among different dates of planting, significantly highest plant emergence at 25 DAP (87.00 and 86.75% at 75 DAP & 90.25 and 89.50% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in potato planted on 15th October (D4) except on D3 (30th September) at 75 DAP during 2018-19 and at 90 DAP during both the years. While comparing the combinations of different dates of planting with different methods of irrigation, highest plant emergence at 25 DAP (90.50 and 91.50% at 75 DAP & 96.50 and 92.50% at 90 DAP) was recorded in treatment D4I2 (where potato planted on 15th October under micro-sprinkler irrigation) during 2017-18 and 2018-19, respectively which was statistically at par with D3I2 (89.00%) and D2I2 (76.50%) at same level of

Table 4: Effect of irrigation methods and planting dates on per cent plant emergence at 15 DAP in potato

Irrigation methods /Planting dates	Harvested at 75 DAP						Harvested at 90 DAP					
	2017-18			2018-19			2017-18			2018-19		
	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean
1st September (D_1)	1.50	3.00	2.25	1.00	12.50	6.75	0.50	2.00	1.25	3.00	7.50	5.25
15th September (D_2)	7.50	11.00	9.25	3.50	19.00	11.25	4.50	13.00	8.75	05.00	15.00	10.00
30th September (D_3)	10.00	17.00	13.50	11.50	20.50	16.00	10.50	16.00	13.25	10.50	19.00	14.75
15th October (D_4)	16.00	23.00	19.50	14.50	28.50	21.50	20.50	26.50	23.50	18.00	24.50	21.25
Mean	8.75	13.50		7.62	20.12		9.00	14.37		9.12	16.50	
CD at 5% level of significance	Irrigation (I): 2.18 Date of planting (D): 2.53 D at same level of I: NS I at same level of D: NS			I Irrigation (I): 2.13 Date of planting (D): 2.09 D at same level of I: 3.33 I at same level of D: 3.26			I Irrigation (I): 2.46 Date of planting (D): 3.10 D at same level of I: NS I at same level of D: NS			Irrigation (I): 2.96 Date of planting (D): 1.80 D at same level of I: 03.15 I at same level of D: 03.61		

Table 5: Effect of irrigation methods and planting dates on per cent plant emergence at 20 DAP in potato

Irrigation methods/ Planting dates	Harvested at 75 DAP						Harvested at 90 DAP					
	2017-18			2018-19			2017-18			2018-19		
	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean
1st September (D_1)	4.00	5.00	4.50	23.50	51.00	37.25	4.50	6.00	5.25	32.00	54.00	43.00
15th September (D_2)	30.00	41.50	35.75	32.50	56.50	44.50	36.00	52.00	44.00	43.50	64.50	54.00
30th September (D_3)	38.00	57.50	47.75	41.00	68.50	54.75	46.50	53.50	50.00	54.00	66.00	60.00
15th October (D_4)	53.50	61.50	57.50	61.00	69.00	65.00	61.50	69.50	65.50	56.50	67.50	62.00
Mean	31.37	41.37		39.50	61.25		37.12	43.25		46.5	63.00	
CD at 5% level of significance	Irrigation (I): 4.75 Date of planting (D): 4.18 D at same level of I: 6.77 I at same level of D: 6.83			Irrigation (I): 2.18 Date of planting (D): 7.15 D at same level of I: 10.25 I at same level of D: 8.99			Irrigation (I): 6.11 Date of planting (D): 4.82 D at same level of I: 7.98 I at same level of D: 8.29			Irrigation (I): 9.70 Date of planting (D): 4.57 D at same level of I: 8.46 I at same level of D: 10.96		

Irrigation and D_4I_1 (82.00%) at same level of date of planting at 75 DAP during 2018-19; D_3I_2 (91.00%) at same level of irrigation and D_4I_1 (84.00%) at same level of date of planting at 90 DAP during 2017-18; and D_3I_2 (92.00%), D_2I_2 (87.00%) at same level of irrigation and D_4I_1 (86.50%) at same level of date of planting at 90 DAP during 2018-19. Lowest plant emergence of potato at 25 DAP was reported in treatment D_1I_1 (where potato planted on 1st September under furrow irrigation) followed by D_1I_2 (where potato planted on 1st September under micro-sprinkler irrigation).

Plant emergence (%) at 30 DAP

Data presented in Table 07 indicates that significantly highest plant emergence at 30 DAP (75.00 and 86.00% at 75 DAP & 75.87 and 85.12% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded under micro-sprinkler irrigation method (I_2) over furrow irrigation method (I_1). Among different dates of planting, significantly highest plant emergence at 30 DAP (91.25 and 94.50% at 75 DAP & 94.50 and 93.75% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in potato planted on15th October (D_4) except on D_3 (30th September) at 75 DAP during both years and at 90 DAP during 2018-19. While, comparing the combinations of different dates of planting with different methods of irrigation, highest plant emergence at 30 DAP (93.50 and 96.00% at 75 DAP & 96.50 and 94.50% at 90 DAP during 2017-18 and 2018-19, respectively) was recorded in treatment D_4I_2 (where potato planted on 15th October under micro-sprinkler irrigation) which was statistically at par with D_3I_2 (94.00%) and D_2I_2 (91.50%) at same level of irrigation and D_4I_1 (93.00%) at same level of date of planting at 75 DAP during 2018-19; D_3I_2 (91.00%) at same level of irrigation and D_4I_1 (92.50%) at same level of date of planting at 90 DAP during 2017-18; and D_3I_2 (93.00%) and D_2I_2 (89.50%) at same level of irrigation and D_4I_1 (93.00%) at same level of date of planting at 90 DAP during 2018-19. Lowest plant emergence of potato at 30 DAP was reported in treatment D_1I_1 (where potato planted on 1st September under furrow irrigation) followed by D_1I_2 (where potato planted on 1st September under micro-sprinkler irrigation).

Discussion

In the present investigation, significantly higher plant emergence at 15 DAP of potato (ranged from 54.28 to 164.04 % harvested at 75 DAP and 59.6 to 80.92% harvested at 90 DAP) was observed under micro-sprinkler irrigation method over furrow irrigation during 2017-18 and 2018-19, respectively. Similar finding of increased in plant emergence of potato by micro-sprinkler irrigation method over furrow irrigation method. whereas, significantly higher plant emergence at 15 DAP of potato (ranged 91.11 to 110.81% harvested at 75 DAP and 112.5 to 168.57% harvested at 90 DAP) was observed in potato planted on 15th October over one month early potato planted on15th September during 2018-19 and 2017-18, respectively. Similar trend of increased in plant height in timely planted potato was observed by Thongam *et al.*, (2017), Singh *et al.*, (2018) and Dash *et al.*, (2018) [28-30].

Similar trend of increased in plant emergence of potato at 20 DAP (ranged from 31.87 to 55.06% harvested at 75 DAP and 16.51 to 35.48% harvested at 90 DAP), at 25 DAP (ranged from 17.56 to 24.71% harvested at 75 DAP and 17.61 to 19.43% harvested at 90 DAP) and at 30 DAP (ranged from 9.89 to 10.61% harvested at 75 DAP and 12.10 to 6.04% harvested at 90 DAP) was observed under micro-sprinkler irrigation method over furrow irrigation method during 2017-18 and 2018-19, respectively.

Table 6: Effect of irrigation methods and planting dates on per cent plant emergence at 25 DAP in potato

Irrigation methods /Planting dates	Harvested at 75 DAP						Harvested at 90 DAP					
	2017-18			2018-19			2017-18			2018-19		
	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean
1st September (D_1)	17.50	21.00	19.25	27.50	61.00	44.25	15.00	23.50	19.25	47.50	63.50	55.50
15th September (D_2)	57.50	81.00	69.25	70.00	76.50	73.25	74.75	88.00	81.37	68.00	87.00	77.50
30th September (D_3)	78.00	85.50	81.75	75.50	89.00	82.25	80.50	91.00	87.75	78.50	92.00	85.25
15th October (D_4)	83.50	90.50	87.00	82.00	91.50	86.75	84.00	96.50	90.25	86.50	92.50	89.50
Mean	59.12	69.50		63.75	79.50		63.56	74.75		70.12	83.75	
CD at 5% level of significance	Irrigation (I): 1.82 Date of planting (D): 4.89 D at same level of I: 7.06 I at same level of D: 6.23			Irrigation (I): 5.92 Date of planting (D): 5.56 D at same level of I: 8.91 I at same level of D: 8.83			Irrigation (I): 5.93 Date of planting (D): 5.38 D at same level of I: NS I at same level of D: NS			Irrigation (I): 9.01 Date of planting (D): 4.61 D at same level of I: 8.38 I at same level of D:10.39		

Table 7: Effect of irrigation methods and planting dates on per cent plant emergence at 30 DAP in potato

Irrigation methods /Planting dates	Harvested at 75 DAP						Harvested at 90 DAP					
	2017-18			2018-19			2017-18			2018-19		
	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean	Furrow (I_1)	Micro-sprinkler (I_2)	Mean
1st September (D_1)	19.00	23.00	21.00	48.00	62.50	55.25	17.00	28.00	22.50	51.00	63.50	57.25
15th September (D_2)	79.50	90.50	85.00	82.00	91.50	86.75	74.75	88.00	81.37	85.50	89.50	87.50
30th September (D_3)	85.50	93.00	89.25	88.00	94.00	91.00	86.50	91.00	88.75	90.50	93.00	91.75
15th October (D_4)	89.00	93.50	91.25	93.00	96.00	94.50	92.50	96.50	94.50	93.00	94.50	93.75
Mean	68.25	75.00		77.75	86.00		67.68	75.87		80.00	85.12	
CD at 5% level of significance	Irrigation (I): 3.67 Date of planting (D): 4.12 D at same level of I: NS I at same level of D: NS			Irrigation (I): 3.83 Date of planting (D): 3.71 D at same level of I: 5.91 I at same level of D: 5.82			Irrigation (I): 4.71 Date of planting (D): 3.80 D at same level of I: 6.27 I at same level of D: 6.47			Irrigation (I): 5.01 Date of planting (D): 3.88 D at same level of I: 6.45 I at same level of D: 6.75		

It may be due to uniform availability of water under micro-sprinkler irrigation method that enhanced the per cent plant emergence.

Likewise, similar trend of increased in plant emergence of potato at 20 DAP (ranged from 46.06 to 60.84% harvested at 75 DAP and 14.81 to 48.86% harvested at 90 DAP), at 25 DAP (ranged from 18.43 to 25.63% harvested at 75 DAP and 15.48 to 10.91% harvested at 90 DAP) and at 30 DAP (ranged from 8.93 to 7.35% harvested at 75 DAP and 7.14 to 16.14% 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. It may be due to the optimization of temperature favourable to plant emergence of potato at timely sown condition in comparison to warmer temperature at one month early planted crop of potato.

Conclusion

Based on the present experimental results, it is concluded that irrigation methods and planting dates significantly influenced on percent of potato crop emergence. Micro-sprinkler irrigation found superior to increase the percent of emergence significantly and to give a high percent of emergence of potato, which was comparatively higher than the percent of emergence of potato under furrow irrigation method.

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