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Impact of irrigation methods and nitrogen levels on growth and yield of potato in Haryana

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Abstract
Present investigation was carried out on influence of irrigation methods and nitrogen levels on plant growth and tuber yield of potato cultivar Kufri Bahar. The experiment was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during *Rabi* season of 2015-16 and 2016-17. The treatments comprising of irrigation methods (drip and furrow) and five doses of nitrogen (60, 80, 100, 120 and 140% of RDN) were laid out in split plot design with three replications. The irrigation methods showed significant differences in all the treatments in both the years. The maximum value for percent plant emergence, number of shoots per hills, plant height (cm), foliage weight (kg/m^2) and total tuber yield (q/ha) were recorded with 100% of RDN and drip irrigation. Hence, 100% of RDN with drip irrigation condition have shown the best treatment combination for potato production under semiarid conditions of Hisar, Haryana.

Keywords: Fertigation, growth parameters, irrigation methods, nitrogen, potato, yield

Introduction
In India, potato was first introduced by the Portuguese traders in 17th century and its cultivation were further extended to North India by the Britishers (Nath *et al.*, 2008, Pandey and Sarkar, 2005) [10, 12]. Presently, India is the second largest producer of potato in the world after China and the crop occupie 21.17 lakh hactares with a production of 434.17 lakh million tonnes and productivity 21.00 t/ha during 2015-16 (Anonymous; 2016) [1]. Potato is a temperate region crop but there is great variation in the gene pool with respect to crop response to thermoperiods. Generally, potato crop is raised in India when maximum temperature is below 35°C and the minimum temperature is below 20°C with ideal tuberization temperature between 16-22°C. Potato can be grown on alluvial, black, red and laterite soils having pH in the range of 5.5-8.0 (Pandey, 2007) [11]. Among various factors playing important role in deciding the production, productivity and keeping quality of the potato, the irrigation and fertilization are most dominant ones. The water either supply in both excess or in deficit declines potato yield. Improper irrigation management practices not only waste the expensive and scare water resources but also reduce the tuber yield and quality.
Sound water management has the potential to improve nutrient use efficiency. The introduction of well-tested, efficient fertilizer application through irrigation water or "fertigation" techniques could help turn vast areas of arid and semi-arid land in many parts of the world into farmland, as well as preventing water from being wasted in conventional irrigation systems. Drip irrigation has the greatest potential for the efficient use of water and ferlilizers. The limited area of wetting under trickle irrigation reduces the active root zone and also the foraging area of plants to draw water and nutrients from the soil. For minimizing the cost of irrigation and fertilizers, adoption of drip irrigation with fertigation is essential which will maximize the nutrient uptake, while using minimum amount of water and fertilizer, minimum loss of N due to leaching, supplying nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost. Thus, fertigation becomes prerogative for increasing the yield of most of the crops under drip irrigation.

Materials and Methods
The experiment comprising of two irrigation methods, *i.e.*, drip irrigation (I_1) and furrow irrigation (I_2) and five levels of nitrogen, *i.e.*, 60% of RDN (N_1), 80% of RDN (N_2), 100% of RDN (N_3), 120% of RDN (N_4) and 140% of RDN (N_5) was carried out at Vegetable Research Farm CCSHAU, Hisar during *Rabi* seasons 2015-16 and 2016-17. The treatments were laid out in split plot design with three replications. The net plot size was 3.60 × 3.60 m. The air temperature (°C), relative humidity (%) and the sum of precipitation (mm) during the potato

vegetation period at the experimental field are summarized in Figure 1. Farm yard manure (FYM) @ 50 t/ha was applied prior to field preparation and full dose of phosphorus and potash were applied as basal dose. Potato tubers of *cv*. Kufri Bahar were planted at 60×20 cm spacing in the last week of October. A common irrigation was applied immediately after planting in all the treatments through conventional furrow method for uniform and rapid germination. The differential drip fertigation treatments were started 20 days after planting and different doses of nitrogen was applied in seven split doses through fertigation in drip irrigation and broadcast in furrow irrigation method. The percent plant emergence, number of shoots per hills, plant height (cm), foliage weight (kg/m^2) and total tuber yield (q/ha) were recorded.

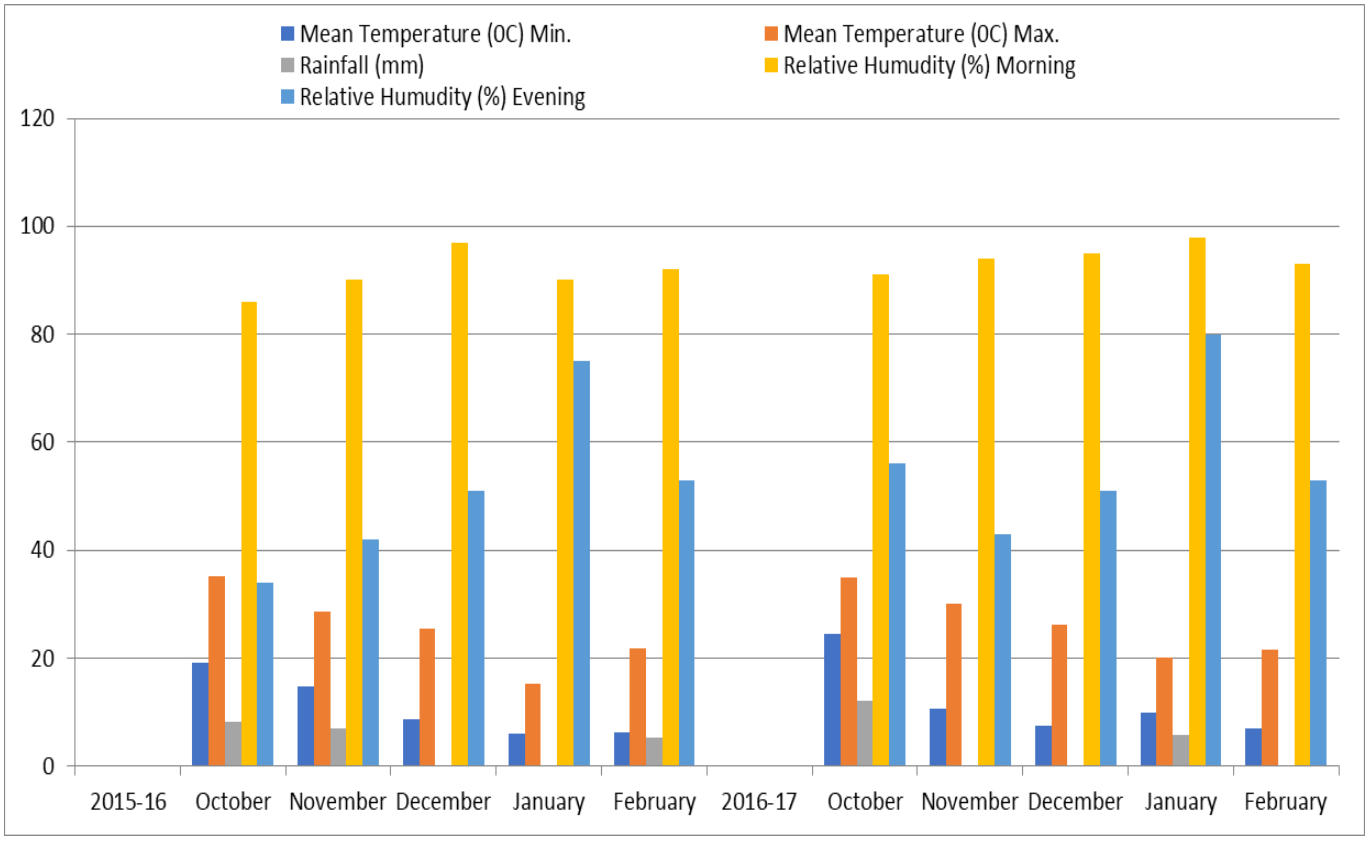

Fig 1: The air temperature (ºC), relative humidity (%) and sum of precipitation (mm) during the potato vegetation period at the experimental field.

Results and Discussion

Plant emergence (%) at 30 days after

In the present study, the mean percent plant emergence at 30 days after planting was increased with nitrogen level up to 100% of recommended dose of nitrogen (RDN) and thereafter it decreased. The maximum plant emergence (95.82% and 96.50%) was accounted under 100% of RDN during 2015-16 and 2016-17, respectively (Table 1). The differences in effect of irrigation methods at same level of RDN and of RDN at same irrigation method were found significant for plant emergence at 30 days after planting during both the years. The maximum plant emergence (97.30% and 98.00%) was observed under drip irrigation with 100% of RDN during 2015-16 and 2016-17, respectively. There was significant effect of interactions among the treatments. The results of the present study are in agreement with the findings of Singh and Lal (2012) [16] who noted that plant emergence in potato varied from 90 to 98 percent, however, the difference was not significant. On the other hand, Verma *et al.* (2013) [16] reported that the emergence of plant in potato ranged from 86.5 to 91.6 percent.

Number of shoots per hill at 30 days after planting

The number of shoots per hill depends upon the uptake of nutrients by the plant at early stages of crop growth and availability of space for the spread of plant and it was affected significantly by nitrogen levels. The data pertaining to number of shoots per hill at 30 days after planting have been described in Table 1. In 2015-16, the nitrogen levels differed significantly from each other with respect to number of shoots per hill, whereas, there were no significant difference in number of shoots per hill at different nitrogen levels during 2016-17. The uppermost mean value for the number of shoots per hill (4.85 and 4.65 per hill) was recorded with 100% of RDN during 2015-16 and 2016-17, respectively. Different irrigation methods also showed significant difference with respective to number of shoots per hill at 30 days after planting during 2015-16, while there was no significant difference in number of shoots per hill at different irrigation methods during 2016-17. There was a greater number of shoots per hill under drip irrigation method than the furrow method of irrigation.

The interaction effect of irrigation method at same level of RDN and of RDN at same irrigation method was found non-significant for number of shoots per hill at 30 days after planting. The present results corroborate the findings of Hooda and Pandita (1980) [4], Kumar *et al.* (2002) [8] and Sandhu *et al.* (2008) [13] who reported that the shoots per unit area increased with each increase in fertilizer dose up to 100% of RDN. Similarly, Suman *et al.* (2003) [18] also observed maximum number of shoots with fertilizer dose of 150:90:90 kg/ha. Nandekar *et al.* (2006) [9] also indicated the same trend. However, Singh *et al.* (2010) [15] found non-significant effect on stem number per plant with varied irrigation and split application of nitrogen in different potato cultivars.

Plant Height (cm)

A perusal of data presented in Table 2 reveals that the mean effects of different nitrogen levels did not differ significantly with respect to plant height at 30 days after planting in potato crop during 2015-16, whereas, in 2016-17, the mean values of plant height at 30 days after planting differed significantly with respect to nitrogen levels. The maximum mean value of plant height was measured at 100% of RDN that was 8.10 and 9.20 cm during 2015-16 and 2016-17, respectively. The differences in mean value of plant height at 30 days after planting were significant under different irrigation methods during 2015-16, while non-significantly difference was observed during 2016-17.

The effects of irrigation methods at same level of RDN and of RDN at same irrigation methods were not significant for plant height at 30 days after planting.

The average height of potato plants at 60 days after planting improved considerably with the increase in nitrogen levels up to 100% of RDN. In the year 2015-16, the tallest plants (39.48 cm) were registered with 100% of RDN, which was statistically at par with 120% of RDN (38.80 cm) and 140% of RDN (38.25 cm). In 2016-17, the highest value for mean plant height was recorded at 100% of RDN (41.72 cm) followed by 120% of RDN (40.23 cm), which differed significantly. There were also significant differences between mean plant height at 60 days after planting with irrigation methods, which was maximum with drip irrigation method (38.87 and 39.81 cm) during 2015-16 and 2016-17, respectively.

The interaction effects of irrigation methods at same level of RDN and of RDN at same irrigation method were also found significant for plant height at 60 days after planting. Under drip irrigation, the plant height at 60 days after planting increased with nitrogen level up to 100% of RDN and then decreased, whereas, under furrow irrigation method, the plant height at 60 days after planting was increased with increased level of nitrogen during both the years. The tallest plants (41.38 cm) at 60 days after planting was measured with 100% of RDN under drip irrigation, which was followed by 120% of RDN (39.38 cm) under same irrigation during 2015-16. Similarly, in 2016-17, the maximum plant height at 60 days after planting was recorded in 100% of RDN (44.25 cm) under drip irrigation, which was followed by 120% of RDN (41.17 cm) and 80% of RDN (41.09 cm) under the same irrigation method, which differed significantly.

These results are in conformation with the findings of Shunka *et al*. (2017) [14] who reported that the maximum plant height was attained under the application of 133 kg/ha nitrogen at Holetta, Ethiopia. Nandekar *et al*. (2006) [9]; Khurana and Bhatia (2008) [6] also observed increased plant height with increasing fertilizer levels.

Foliage Weight (kg/m^2)

The data presented in Table 3 revealed that all the nitrogen levels and irrigation methods differed significantly during both the years with respect to foliage weight of potato crop. The mean value of foliage weight significantly increased with the increase levels of nitrogen levels up to 100% of RDN and thereafter it decreased. This might be due to more availability of nutrients and increased uptake of nutrients. The maximum mean value of foliage weight (1.34 and 1.04 kg/m^2) was recorded and differed significantly, which was followed by 120% (0.93 and 0.98 kg/m^2) of RDN during 2015-16 and 2016-17, respectively. Drip irrigation method showed significantly higher foliage weight (1.02 kg/m^2) than furrow irrigation during 2015-16. In general, on an average, drip irrigation produced higher foliage weight of plant than furrow method of irrigation during both the years up to 120% of RDN.

The interaction effect of irrigation method at same level of RDN and of RDN at same irrigation method was found significant on foliage weight in potato crop. There was significantly increased trend of 100% of RDN under drip irrigation method and the maximum foliage weight (1.97 kg/m^2) was observed under drip irrigation with 100% of RDN. It was followed by 80% of RDN (1.01 kg/m^2) and 120% of RDN (1.01 kg/m^2) under the same irrigation method during 2015-16, whereas, in furrow method, there was a significant increase in foliage weight with increased levels of nitrogen fertilizer and the highest foliage weight was recorded under 140% of RDN during 2015-16.

These results are not in agreement with the findings of Sandhu *et al.* (2008) [13], Chaurasia and Singh (1996) [2], Singh and Mangal (1996) [17] and Yadav *et al.* (2003) [20] who reported maximum foliage weight with 100 kg N/ha in potato.

Total tuber yield

The total tuber yield for different irrigation methods and different nitrogen levels differed significantly in both the years (Table 3). The interaction effect of irrigation method at same level of RDN and of RDN at same irrigation method was found significant for total tuber yield in potato crop. The total tuber yield with regards to nitrogen levels during 2015-16 and the maximum yield (279.93 q/ha) was recorded at 100% of RDN. Similar trend was found during 2016-17 and it was maximum in 100%. The maximum total tuber yield of 300.80 q/ha was recorded with 100% of RDN, which was followed by 140% of RDN (278.70 and 298.03q/ha) and 120% of RDN (277.41 and 296.45 q/ha) during 2015-16 and 2016-17, respectively. Under drip irrigation method, the total tuber yield was significantly higher (303.22 and 307.32 q/ha) than furrow method of irrigation during 2015-16 and 2016-17, respectively. Among the irrigation methods, the maximum total tuber yield during 2015-16 (320.46 q/ha) and 2016-17 (323.25 q/ha) was observed under drip irrigation with 100% of RDN. The results confirm the findings of Kashyap and Panda (2002) [5] and Kumar *et al.* (2009) [7] who recorded significantly higher potato tuber yield under micro- sprinkler irrigation than furrow irrigation method. Hanson *et al.* (1997) [3] observed that frequent watering resulted in to higher water potential, thus minimizing fluctuation in soil moisture in the effective root zone, which resulted increase in yield.

Table 1: Effect of different nitrogen levels and irrigation methods on plant emergence (%) and number of shoots per hill at 30 after planting in potato crop

Nitrogen levels	Plant emergence (%)						Number of shoots per hill					
	2015-16			2016-17			2015-16			2016-17		
	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean
N_1	94.90	92.00	93.45	94.00	93.00	93.50	4.00	3.33	3.67	4.40	4.57	4.48
N_2	95.92	93.00	94.46	96.00	94.00	95.00	4.40	3.57	3.98	4.40	4.07	4.23
N_3	97.30	94.33	95.82	98.00	95.00	96.50	6.23	3.47	4.85	5.12	4.18	4.65
N_4	96.19	94.67	95.43	97.00	95.67	96.33	5.50	3.29	4.40	4.67	4.37	4.52
N_5	95.50	94.80	95.15	95.00	97.00	96.00	4.53	4.03	4.28	4.27	4.07	4.17
Mean	95.96	93.76		95.80	95.13		4.39	3.54		4.47	4.35	
CD at 5% level	N: 1.25			N: 1.4			N: 0.30			N: NS		
	I: NS			I: NS			I: 0.30			I: NS		
	I at same level of N: 3.28			I at same level of N: 1.93			I at same level of N: NS			I at same level of N: NS		
	N at same level of I: 2.70			N at same level of I: 2.11			N at same level of I: NS			N at same level of I: NS		

N- Nitrogen levels, I-irrigation methods, RDN – recommended dose of nitrogen, CD- critical difference

Table 2: Effect of different nitrogen levels and irrigation methods on plant height (cm) at 30 and 60 after planting in potato crop

Nitrogen levels	Plant height (cm) at 30 DAP						Plant height (cm) at 60 DAP					
	2015-16			2016-17			2015-16			2016-17		
	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean	Drip Irrigation (I_1)	Furrow Irrigation (I_2)	Mean
N_1	7.16	6.12	6.64	7.26	7.18	7.22	38.06	32.14	35.10	36.43	37.17	36.80
N_2	8.27	7.03	7.65	8.85	8.07	8.46	38.26	34.26	36.16	41.09	37.28	39.18
N_3	9.03	7.17	8.10	10.23	8.18	9.20	41.38	37.59	39.48	44.25	39.19	41.72
N_4	8.57	7.05	7.81	9.17	8.65	8.91	39.38	38.22	38.80	41.17	39.29	40.23
N_5	7.30	7.36	7.33	7.51	9.06	8.28	37.25	39.25	38.25	38.10	40.16	39.13
Mean	8.07	6.95		8.41	8.23		38.87	36.29		39.81	38.42	
CD at 5% level	N: NS			N:0.95			N: 1.52			N: 1.20		
	I: 0.756			I: NS			I: 1.68			I: 1.21		
	I at same level of N: NS			I at same level of N: NS			I at same level of N: 2.41			I at same level of N: 1.84		
	N at same level of I: NS			N at same level of I: NS			N at same level of I: 2.50			N at same level of I: 1.94		

N- Nitrogen levels, I-irrigation methods, RDN – recommended dose of nitrogen, CD- critical difference

Table 3: Effect of different nitrogen levels and irrigation methods on foliage weight (km/ m^2) and total tuber yield (q/ ha) in potato crop

Nitrogen levels	Foliage weight (km/ m^2)						Total tuber yield (q/ ha)					
	2015-16			2016-17			2015-16			2016-17		
	Drip irrigation (I_1)	Furrow irrigation (I_2)	Mean	Drip irrigation (I_1)	Furrow irrigation (I_2)	Mean	Drip irrigation (I_1)	Furrow irrigation (I_2)	Mean	Drip irrigation (I_1)	Furrow irrigation (I_2)	Mean
N_1	0.81	0.56	0.68	0.75	0.71	0.73	282.89	228.15	255.52	292.51	258.73	275.62
N_2	1.01	0.66	0.83	0.90	0.85	0.88	309.31	234.12	271.71	300.58	268.80	284.69
N_3	1.97	0.72	1.34	1.17	0.90	1.04	320.46	239.40	279.93	323.25	278.36	300.80
N_4	1.01	0.85	0.93	0.96	0.99	0.98	306.21	248.61	277.41	313.17	279.73	296.45
N_5	0.85	0.91	0.88	0.83	1.05	0.94	302.23	257.17	278.70	312.08	283.98	298.03
Mean	1.02	0.74		0.92	0.90		303.22	241.89		307.32	273.92	
CD at 5% level	N: 0.03			N:0.03			N: 5.90			N: 6.27		
	I: 0.02			I: NS			I: 6.81			I: 8.27		
	I at same level of N: 0.04			I at same level of N: 0.05			I at same level of N: 5.37			I at same level of N: 6.26		
	N at same level of I: 0.04			N at same level of I: 0.05			N at same level of I: 6.26			N at same level of I: 7.24		

N- Nitrogen levels, I-irrigation methods, RDN – recommended dose of nitrogen, CD- critical difference

Conclusion

Based on the present experimental results, it is concluded that the irrigation method and nitrogen levels improved the growth and yield of potato crop. Drip irrigation (I_1) with 100% of RDN (N_3) was found superior to increase growth significantly and to give maximum total tuber yield of potato, which was comparatively higher than the yield of potato under furrow irrigation method. In 2015-16 tuber yield was increased 20.22% in drip irrigation than the furrow irrigation, while 10.55% increased tuber yield was noticed in year 2016-17.

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