



Optimizing Sowing Windows and Irrigation Schedules to Enhance Growth and Productivity of Potato Crop

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Authors' contributions

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

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ABSTRACT

Potato is the world's fourth most important staple food crop with significant role in global food and nutritional security. The field study was carried out at research farm of Department of Agronomy, CSK HPKV, Palampur. The present field investigation was conducted to evaluate the effect of

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various sowing windows (10th December, 2020; 30th December, 2020; and 10th January, 2021) and irrigation schedules (2, 3, 4 and 5 irrigations) on potato growth and productivity. The study was conducted in a randomized block design with factorial arrangement, 12 treatments and 3 replications. The results of the investigation revealed that higher plant height, number of leaves, shoots, tubers per plant, average tuber weight and tuber yield were recorded for the 10th December sown crop whereas irrigation schedule consisting of 5 irrigations resulted in the higher plant height, number of leaves, shoots, tubers per plant, average tuber weight and tuber yield for potato crop. However, 10th January sown crop and 2 or 3 irrigation-based schedules resulted in the lowest plant height, number of leaves, shoots, tubers per plant, average tuber weight and tuber yield for the potato crop. Therefore, it can be recommended that sowing the crop on 10th December and following a 5- irrigation based schedule can result in enhanced growth and tuber yield for the potato crop.

Keywords: Growth; irrigation; potato; sowing windows; tuber.

1. INTRODUCTION

Potato (*Solanum Tuberosum* L.) has been a highly valuable and prominent crop for food and nutritional security across the globe (Rana et al., 2004). Potato has been advocated primarily for carbohydrate, mineral and vitamin supply at considerable rates. Potato is cultivated widely across various countries of the globe with 16.8 million hectares cultivation area, production and productivity of around 383 million tonnes and 22 ton per hectare, respectively (FAOSTAT, 2025). Potato also occupies a significant place in food value chain of Indian population. Potato is cultivated over an area of 2.3 million hectare with production and productivity of around 60.1 million tonnes and 25.8 ton per hectare, respectively (FAOSTAT, 2025).

Crop production systems are facing a significant issue of climate change in the 20th century (Mrabet et al., 2023; Verma et al., 2023, Sharma et al., 2024b). Rising temperatures and fluctuating rainfall regimes under the scenario of climate change has influenced magnitude of water resources, crop water availability and crop demand (Rana et al., 2013; Rana et al., 2018; Pareek et al., 2021). Among cultivated crops, C3 crops like potato are highly vulnerable to the issue of climate change. Several scientific investigations have advocated malign effects of temperatures and rainfall regimes on crop productivity. Optimum growing conditions for potato includes temperature regimes of 14-18 °C wherein rising temperatures above 28 °C leading to substantial reduction in potato productivity (Kirina et al., 2025; Rana et al., 2025; Sharma et al., 2025). Rising temperatures may have several effects on photosynthesis, respiration, sprouting and tuber formation in potato crop (Rai and Dong, 2025). Apart from rising temperatures,

fluctuating rainfall regimes may highlight vulnerability of potato crop to drought and waterlogging conditions severely due to shallow rooting system of the crop (Rana et al., 2021; Naik et al., 2024; Sharma et al., 2024a). Therefore, water application based on prevailing climatic conditions *i.e.*, evapotranspiration-based irrigation scheduling can play a significant role in optimizing crop productivity levels (Kumar et al., 2024). Several field investigations have reported significant effects of evapotranspiration-based irrigation scheduling on potato growth and productivity. Apart from climatic condition-based irrigation scheduling, optimizing sowing windows may play a substantial role in improving crop productivity levels (Pathania et al., 2018; Pathania et al., 2019; Chandel et al., 2022).

Altering the sowing window of potato crops can significantly influence their exposure to variable climatic conditions, subsequently impacting biomass accumulation (Singh et al., 2023; Pareek et al., 2023; Kumar et al., 2024). Early sowing or planting of potato has been reported to expose potato crop to higher temperatures especially at reproductive or flowering stages leading to reduced tuber yield levels. Similarly, late planting of potato crop may lead to reduced biomass accumulation and subsequently lower tuber yield. Similarly, optimizing sowing windows of wheat crop significantly improved wheat yield levels considerably with the highest grain yield levels for wheat crop sown on 15th October under conditions of North-western Himalayas of Himachal Pradesh (Salaria et al., 2024a; Choudhary et al., 2024).

Therefore, keeping in consideration the potential of sowing windows and irrigation schedules in influencing potato yield levels, the field investigation was conducted to evaluate the

effect of various sowing dates and irrigation schedules on potato growth and productivity.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field study was carried out at research farm of Department of Agronomy, CSK HPKV, Palampur. The experimental field was located at an elevation of 1290.8 m above mean sea level. The experimental field was located at 32°6' N latitude and 76°3' E longitude. The experimental site was characterized agro-climatically for its mild summers, severe winters and high rainfall. During the cropping season of the field investigation, the average weekly maximum and minimum temperature ranged between 0.83 to 16.57°C and 15.93 to 26.79 °C, respectively. The relative humidity during the cropping season varied between 48.57 to 80.14 percent, respectively.

The soil at the experimental site was analyzed before sowing of crop and it was observed that the soil at the experimental site was silty clay loam in texture with an acidic pH of 5.4 and soil organic carbon content of 0.67 percent, whereas the available nitrogen, phosphorus, and potassium content were 257 kg ha⁻¹, 17.9 kg ha⁻¹, and 183.2 kg ha⁻¹, respectively.

2.2 Experimental Design

The present field experiment was laid in a randomized block design involving 12 treatments with three replications for each. The treatment combinations were based on three sowing dates and four irrigation schedules. Three sowing dates involved were: December 10th, 2020; December 30th, 2020; January 10th, 2021, with four irrigation regimes included: limited irrigations (2 irrigations), three irrigations, four irrigations and five irrigations. The crop variety *Kufri Jyoti* was sown with row to plant spacing of 50 cm and 20 cm, respectively. The potato variety was sown with all recommended agronomic practices, except the different dates of sowing and irrigation schedules which were modified as per the experimental design to study their influence on growth and productivity of potato.

2.3 Data Collection and Analysis

The data for plant height, number of shoots per plant, number of leaves per plant and leaf area index, number of tubers per plant were collected using five randomly selected plants from net plot area. Similarly, the data for average tuber weight

was collected using ten different tubers of different grades. The tuber yield was determined by collecting and weighing tubers from net plot area and converting the yield as quintals per hectare. The data was analyzed using OPSTAT as per Gomez and Gomez, 1984 standard protocols for Randomized Block Design.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Sowing windows and irrigation schedules exerted significant influence over plant height of potato crop. The plant height was recorded to be increased from sowing till harvest. Significantly taller plants of potato crop were recorded for 10th December planted crop across all observational stages at 60, 90 and 120 days after planting and at harvest. The lowest plant height was recorded for the 10th January sown crop. Similarly, the highest plant height was recorded when the potato crop was irrigated following 5 irrigation-based schedule.

However, number of leaves and leaf area index were found to be significantly higher for 10th January sown crop (Table 1 and Table 2). Significantly lower number of leaves per plant and leaf area index were found for the 10th December sown crop.

3.2 Number of Shoots Per Plant

Number of shoots were significantly influenced under the effect of various sowing windows and irrigation schedules. Substantially higher number of shoots per plant were recorded for the 10th December sown crop followed by 30th December and 10th January sown crop. Similarly, potato crop cultivated using 5 irrigation based schedule resulted in significant higher number of shoots per plant followed by 4, 3 and 2 irrigation-based schedules.

3.3 Average Number of Tubers Per Plant

Sowing windows and irrigation schedules exerted significant influence over average number of tubers per plant. The highest average number of tubers per plant were recorded for the 10th December sown crop followed by 30th December and 10th January sown crop. Among irrigation schedules, schedule based on 5 irrigations resulted in the highest number of tubers per plant followed by irrigation schedules following 4, 3 and 2 irrigations for the potato crop.

Table 1. Effect of different sowing dates and irrigation scheduling on plant height and number of leaves per plant of potato

Treatments	Plant height (cm)				Number of leaves per plant			
	60 DAP	90 DAP	120 DAP	At harvest	60 DAP	90 DAP	120 DAP	At harvest
Date of sowing								
10 th December	25.04	29.46	41.50	44.67	6.08	11.53	16.21	12.47
30 th December	23.60	28.12	39.56	40.75	5.68	10.84	15.42	13.12
10 th January	22.34	27.09	38.24	38.67	5.31	10.57	14.58	13.52
SEm±	0.36	0.41	0.66	0.92	0.10	0.17	0.26	0.20
CD (P=0.05)	1.06	1.20	1.94	2.70	0.29	0.50	0.78	0.59
Irrigation scheduling based on ET Method								
2 irrigations	20.72	24.41	35.52	37.94	4.83	10.18	14.27	12.29
3 irrigations	21.24	24.89	37.12	39.88	5.39	10.43	14.60	12.30
4 irrigations	24.32	29.74	41.63	42.60	6.02	11.07	16.06	13.34
5 irrigations	28.36	33.84	44.79	45.02	6.52	11.51	16.69	14.21
SEm±	0.42	0.47	0.76	1.06	0.12	0.20	0.31	0.23
CD (P=0.05)	1.22	1.38	2.24	3.11	0.34	0.58	0.90	0.68

Table 2. Effect of different sowing dates and irrigation scheduling on leaf area index of potato

Treatment	Leaf Area Index			
	60 DAP	90 DAP	120DAP	At harvest
Date of sowing				
10 th December	2.42	3.23	3.13	2.54
30 th December	2.18	2.99	2.88	2.68
10 th January	1.93	2.81	2.62	2.88
SE(m)±	0.04	0.05	0.04	0.04
LSD (P=0.05)	0.12	0.15	0.13	0.11
Irrigation scheduling based on ET Method				
2 Irrigations	1.91	2.72	2.63	2.44
3 Irrigations	2.01	2.92	2.77	2.53
4 Irrigations	2.27	3.14	2.99	2.86
5 Irrigations	2.51	3.26	3.13	2.98
SE(m)±	0.05	0.06	0.05	0.05
LSD (P=0.05)	0.14	0.18	0.15	0.13

Table 3. Effect of different sowing dates and irrigation scheduling on yield attributes and yield of potato

Treatments	No. of shoots/plant	Average number of tubers/plant	Average tuber weight (g)	Tuber yield (q/ha)
Date of sowing				
10 th December	3.09	7.67	74.91	272.9
30 th December	2.76	7.29	71.15	244.6
10 th January	2.44	7.17	69.69	228.6
SE(m)±	0.05	0.14	1.10	5.54
LSD (P=0.05)	0.16	0.42	3.23	16.26
Irrigation scheduling based on ET Method				
2 Irrigations	1.57	6.80	65.61	209.9
3 Irrigations	2.41	7.02	68.24	233.4
4 Irrigations	3.37	7.77	75.15	268.4
5 Irrigations	3.71	7.91	78.65	282.4
SE(m)±	0.06	0.14	1.27	6.40
LSD (P=0.05)	0.18	0.42	3.73	18.78

3.4 Average Tuber Weight

Average tuber weight was significantly affected by sowing windows and irrigation schedules. Substantially higher average tuber weight was recorded for 10th December sown crop followed by 30th December and 10th January sown crop. Similarly, crop cultivated with 5 irrigation-based schedules resulted in the highest average tuber

weight followed by 4 irrigation-based schedule. However, 2 and 3 irrigation-based scheduling resulted in considerably lower average tuber weight for the potato crop.

3.5 Tuber Yield

Tuber yield for the potato crop was significantly influenced under the effect of various sowing

windows and irrigation schedules. Sowing of the crop on 10th December resulted in substantially higher tuber yield followed by 30th December and 10th January sown crop. However, among irrigation schedules, potato crop cultivated with 5 irrigation-based schedule resulted in considerably improved tuber yield levels followed by 4 irrigation-based schedule. Limited irrigation regime based on schedule involving 2 or 3 irrigations resulted in significantly lower tuber yield level.

4. DISCUSSION

Optimizing the sowing windows may help in aligning the crop development stages with favorable environmental conditions resulting in increased biomass accumulation and productivity (Devi et al., 2024; Salaria et al., 2024b). Early sowing of the potato crop, under favorable environmental conditions, may have led to an optimized source-sink relationship by providing the crop with an optimal temperature for tuberization, extending the vegetative growth period, and improving radiation use efficiency (Ji et al., 2024). Therefore, in the present investigation sowing of the potato crop on 10th December led to substantially higher values for growth attributes and ultimately the yield attributes and yield levels. Sowing crops under favorable environmental regimes resulted in adequate soil moisture supply, optimal temperature regimes, longer photoperiods and improved growth. Delaying of the crop by 10th January resulted in substantially reduced growth response in terms of plant height and number of shoots per plant. A declined growth response was further reflected in decreased yield levels for the potato crop due to delayed sowing i.e., 10th January. Optimizing irrigation scheduling for potato is significantly critical owing to shallow root system, sensitivity to water stress particularly at critical stages such as tuber initiation and bulking stages (Rai and Dong, 2025). Maintaining optimized consistent supply under 5 irrigation-based regimes may have improved soil moisture regime, photosynthetic efficiency, nutrient uptake, utilization and assimilation which resulted in enhanced potato productivity (Badr et al., 2022; Kumari et al., 2025). Improved photosynthetic efficiency, nutrient uptake, utilization and assimilation were reflected in improved growth response and yield levels for the potato crop growth under 5 irrigation-based schedules.

5. CONCLUSION

Sowing windows and irrigation schedules significantly influenced potato growth and yield. Sowing of the crop by 10th December resulted in highest plant height, number of leaves, shoots, tubers per plant, average tuber weight and tuber yield. Delayed sowing by 10th January lead to considerable reduction in growth attributes such as plant height, number of leaves, shoots per plant as well as for tubers per plant, average tuber weight and potato tuber yield. Similarly, irrigation schedule consisting of 5 irrigations considerably enhanced potato growth attributes such as plant height, number of leaves, shoots per plant and tubers per plant, average tuber weight and potato tuber yield. However, limited irrigation regimes lead to substantial reduction in growth attributes such as plant height, number of leaves, shoots per plant as well as for tubers per plant, average tuber weight and potato tuber yield. Therefore, sowing of potato crop on 10th of December and following 5 irrigation-based scheduling can be recommended to farmers for enhanced growth and productivity of potato crop.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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