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Productive and Economic Evaluation of Potato Hybrids under Different Water Stress Conditions

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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

As the scarcity of water increases, India will face the problem of decreasing annual freshwater use per capita. Drought can cause significant output losses, particularly for crops with shallow root system like potato (*Solanum tuberosum*). An experiment was carried out to measure the effects of different levels of irrigation on yield parameters of different potato hybrids under water stress conditions during the winter season 2018-19 in open field conditions at the field of department of vegetable science in CCS Haryana Agricultural University, Hisar. The experiment included four irrigation levels I_1 (irrigation at 20mm Cummulative Pan Evaporimeter (CPE)), I_2 (irrigation at 25mm CPE), I_3 (irrigation at 30mm CPE) and I_4 (irrigation at 30mm CPE + 5 t/ha grass mulch) and five potato hybrids under two different crops at 60 and 75 days. The results revealed that yield

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parameters i.e., total tuber yield, number of tubers in each grade, yield of tubers in each grade, harvest index, and biological yield were higher in both 60 and 75 days of crops under irrigation level 20 mm CPE (I_1) and hybrid P-38. But, under water-stressed conditions, hybrid P-38 with an I_4 schedule saves one irrigation and yields more than I_3. The maximum water use efficiency (19.27 and 20.56 q/ha/mm) was attained with irrigation level I_4 in 60 and 75 days of crop. In water stress conditions (I_4) potato hybrid P-38 produced the highest net returns and benefit cost ratio (1.49 and 2.29). It was found that the potato hybrid P-38 with I_4 was more cost-effective and produced more tubers in areas with lower water tables and less water.

Keywords: Water stress; irrigation; high yield; water use efficiency; economics.

1. INTRODUCTION

Water is the primary substance on Earth, although just 2.5% of it is fresh water [1]. World's 99.74% of the freshwater supply is covered as ice in glaciers or deep below, making it impossible to access [2]. Water scarcity is increasing as the population grows, which means that the need for freshwater is increasing as well. As a result of excessive water use and pollution over the last two decades [3,4], the annual freshwater supply per capita has decreased by more than 20%, around 1.2 billion people around the world are facing water scarcity due to their habitation in agricultural areas [3]. In the world, 92% of all freshwater is used for agricultural purposes, whether it's in the form of rivers, lakes, or underground aquifers [3,5]. In the coming decades, India will face a challenge in increasing food production to feed a growing population while simultaneously decreasing yearly freshwater consumption per capita. Water scarcity is the primary obstacle to potato production in many parts of the world. Higher tuber yields per unit of water are an important goal for both agronomists and potato grower farmers.

Potato (*Solanum tuberosum* L.) is a major crop grown in almost 150 countries globally. It is the world's fourth most cultivated crop, after wheat, rice, and maize. Potato is a member of the Solanaceae family and is one of the most important tuberous crops grown in India. It is native to South and Central America. This crop generates more edible energy and protein per unit area and time than many other crops and has an extraordinarily high yield (up to 25-30 t/ha). It contains a lot of carbohydrates, protein, and vitamin C [6]. On the global stage, the production of potatoes is 370 metric tonnes and 17.3 million cultivated hectares [7].

India is the world's second largest potato producer after China, with an average output of 23.95 t/ha. In 2019–20, the area and production of potatoes in India were 21.58 lakh hectares, yielding 513.00 lakh metric tons. In 2017-18, the area and production and productivity of potatoes in Haryana were 34.72 thousand hectares, 857.98 thousand tonnes, and 25.85 t/ha, respectively [8].

Potato is considered a drought-sensitive crop and are subjected to yield loss due to drought stress. Also as climate change, the severity, frequency, and extent of droughts have been increasing worldwide. Potato's susceptibility to dryness has mostly been attributed to their weak roots. In the last few decades, several studies reported that the susceptibility of potatoes to drought depends on their genotype, stage of development, shape, and the length and severity of the drought stress. On the other hand, some researcher thought that the depth of the roots is the only main reason why potatoes are sensitive to dryness [9].

The biggest difficulty in restricting good potato yield to meet global demand is irrigation scheduling, which can be mitigated by effective water management and agronomic measures such as mulching.

Excessive or insufficient water availability have an impact on potato development and production [10]. Mulching applications efficiently affect the plant's hydrothermal microenvironment; although, the effects of mulching on potato yield vary with field management and climate. Straw and plastic mulching boosted potato output by 24.3% and 16.0%, respectively, while increasing water use efficiency (WUE) by 5.6% and 28.7%. There is still a large effect of mean growing season air temperature, water input, soil basic fertility, and fertiliser treatments on potato output and WUE in response to mulching. In regions with 400 mm of annual precipitation, potato yield and WUE increased [11].

In this study, we did performed selection of high yield potato hybrid in water stress conditions and compare of economics of the different treatments.

2. MATERIALS AND METHODS

2.1 Experimental Design

The experiment was conducted in an open field at the research farm of the Department of Vegetable Science at CCS Haryana Agricultural University, Hisar during the rabi (winter) season, 2018-19. The field was tilled 3 to 5 times by disc harrow and cultivator. Each tilling was followed by planking to make the soil well pulverised and levelled. Four main plot treatments were taken as four different levels of irrigation, irrigation at 20mm Cummulative Pan Evaporimeter (CPE), irrigation at 25mm CPE, irrigation at 30mm CPE and irrigation at 30mm CPE + 5 t/ha grass mulch at planting. Five sub-plot treatments of potato hybrids were used in this experiment, which are V1: AICRP-P-21, V2: AICRP-P-32, V3: AICRP-P-37, V4: AICRP-P-38, and V5: Kufri Bahar. There were 60 plots comprising of three replications, with a net plot size and gross plot size of 4.2m× 3.4m and 3.0m× 3.0m and the crop was grown with a spacing of 60×20cm. Irrigation was done in furrows according to the specified irrigation schedules. The experiment was studied completely in a split-plot design with three replications each of 60 and 75 days of crop. By comparing results under the different irrigation schedules, we can quantify the best suited potato hybrid for water stress on potato yield, tuber characteristics, and water use efficiency.

2.2 Yield Parameters

2.2.1 Number of tubers in each grade (0-25g, >25-50g, >50-75g and over 75 g)

After harvesting tubers of both 60 and 75 days of crops, they were differentiated 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), which were counted separately in each plot, and the number of tubers of different grades per plot was divided by plot size for calculating the number of tubers of different grades per square meter.

Number of tubers in different grade/m^2 = Number of tubers in different grades per net plot/ Net plot size

2.2.2 Yield of tubers in each grade (0-25g, >25-50g, >50-75g, and over 75 g)

At the time of harvest, the potato tubers of both 60 and 75 days of crops from each net plot were graded into four grades, i.e., A grade (>75 g), B grade (>50-75 g), C grade (>25-50 g), and D grade (up to 25 g), which were weighted separately and the weight of tubers in different grades in kilogrammes per square metre area was calculated.

Yield of tubers in different grades (kg/m2) = Weight of tubers in different grades per net plot/ Net plot size

2.2.3 Total tuber yield (q/ha)

The overall yield was calculated by adding the weight of all grades of tubers (A, B, C, and D grade tubers) to each net plot. The weight of tubers of different grades was taken per plant and later the values were expressed in kilogrammes per square metre and quintals per hectare.

2.2.4 Biological yield (q/ha)

To obtain biological yield, weight of total tuber yield was added in the weight of the haulm of each net plot. Later, the values were converted into quintals per hectare.

2.2.5 Harvest index

For calculating the harvest index, total tuber yield or economic yield, was divided by the biological yield per net plot, which is expressed in per cent. [12]

Harvest index (%) = Economic yield/ Biological yield (economic yield + foliage weight) x 100

Water use efficiency (q/ha/cm)

Water use efficiency was calculated according to the formula given by F.G. Viets [13]:

Water use efficiency (q/ha/cm) = Total tuber yield (q/ha)/ Water applied to each treatment (cm)

2.3 Economics of Various Treatments

By taking into account as per standard procedure and current market pricing, the cost of cultivation for the crop and the cost of cultivation for each treatment were determined. These two costs were then added to determine the total cost of cultivation for each treatment. The value of the product, or the tuber yield at market prices, was subtracted from the cost of cultivation for each treatment to determine the gross return for each treatment.

Benefit cost ratio = Net return/Total cost

2.4 Data Analysis

The information that was gathered throughout the course of the research on a variety of parameters was subjected to statistical analysis utilising the analysis of variance method (ANOVA). To evaluate the significance of the difference in mean between two treatments, the following procedure was used to calculate the critical difference, often known as the C.D.:

C.D. = SE ×'t'

Where, S.E. is a standard error of the difference of treatment means, which was calculated as follows:

S.E. $=\sqrt{\frac{2ESM}{r}}$

C.D. : Critical difference, EMS: Error mean sum of squares, r: Number of replication.

't': Tabulated 't' value at error degrees of freedom at 5% level of significance.

3. RESULTS

3.1 Total Number of Potato Tubers (Thousand per Hectare)

Mean values of treatments presented in Table 1 showed a significant variation among irrigation levels and potato hybrids with respect to total number of tubers, and among the irrigation levels, 20 mm CPE (I_1) produced significantly highest number of tubers (744.5 and 747.6 thousand per hectare) of 60 and 75 days crop, while the minimum number of tubers (393.0 and 397.1 thousand per hectare) was observed in 30 mm CPE (I_3) at 60 and 75 days of crop. Among the potato hybrids, the total number of tubers were recorded highest (622.1and 627.6 thousand per hectare) for hybrid P-38 of both 60 and 75 days crop which was significantly higher than other potato hybrids, while the minimum number of tubers (526.9 and 531.4 thousand per hectare) was recorded for hybrid Kufri Bahar of both 60 and 75 days crop. The interaction effect of hybrids at the same level of irrigation and irrigation at the same level of hybrid was found non-significant of 60 and 75 days crop with respect to total number of tubers per hectare.

3.2 Total Tuber Yield (q/ha)

Water stress had a strong effect on yield of potato. The mean values of treatments presented in Table 2 showed that tuber yield was reduced due to water stress. The irrigation levels also significantly affected the total tuber yield of 60 and 75 days crop duration, which increased significantly with the increase in irrigations. The total tuber yield was highest (329.6 and 457.8 q/ha) under irrigation level I_1 (20 mm CPE) which was significantly highest as compared to all other irrigation levels. While the minimum total tuber yield (192.0 and 243.8 q/ha) was observed under irrigation level 30mm CPE (I_3). Among the potato hybrids, the total tuber yield was recorded significantly higher (290.1 and 393.8 q/ha) under hybrid P-38 in both 60 and 75 days of crop, while the lowest total tuber yield (243.1 and 319.2 q/ha) was recorded in hybrid Kufri Bahar for both 60 and 75 days of crop. The total tuber yield (496.9 q/ha) was recorded maximum under irrigation level 20 mm CPE (I_1) in combination with hybrid P-38, which was significantly higher among other hybrids at same level of irrigation and among different irrigation levels at same level of hybrid. The minimum total tuber yield was recorded under irrigation level 30mm CPE (I_3) with hybrid Kufri Bahar (188.1 q/ha) for 75 days of crop [14-15].

3.3 Harvest Index

The information in Table 3 showed that, among the irrigation levels, 20 mm CPE (I_1) significantly observed maximum harvest index (56.3 and 60.3%) of 60 and 75 days of crop, followed closely by I_2 (53.3 and 58.2%), and the minimum harvest index was recorded in I_3 (40.0 and 45.0%) of both 60 and 75 days crop. Irrigation practices have a positive impact on the harvest index.

3.4 Water Use Efficiency (q/ha/mm)

The water was used more efficiently in deficit irrigation treatments because these treatments frequently use lower volumes of water but have higher WUE values. The data presented in Table 4 demonstrates how hybrids and irrigation levels have an impact on the water use effectiveness in both 60 and 75 days crops. The irrigation level I_4

(30 mm CPE+ mulch) produced the highest water use efficiency (19.27 and 20.56 q/ha/mm), closely followed by irrigation level I_2 (17.93 and 19.53 q/ha/mm in 60 and 75 days of crop), and the irrigation level I_3 (30 mm CPE) produced the lowest water use efficiency (16.02 and 15.24). Among the potato hybrids, P-38 had the highest WUE while Kufri Bahar had the lowest WUE.

3.5 Economics of Various Treatments

Total cost of cultivation varied from treatment to treatment. The economics of various treatment combinations for crops with 60 and 75 days to harvest are shown in Tables 5a and 5b. By deducting the cost of cultivation from gross income, the net returns from cultivation under various treatments were calculated. The treatment combinations I_1 (20 mm CPE) and hybrid P-38 produced the highest net returns, 1,632.22 U.S. Dollar and 2,536.48 U.S. Dollar of Rs.133591 and Rs.207601 per hectare, followed by treatment combinations I_1 (20 mm CPE) and hybrid P-21, with net returns of Rs.113071 and Rs.191821 per hectare in 60 and 75 days of crop, respectively. In treatment combination I_3 (30 mm CPE) and Kufri Bahar in 60 and 75 days of crop, respectively, the minimum net returns of Rs.16591 and Rs.23821 were found.

The findings in Tables 5a and 5b further reveals that the treatment combination I_1 (20 mm CPE) and hybrid P-38 produced the highest B:C ratio (1.49 and 2.29). In treatment combination I_3 (30 mm CPE) and Kufri Bahar in 60 and 75 days of crop, the lowest B:C ratio (0.19 and 0.27) was recorded.

Table 1. Effect of irrigation levels and potato hybrids on total number of tuber (thousand per hectare) of 60 and 75 days crop

Irrigation levels	Potato hybrids											
	60 Days crop						75 Days crop					
	K.B.	P-38	P-32	P-37	P-21	Mean	K.B.	P-38	P-32	P-37	P-21	Mean
I_1	685.5	796.7	751.2	707.2	781.6	744.5^{a}	689.6	798.0	752.3	709.4	788.9	747.6^{a}
I_2	603.4	661.7	619.2	614.2	632.7	626.2^{b}	607.8	671.6	628.5	620.8	634.3	632.6^{b}
I_3	342.5	453.2	400.9	361.2	407.2	393.0^{d}	346.5	457.8	400.9	367.2	413.0	397.1^{d}
I_4	476.2	577.0	518.6	511.2	542.9	525.2^{c}	481.7	583.1	522.4	512.2	549.0	529.7^{c}
Mean	526.9^{C}	622.1^{A}	572.5^{B}	548.5^{C}	591.1^{B}		531.4^{E}	627.6^{A}	576.0^{C}	552.4^{D}	596.3^{B}	
C.D. at 5%												
Irrigation						29.3						27.6
Hybrid						26.0						21.1
Hybrid at same level of irrigation						N.S.						N.S.
Irrigation at same level of hybrid						N.S.						N.S.

K.B.: Kufri Bahar, I_1:20mm CPE, I_2:25 mm CPE, I_3:30mm CPE and I_4:30mm CPE+ mulch

Table 2. Effect of irrigation levels and potato hybrids on total tuber yield (q/ha) in 60 and 75 days crop duration

Irrigation levels	Potato hybrids											
	60 Days crop						75 Days crop					
	K.B.	P-38	P-32	P-37	P-21	Mean	K.B.	P-38	P-32	P-37	P-21	Mean
I_1	308.5	372.3	319.3	309.9	338.1	329.6^{a}	424.4	496.9	452.4	444.6	470.6	457.8^{a}
I_2	265.4	307.3	289.7	281.1	290.7	286.8^{b}	365.5	418.9	389.6	384.8	394.1	390.6^{b}
I_3	174.8	214.9	190.6	181.8	198.0	192.0^{d}	188.1	294.6	237.0	218.0	281.2	243.8^{d}
I_4	223.9	266.0	236.8	227.0	245.2	239.8^{c}	298.8	364.8	320.4	316.4	343.8	328.8^{c}
Mean	243.1^{D}	290.1^{A}	259.1^{BC}	250.0^{CD}	268.0^{B}		319.2^{D}	393.8^{A}	349.8^{C}	340.9^{C}	372.4^{B}	
C.D. at 5%												
Irrigation						17.7						14.2
Hybrid						14.1						11.7
Hybrid at same level of irrigation						N.S.						24.3
Irrigation at same level of hybrid						N.S.						25.3

K.B.: Kufri Bahar, I_1:20mm CPE, I_2:25 mm CPE, I_3:30mm CPE and I_4:30mm CPE+ mulch

Table 3. Effect of irrigation levels and potato hybrids on harvest index at 60 and 75 days of crop

Irrigation levels	Potato hybrids											
	60 Days Crop						75 Days Crop					
	K.B.	P-38	P-32	P-37	P-21	Mean	K.B.	P-38	P-32	P-37	P-21	Mean
I_1	53.8	62.3	55.2	53.7	56.7	56.3^{a}	60.3	62.9	59.0	59.7	59.7	60.3^{a}
I_2	49.7	55.8	54.1	52.6	54.5	53.3^{b}	55.9	60.7	58.7	58.3	57.7	58.2^{b}
I_3	40.7	42.7	39.4	37.1	40.1	40.0^{d}	40.1	48.3	43.0	44.0	49.9	45.0^{d}
I_4	47.9	50.8	46.7	45.0	47.3	47.5c	47.7	57.5	50.3	49.8	54.2	51.9^{c}
Mean	48.0^{BC}	52.9^{A}	48.8^{BC}	47.1^{C}	49.6^{B}		51.0^{C}	57.3^{A}	52.7^{C}	52.9^{C}	55.4^{B}	
C.D. at 5%												
Irrigation						3.9						6.4
Hybrid						N.S.						N.S.
Hybrid at same level of irrigation						N.S.						N.S.
Irrigation at same level of hybrid						N.S.						N.S.

K.B.: Kufri Bahar, I_1:20mm CPE, I_2:25 mm CPE, I_3:30mm CPE and I_4:30mm CPE+ mulch

Table 4. Effect of irrigation levels and potato hybrids on water use efficiency (q ha^{-1}mm) of 60 and 75 days of crop

Irrigation levels	Potato hybrids											
	60 DAP						75 DAP					
	K.B.	P-38	P-32	P-37	P-21	Mean	K.B.	P-38	P-32	P-37	P-21	Mean
I_1	15.43	18.62	15.97	15.50	16.91	16.49	17.68	20.70	18.85	18.53	19.61	19.07
I_2	16.59	19.21	18.11	17.57	18.17	17.93	18.28	20.95	19.48	19.24	19.71	19.53
I_3	14.57	17.91	15.88	15.15	16.60	16.02	11.76	18.41	14.81	13.63	17.58	15.24
I_4	18.66	18.63	19.73	18.92	20.43	19.27	18.68	22.80	20.03	19.78	21.49	20.56
Mean	16.31	18.59	17.42	16.79	18.03		16.60	20.72	18.29	17.80	19.60	

K.B.: Kufri Bahar, I_1:20 mm CPE, I_2:25 mm CPE, I_3:30mm CPE and I_4:30 mm CPE + mulch

4. DISCUSSION

4.1 Total Number of Tubers in Each Grade (0-25g, 25-50g, 50-75g and above 75g)

Variable irrigation techniques and potato hybrids resulted in considerable different numbers of tubers in both the 60-day and 75-day crops. The current investigation showed that the highest number of each grade was observed under I_1 (irrigation at a 20 mm CPE) in both crops. Some findings [16,17,18] are substantially similar. Additionally, [19] the most frequent irrigation circumstances may be the cause of the increased number of tubers per plant.

Increased soil aeration in the rhizosphere and maintenance of low soil strength could be another factor contributing to the maximum number of tubers of various grades being irrigated with I_1 [20]. The finding of Singh [21] is in accordance with the present findings.

4.2 Total Tuber Yield (q/ha)

The overall tuber production of the 60- and 75-day crops was strongly impacted by the irrigation schedules, and it dramatically increased as irrigation frequency increased. The observation clearly demonstrated that at irrigation level (I1) 20 mm CPE, the overall tuber yield was maximum (329.6 and 457.8 q/ha). In both 60 and 75 days of crop, hybrid P-38 had the highest total tuber yield among hybrids (290.1 and 393.8 q/ha). According to Hanson [22], regular irrigation led to a higher water potential, which reduced soil moisture fluctuations in the effective root zone and increased production.

4.3 Harvest Index

The application of irrigation techniques and potato hybrids were found to have a positive impact on the harvest index. Different irrigation levels have a substantial impact on the harvest index. In terms of irrigation levels, (I_1) 20 mm CPE was substantially associated with maximum harvest index (56.3 and 60.3%) of 60 and 75 days of crop, and (I_2) 25 mm CPE was closely behind it (53.3 and 58.2%). Similarly Singh and Lal [23], also found same that increasing the nitrogen and potassium doses in potatoes by up to 150 kg/ha and 100 kg/ha, respectively, boosted the harvest index.

4.4 Water Use Efficiency (q/ha/cm)

Among irrigation levels and hybrids, in both 60 and 75 days of crop, there are substantial variances in water use efficiency. The irrigation level (I4) 30 mm CPE + mulch produced the highest water use efficiency (19.27 and 20.56 q/ha/mm), which was closely followed by irrigation level (I2) 25 mm CPE, which produced 17.93 and 19.53 q/ha/mm in 60 and 75 days of crop. In the non-mulched plots, water use efficiency and tuber production differ considerably between irrigation treatments, while they do not after mulched plots with the three and four irrigations. In order to grow potatoes in the area with limited water resources, three irrigations of 75 mm each were advised, along with mulching. Nitrogen input boosted the WUE, but its impact decreased as irrigation level increased. In general, improved WUE can be attained by producing the same yield with less water or by using a deficit irrigation strategy and scheduling watering to prevent water losses through evaporation [24,25,26].

4.5 Economics of Various Treatments

The treatment combinations (I1) 20 mm CPE and hybrid P-38 yielded the highest net return and B: C (Rs. 133591 & 1.49) and (Rs. 207601 & 2.29) per hectare in both 60 and 75 days of crop. The results support the finding that labour accounted for 68% of the overall cost of production according to the cost and returns analysis [27]. Capital inputs had the least effect on profit, whereas yield had the most impact on raising the money value. Similar to this, [28] it has been concluded that consistent yield loss (24.43 to 88.39%) was observed with the reduction in irrigation frequency, while water-use efficiency improved linearly in response to water stress from 80.78 to 114.33 kg/ha-mm. Maximum net income and benefit: cost ratio were recorded with crop irrigation 20 mm CPE, accounting for 179 and 54% more as compared to the control treatment, respectively. Regardless of irrigation levels, crops in mulched plots at 5 t/ha produced higher net returns and benefit: cost ratios than crops in non-mulched plots.

Table 5a. Economics of various treatments as affected by various irrigation levels and potato hybrids at 60 days crop duration

Teatments	Varieties	Common cost (Rs/ha.)	Treatment cost (Rs./ha.)	Total cost (Rs./ha)	Yield (q/ha)	Gross return (Rs./ha)	Net returns (Rs./ha)	B:C ratio
I_1	K. B.	86039	3750	89789	308.5	185100	95311	1.06
	P-38	86039	3750	89789	372.3	223380	133591	1.49
	P-32	86039	3750	89789	319.3	191580	101791	1.13
	P-37	86039	3750	89789	309.9	185940	96151	1.07
	P-21	86039	3750	89789	338.1	202860	113071	1.26
I_2	K. B.	86039	3000	89039	265.4	159240	70201	0.79
	P-38	86039	3000	89039	307.3	184380	95341	1.07
	P-32	86039	3000	89039	289.7	173820	84781	0.95
	P-37	86039	3000	89039	281.1	168660	79621	0.89
	P-21	86039	3000	89039	290.7	174420	85381	0.96
I_3	K. B.	86039	2250	88289	174.8	104880	16591	0.19
	P-38	86039	2250	88289	214.9	128940	40651	0.46
	P-32	86039	2250	88289	190.6	114360	26071	0.30
	P-37	86039	2250	88289	181.8	109080	20791	0.24
	P-21	86039	2250	88289	198.0	118800	30511	0.35
I_4	K. B.	86039	6750	92789	223.9	134340	41551	0.45
	P-38	86039	6750	92789	226.0	135600	42811	0.46
	P-32	86039	6750	92789	236.8	142080	49291	0.53
	P-37	86039	6750	92789	227.0	136200	43411	0.47
	P-21	86039	6750	92789	245.2	147120	54331	0.59

K.B.:Kufri Bahar, I_1:20 mm CPE, I_2:25 mm CPE, I_3:30 mm CPE and I_4:30 mm CPE + mulch

Table 5b. Economics of various treatments as affected by various irrigation levels and potato hybrids at 75 days crop duration

Teatments	Varieties	Common cost (Rs/ha.)	Treatment cost (Rs./ha.)	Total cost (Rs./ha)	Yield (q/ha)	Gross return (Rs./ha)	Net returns (Rs./ha)	B:C ratio
I_1	K. B.	86039	4500	90539	424.4	254640	164101	1.81
	P-38	86039	4500	90539	496.9	298140	207601	2.29
	P-32	86039	4500	90539	452.4	271440	180901	2.00
	P-37	86039	4500	90539	444.6	266760	176221	1.95
	P-21	86039	4500	90539	470.6	282360	191821	2.12
I_2	K. B.	86039	3750	89789	365.5	219300	129511	1.44
	P-38	86039	3750	89789	418.9	251340	161551	1.80
	P-32	86039	3750	89789	389.6	233760	143971	1.60
	P-37	86039	3750	89789	384.8	230880	141091	1.57
	P-21	86039	3750	89789	394.1	236460	146671	1.63
I_3	K. B.	86039	3000	89039	188.1	112860	23821	0.27
	P-38	86039	3000	89039	294.6	176760	87721	0.99
	P-32	86039	3000	89039	237.0	142200	53161	0.60
	P-37	86039	3000	89039	218.0	130800	41761	0.47
	P-21	86039	3000	89039	281.2	168720	79681	0.89
I_4	K. B.	86039	7500	93539	298.8	179280	85741	0.92
	P-38	86039	7500	93539	364.80	218880	125341	1.34
	P-32	86039	7500	93539	320.40	192240	98701	1.06
	P-37	86039	7500	93539	316.40	189840	96301	1.03
	P-21	86039	7500	93539	343.80	206280	112741	1.21

K.B.:Kufri Bahar, I_1:20 mm CPE, I_2:25 mm CPE, I_3:30 mm CPE and I_4:30 mm CPE + mulch

5. CONCLUSION

Severe drought stress reduced tuber yield compared to low or moderate stress. This study used different irrigation levels to find high-yielding potato hybrids under water stress. Our research shows it's possible to save irrigation water while maintaining high tuber growth and nutritional composition. Irrigation with 30mm CPE + 5 t/ha grass mulch increases tuber output. Contrarily, irrigating with less irrigation and mulching offers better yields than non-mulch plots, which is advantageous for tuber growth in water-stressed or low-water-availability situations. It would be interesting to analyse in additional research the impacts of irrigation regimes with less harsh water stress circumstances to better understand irrigation levels, potato hybrids, and their growth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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