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Effect of irrigations on the basis of IW/CPE under sprinkler system on quality, yield and economics of potato

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Abstract
Potato is a one of important crop under North Gujarat condition. Irrigation management is about controlling the rate, amount, and timing of applied irrigation water in a planned and efficient manner. With the best irrigation management practices, a potato crop. The purpose of this experiment is to investigate the effect of levels of sprinkler irrigation on yield and quality of potato. The experiment was undertaken during *rabi* season of year 2018-19, 2019-20 and 2020-21 at Agricultural Research Station, S. D. Agricultural University, Aseda (Gujarat). The treatments comprised of three levels of irrigation (I_1: 0.8 IW/CPE, I_2: 1.0 IW/CPE and I_3: 1.2 IW/CPE) and four levels of depth of irrigation (D_1: 20 mm, D_2: 30 mm, D_3: 40 mm and D_4: 50 mm. The experiment was laid out in a large plot technique with four quadrate. Higher tuber yield (29.25 t/ha) and net return was recorded under the treatment I_3: 1.2 IW/CPE while lower value 24.84 t/ha found under the treatment I_1:0.8 IW/CPE. In case of depths of irrigation, D_1: 20 mm recorded significantly higher tuber yield (28.87 t/ha) and net return among all treatments while lower value (25.05 t/ha) was recorded under the 50 mm depth of irrigation. The combination of I_3D_1 (1.2 IW/CPE + 20 mm) recorded significantly higher tuber yield 31.92 t/ha, which was statistically at par with the treatment I_3D_2 and lower value was recorded under the treatment I_1D_4 (20.83t/ha).

Keywords: Potato, Tuber, Irrigation depth, Levels of irrigation, WUE

Introduction
India is the 2nd largest Potato producer in the world with a production of about 48.6 million ton from about 2.1 million hectares with 22.3 t/ha productivity. The major potato producing states are UP, West Bengal, Bihar, Punjab, Gujarat and Madhya Pradesh and they jointly contribute about 90% of the total potato production of the country. West Bengal tops in potato productivity with 24.7 t/ha followed by Haryana with 24.6 t/ha, Gujarat with 23.9 t/ha and Uttar Pradesh with 20.9 t/ha (Anonymus, 2020) [1]. Potato is botanically known as *Solanum tuberosum* L., is one of the largest genera in the vegetable kingdom, with about 900 species. Potato is a perennial but as a crop it is treated as an annual. It is vegetatively propagated by means of tubers. Now it is also propagated by true potato seed (TPS). The tuber is an enlarged underground stem produced on the end of a stolon. It is only six of these that grow filler potatoes. Water is most important factor for the living organism. Without the supply of adequate quantity the crop can't meet the optimum growth which ultimately results in to poor yield of crop. Potato (*Solanum tuberosum* L.) crop requires 350-550 mm depending upon the length of growing season, atmospheric demand, soil type, crop variety, etc. According to FAO, for high yields, the crop water requirements (ETm) for a 120 to 150 day crop are 500 to 700 mm, depending on climate. The water needs of potato plants are generally smaller during the first stages of the plant development and they gradually increase during maturation and the later stages of tuber growth. For winter cultivation, many farmers irrigate as much as two times a week (depending on rainfall), while during drought they normally irrigate more often. In sandy soils, farmers shall irrigate more frequently than in heavy soils. It is important for the soil to remain wet at all times. To optimize yields, the total available soil water should not be depleted by more than 30 to 50%. Irrigation scheduling is one of the most important tools for developing best management

practices for irrigated areas. Plant experiencing water stress condition during the crop growth period shows different symptoms, such as reduced leaf size, fewer leaves, reduced plant height compared to plant grown in non-stressed condition and finally yield is reduced due to water stress. But the extent to which yield is reduced depends largely on the stage of development at which plant suffers from stress. If the moisture stress prevails at tuber initiation stage, the yield loss is greater (31%) than at tuber development stage (21%), this is due to greater reduction in photosynthesis (40%) and leaf area (35%) at tuber initiation stage than at tuber development stage. Presently world production is about 388.19 million tonnes fresh tubers from an area of 19.33 million ha of potato. India is a major potato growing country in the world with 2.18 million-hectare area under cultivation with total production of 48.60 million tonnes (Rana and Anwer, 2018) [14]. However, average potato yield in India is 22.3 t ha^{-1}, which is only half of that in the other parts of world. Growth in the production of potato in India has largely been due to expansion of area rather than increase in productivity. Improper water scheduling is one of the main factors limiting productivity of potato. The difference between potential and realizable yields may be minimized by use of proper irrigation methods and scheduling matching soil characteristics and crop water needs (Rana *et al.*, 2010; Dingre and Pawar, 2020) [15, 5]. Potato requires high and nearly constant soil matric potential along with high soil oxygen diffusion rate, and optimal nutrients for proper growth (Bhardwaj *et al.*, 2015) [3]. The extent to which crop productivity is affected due to water related limitations depends on the stage of development (Kashyap and Panda, 2002) [8]. Irrigation scheduling bears special importance besides total water availability. Need based application saves water, and crop also does not suffer (Singh *et al.*, 2018) [16]. Indiscriminate use of water through conventional furrow irrigation with low application and distribution efficiency is a serious threat to available water resources, and it results in reduced yields due to over or deficit irrigation. The amount and schedule of irrigation water application should be such that there is a little fluctuation is the soil moisture content in the root zone (Kumar *et al.*, 2008). Use of modern irrigation systems coupled with appropriate irrigation scheduling can increase yield and quality of potato tubers. Drip or sprinkler irrigation is considered to be a better option over traditional flooding irrigation methods for yield and economics of potato crop (Pawar and Dingre, 2014) [13]. The suitability of sprinkler or microsprinkler irrigation as affected by irrigation schedule for potato cultivation is not clear. The investigation was undertaken to evaluate response of potato to irrigation method and schedule Soil moisture stress increases the number of epidermal cells and stomata but decreases their size. An adverse moisture regime also reduces leaf area and hastens leaf senescence, thereby, decreasing the productivity of the crop to a greater extent.

Materials and Methods

The experiment was undertaken during *rabi* season of year 2018-19, 2019-20 and 2020-21 at Agricultural Research Station, S. D. Agricultural University, Aseda (Gujarat). The treatments comprised of three levels of irrigation (I_1: 0.8 IW/CPE, I_2: 1.0 IW/CPE and I_3: 1.2 IW/CPE) and four levels of depth of irrigation (D_1: 20 mm, D_2: 30 mm, D_3: 40 mm and D_4: 50 mm. The experiment was laid out in a large plot technique with four quadrate. The texture of the soil was loamy sand. The soil of the experimental field was low in available nitrogen (224 kg/ha), medium in available phosphorus (79 kg P_2O_5/ ha) and available potash (190.0 kg K_2O/ha) and normal in soil reaction (pH 7.58) and electrical conductivity (0.2 mmhos/cm). The crop is fertilized with 275-140-275 kg N-P_2O_5-K_2O/ha) with entire quantity of phosphorus and potash were applied in form of DAP and MOP at of sowing and the remaining quantity of nitrogen is being applied in five equal split in form of urea. The irrigation was applied as per treatment to crop when the CPE reached at the defined levels and sprinkler was run at specified time to maintain the depth f irrigation according to the discharge rate of sprinkler (3 kg/cm^2). The data were analyzed statistically by standard analysis of variance (ANOVA). Overhead sprinklers with nozzles having 550 Lh^{-1} discharge were spaced 9 × 9 m apart. Plant height was measured to the highest point of the shoot. Tubers were harvested at 12 weeks after planting for fresh tuber yield. Haulm yield was recorded after constant weight achieved under field conditions. The TSS measured by the hand refractometer and specific gravity was measured by the weighing the tuber in water and air. Least significant difference (LSD) test was used to determine whether differences exist between certain comparisons. The probability level for determination of significance was 0.05. The pooled analysis was done for all important characters of the study (Panse and Sukhatme, 1995) [11].

Results and Discussion

Effect of irrigation levels and depth of irrigation on growth and quality parameters

The results show that the emergence (%), dry matter content, specific gravity and starch content were found non significant due to different levels of irrigation and different depth of irrigation. In case of levels of irrigation, higher plant height at 50 DAS (40.95 cm) and number of shoots (2.81) per plant was recorded under the I_3: 1.2 IW/CPE, which remained statistically at par with the treatment I_2:1.0 IW/CPE and lower value (37.70 and 2.58) recorded in the treatment I_1:0.8 IW/CPE, In case of depth of irrigation, significantly highest plant height at 50 DAS was recorded in D_1: 20 mm depth of irrigation. The difference in plant growth parameters with irrigation regimes was mainly due to the variation in available soil moisture.

The result of interaction found non significant in the case of emergence (%) dry matter content, specific gravity and starch content but remained significant in case of plant height at 50 DAS and number of shoots per plant. Higher plant height at 50 DAS (45.70 cm) was recorded under the treatment of D1I1 and at par with D1I2, D1I3 and D2I3 and lower value under treatment I1D4 (31.41 cm), while significantly higher number of shoots per plant was recorded under the treatment D2I3 (2.98) and remained at par with treatment I2D4 and I3D3 and lower value was recorded under the treatment I1D4 (2.47).

The emergence (%), dry matter content, specific gravity and starch content were found non significant due to different levels of irrigation and different depth of irrigation is due to the water stress before tuber initiation has no deleterious effect on tuber quality reported by Singh & Arora 1980 [17] and Shock *et al.* [19], 1993. In case of levels of irrigation, higher plant height at 50 DAS and number of shoots per plant were recorded under the I_3: 1.2 IW/CPE and D_1: 20 mm depth of irrigation. It may be due to larger supply of moisture along with nutrients which has boosted the vegetative growth. Higher moisture regime has also produced taller plants, which ultimately resulted in the production of more number of leaves. Similar findings have also been made by Irfan *et al.* (2015) [7], Grewal and Singh (1978) [6] and Patel and Patel (2001) [12] and Kumar *et al.*, (2007) [9].

Effect of irrigation levels and depth of irrigation on tuber yield of potato

Effect of different levels of irrigation on tuber yield and haulm yield found significant. Significantly highest tuber yield (29.25 t/ha) and haulm yield (2417 kg/ha) was recorded under the treatment I_3: 1.2 IW/CPE while highest water use efficiency (97.23 kg/ha-mm) was observed under the treatment I_1: 0.8 IW/CPE. While, grade wise tuber yield, Haulm yield and WUE did not affected by depth of irrigation except total tuber yield.

Significantly higher tuber yield (28.87 t/ha) was recorded under the treatment D_1: 20 mm and remained at par with the treatment D2: 30 mm and lower value was recorded under the treatment D4: 50 mm (25.05 t/ha).In case of irrigation levels, Highest tuber yield (29.25) and haulm yield (2417 kg/ha) were recorded under the treatment I_3: 1.2 IW/CPE, while lower value was recorded under I1:0.8 IW/CPE (24.84 t/ha and 1984 kg/ha respectively). The reduction in tuber yield was recorded due to reduction in mean tuber weight under water stress condition

The result of interaction found significant. Significantly higher tuber yield (31.92 t/ha) and haulm yield (2466 kg/ha) was recorded under the treatment I3D1 and remained statistically at par with the treatment I3D2 and I2D4, I3D2 and I3D3 respectively, while lower value was recorded under the treatment I1D4 (20.83 t/ha and 1597 kg/ha respectively).

Significantly higher tuber yield was recorded under the treatment D_1: 20 mm and in case of irrigation levels, the treatment I_3: 1.2 IW/CPE. Significantly higher tuber yield and haulm yield were recorded under the treatment I3D1 and remained statistically at par with the treatment I3D2 and I2D4, I3D2 and I3D3 respectively, while lower value was recorded under the treatment I1D4. Higher total number of tubers and their better development under higher moisture regime is possible due to more moisture availability and higher nutrient uptake. Similar findings were observed by Chandra *et al*., (2001) [4], Patel and Patel (2001) [12]. Singh *et al*. (2005) [18], Begum *et al*. (2018) [2].

Economics

Higher net return of potato crop was recorded under the treatment T9:I3D1 (97257 Rs/ha) followed by the treatment T10: I3D2 (88289 Rs/ha), while lower net return was recorded under the treatment T4:I1D4 (24475 Rs/ha). In case of groundnut, treatment T11:I3D3 recorded higher net return (115120) followed by T3:I1D3, T8:I2D4 and T2: 1D2, while lower net return was recorded under the treatment T1: I1D1(68812 Rs/ha)

Table 1: Effect of levels and depth of irrigation on growth, quality and yield of potato.

Treatments	Emergence (%)	Plant height (cm)	Number of shoots	Dry matter content (%)	Starch content (%)	Specific gravity (kg/m^3)	Total tuber yield (t/ha)
L. Levels of Irrigation (I)							
I1:0.8 IW/CPE	90.14	37.70	2.58	18.78	12.65	1.072	24.84
I2:1.0 IW/CPE	88.75	39.70	2.74	18.38	12.36	1.070	27.09
I3:1.2 IW/CPE	90.28	40.95	2.81	18.36	12.31	1.071	29.25
S.Em. ±	0.57	0.76	0.04	0.25	0.23	0.002	0.51
C.D. (P=0.05%)	NS	2.12	0.10	NS	NS	NS	1.43
D. Depth of irrigation							
D1: 20 mm	89.44	43.35	2.71	18.22	12.21	1.070	28.87
D2: 30 mm	90.37	40.47	2.73	18.25	12.26	1.070	27.94
D3: 40 mm	89.00	37.96	2.74	18.74	12.69	1.072	26.36
D4: 50 mm	90.07	36.01	2.67	18.81	12.61	1.073	25.05
S.Em. ±	0.66	0.87	0.05	0.44	0.26	0.002	0.59
C.D. (P=0.05%)	NS	2.43	NS	NS	NS	NS	1.65
Interaction (P x B)							
I x D	NS	4.22	0.20	NS	NS	NS	2.85
Y x I x D	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	3.80	11.42	8.24	7.80	10.46	0.58	11.30

Table.2: Economics of different treatment

Treatments	Yield main product (kg/ha)	Gross Realization (Rs/ha)	Total Cost of Cultivation (Rs/ha)	Net realization (Rs/ha)	BCR
(1)	(2)	(4)	(5)	(6)	
T1: I1D1	27201	190405	123166	67239	1.55
T2: 1D2	24540	171782	123366	48416	1.39
T3:I1D3	26777	187441	122566	64875	1.53
T4:I1D4	20834	145841	121366	24475	1.20
T5:I2D1	27496	192473	124366	68107	1.55
T6:I2D2	28652	200567	124366	76201	1.61
T7:I2D3	23359	163514	123766	39748	1.32
T8:I2D4	28837	201857	124366	77491	1.62
T9:I3D1	31918	223423	126166	97257	1.77
T10: I3D2	30636	214455	126166	88289	1.70
T11:I3D3	28942	202595	126166	76429	1.61
T12: I3D4	25486	178405	125866	52539	1.42

Table 3: Details of irrigation treatments and water used.

CPE	2018-19		2019-20		2020-21		Pooled	
	No. of irrigations	Water used (mm)	No. of irrigations	Water used (mm)	No. of irrigations	Water used (mm)	No. of irrigations	Water used (mm)
25.0	12	240	13	260	14	280	13	260
37.5	8	240	8	240	9	270	8	250
50.0	6	240	6	240	7	280	6	253
62.5	5	250	5	250	5	250	5	250
20.0	15	300	16	320	18	360	16	327
30.0	10	300	10	300	12	360	11	320
40.0	7	280	8	320	9	360	8	320
50.0	6	300	6	300	7	350	6	317
16.7	18	360	19	380	21	420	19	387
25.0	12	360	13	390	14	420	13	390
33.3	9	360	9	360	10	400	9	373
41.7	7	350	7	350	8	400	7	367

Conclusion

For obtaining higher tuber yield and net return from the potato cultivation under sprinkler irrigation system, potato crop should be irrigated at 20 cm depth and 1.2 IW/CPE ratio and should be irrigated as per given schedule.

Lateral spacing: 9 metre Sprinkler spacing: 9 metre Sprinkler discharge rate: 550 lt/hr Pressure: 3 kg/cm^2	Time interval: 2 hr 57 minutes November: 8 days interval December: 6 days interval Jan-Feb: 4 days interval

Conflict of Interest

The authors declare that they have no conflict of interest

Ethical statement

This article does not contain any studies with human participants or animals performed by any of the authors

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