International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 626-630

Received: 28-09-2019
Accepted: 30-10-2019

PK Sharma
Department of Vegetable Science, IGAU, Raipur, Chhattisgarh, India

PK Joshi
Department of Genetics and Plant Breeding, IGAU, Raipur, Chhattisgarh, India

Smita Bala Rangare
Department of Vegetable Science, IGAU, Raipur, Chhattisgarh, India

Vandana Yadav
Department of Vegetable Science, IGAU, Raipur, Chhattisgarh, India

Corresponding Author:
Smita Bala Rangare
Department of Vegetable Science, IGAU, Raipur, Chhattisgarh, India

Impact of different irrigation levels and varieties on growth and yield parameters of potato (*Solanum tuberosum* L.) under Chhattisgarh condition

PK Sharma, PK Joshi, Smita Bala Rangare and Vandana Yadav

Abstract
The field experiment was conducted under All India coordinated Research project on potato at Department of Vegetable Science, IGKV, Raipur during 2016-17. Potato crop is highly sensitive to water availability to the crop. Now a day, water becomes a limiting source for crop production. Keeping these all the fact the experiment was designed to evaluate crop water stress tolerant variety (K. Pukhraj and WS/05-146) along with four different irrigation scheduling. However, among the irrigation scheduling higher total tuber yield 25.10 t/ha was recorded with the variety WS/05-146 with irrigation applied at 25 mm CPE.

Keywords: Irrigation, water stress, potato varieties, *Solanum tuberosum* L.

Introduction
India is the world's second largest producer of potatoes after China with 45 million tones production, which is 12 % of the total of the world production (Anon., 2013a) [1]. India has taken a massive stride by doubling its potato production in the last two decades. This crop prefers adequate moisture in the root zone owing to its shallow root system as well as for the maintenance of low soil strength, which are conducive for the development and enlargement of tuber (Ahuja and Khurana, 2014) [3].

The potato is pretty sensitive to water deficiency in soil. Optimum yield is obtained when the utilizable water in soil is not over 30-50%. If it drops below 50% the available utilizable moisture, yield may decrease. While the potato is considerably affected by water deficiency during germination, tuber formation and tuber bulking periods, it is less sensitive to water during ripening and early vegetative periods. (Ayas and Korukcu, 2010) [4]. Water has been recognized as an important manageable input influencing potato tuber growth, development, quality and yield (Belanger *et al.*, 2000) [6]. Potato leaves close their stomata at relatively low soil moisture deficits leading to faster decrease in photosynthesis and transpiration rate than other field crops (Kumar *et al.*, 2003) [7]. Moreover, potato has a shallow root system, hence requires frequent irrigation in soils with low water holding capacity. Water stress not only reduces total tuber yield but also changes tuber size distribution, and tuber quality traits (Gregory and Simmonds, 1992; Kumar *et al.*, 2003) [7]. Potato needs frequent-irrigation for a good growth and yield. Yield is considerably affected by storage quality, disease resistance, and the time, amount and frequency of irrigation (Bartoszuk, 1987) [5]. Optimum management of irrigation water must be cultivar dependent as some potato varieties are more tolerant to water stress (Gregory and Simmonds, 1992) [7].

The aim of effective and efficient watering of a growing crop is to replenish depleted soil moisture at a given time to avoid physiological water stress in the growing plants. Furrow irrigation method is a commonly used for potato (*Solanum tuberosum* L.) irrigation in India, due to cost-effectiveness and low maintenance requirements of the method. Generally potato is grown in the winter season in the eastern, northern and central regions of India through utilization of furrow irrigation.

There are very few researchers who study the reactions of crop plants, especially the reactions of potato, to water stress (Hassan *et al.*, 2002). The present study was undertaken to: i) find out the irrigation requirements of recently released Indian potato processing cultivars *viz.*, Kufri

Pukhraj and WS/05-146, and (ii) assess the effect of different irrigation levels on processing-grade tuber yield and processing quality of these cultivars. The aim of this study is to investigate the water-yield relationship of the potato plant under the conditions in Raipur, Chhattisgarh and the effects of water applied in different amounts on different growth periods of potato and to show the yield and quality difference between the crops.

Materials and Methods

The experiment was conducted AICRP on Potato at Department of vegetable science, IGKV, Raipur (C.G.) during the *rabi* 2015-16. The experiment consistsof eight treatments under split plot design. Irrigation levels are assigned in main plot, while, the varieties are assigned in the subplot. The amount of water was calculated by taking weekly meteorological data from Department of agro meteorology, IGKV, Raipur, (C.G.). Cultural operation for the crop was similar for all the treatments *i.e.* amount of fertilizers (N: P: K) (150:100:100 Kg/ha) and other operations as earthing up, weeding operations and application of plant protection chemicals as and when required. On the basis of CPE the treatments were received following amount and number of irrigations.

Table 1: Details of irrigation treatments and water used

Irrigation levels (mm CPE)	No. of irrigation	Water used (mm)
20 mm CPE	6	300
25 mm CPE	5	250
30 mm CPE	4	200
30 + mulching with paddy straw	4	200

Table 2: Details of Treatments

S. No.	Symbol	Main Plot	Sub Plot
1	V1I1	Kufri Pukhraj	Irrigation at 20 mm CPE (6, adequate irrigations)
2	V1I2		Irrigation at 25 mm CPE (6, adequate irrigations)
3	V1I3		Irrigation at 30 mm CPE (4, irrigations at critical stages *viz.* SF, TI, ETES & LTES)
4	V1I4		I_3 + paddy straw mulch @ 5 t/ha at planting
5	V2I1	WS/05-146	Irrigation at 20 mm CPE (6, adequate irrigations)
6	V2I2		Irrigation at 25 mm CPE (6, adequate irrigations)
7	V2I3		Irrigation at 30 mm CPE (4, irrigations at critical stages *viz.* SF, TI, ETES & LTES)
8	V2I4		I_3 + paddy straw mulch @ 5 t/ha at planting

The experiment was laid out in split plot design and each treatment replicated three times. The soil of experimental field was sandy loam and texture with high organic carbon (0.58), pH (7.02), available nitrogen, phosphorous and potassium were 240.5, 22.54 and 354.56 kg/ha, respectively. The half dose of nitrogen (75 kg N /ha) through urea along with full dose of phosphorus (100 kg P/ha) and potash (100 kg K/ha)was applied in the ridges as basal at the time of planting. The remaining half dose of N given at earthing – up stage after 30 days of planting when plants were attain 10-12 cm high.

Table 3: Experimental Details

S. No.	Content	
1	Variety Planted	V1 - K. Pukhraj V2 - WS/05-146
2	Replication	3
3	Gross Plot size	12.96 m^2
4	Net Plot size	3.6 X 3.0 m^2
5	Spacing	60 cm X 20 cm
6	Date of planting	16 November 2015
7	1st pre irrigation	23 November 2015
8	Date of haulm cutting	14th February 2016
9	Date of harvesting	22nd February 2016
10	Recommended dose of NPK	150 : 100 :100 kg/ha

The plot size prepared was 12.96 m^2. The well sprouted seed tubers of potato variety of Kufri Pukhraj and WS/05-146 were planted on ridges at 60 X 20 cm spacing on 16 November, 2015. The first pre-emergence irrigation was given just after seven days of planting, thereafter irrigation were scheduled as per treatment. 50 mm irrigation depth was applied for each irrigation. The total 300, 250, 200 and 200 mm irrigation water (excluding one pre-planting irrigation) was applied to the crop for I_1, I_2, I_3 and I_4 irrigation treatment, respectively. All the recommended package and practice for potato for Raipur region were adopted to fetch high yield. The duration of crop was 90 days. The haulm cutting was done at full maturity on 14th February and the crop harvested on 22nd February, 2016. Total rainfall receivedduring crop season (planting to haulm cutting) was 15.8 mm. Details on irrigation treatments are presented in Table 3.

The final emergencecount was taken at 30 DAP; whileobservations on plant height (cm), number of shoots per plant, number of leaves per plant wererecorded at full growth stage (50days afterplanting). Data on graded tuber yield (t/ha) *i.e.* 0-25g, 25-50g, 50-75g and > 75 g, total tuber yield (t/ha), graded number of tuber yield (t/ha) *i.e.* 0-25g, 25-50g, 50-75g and > 75 g, total number of tuber per hectare were recorded at the time of harvesting. Wateruse efficiency (WUE) was also worked with the following formula:

$$WUE = \frac{\text{Tuber yield (kg ha}^{-1})}{\text{Water applied through irrigation (mm)}}$$

Results and Discussion

Growth Parameters

Plant emergence (%): Plant emergence was moderate (> 80 %) for all the irrigation level except I_3 (76 %) and in both the cultivars as one post planting irrigation were applied to all the treatments to have uniform crop emergence.

Plant height (cm): The plant height was high 46.16 cm with variety WS/05-146 followed by K. Pukhraj (44.54 cm). However, it was found that both the variety were *at par*. Under different irrigation levels, highest plant height (47.21 cm) recorded with I_3*i.e.* 4 irrigations at critical stages. However, it was recorded *at par* with the treatment I_2 - Irrigation at 25 mm CPE (46.07 cm) and I_4 (45.89 cm). The poor plant height was recorded with the treatment I_1- Irrigation at 20 mm CPE. On contrary, plant height reduced in response to water stress at higher CPE levels (Kumar *et al.*, 2007) [11].

Number of Shoots per Plant: Number of Shoots per plant was affected significantly by both the factor *i.e.* variety and irrigation levels. In case of variety, WS/05-146 having higher number of shoots per plant (3.63) as compare to K. Pukhraj. The irrigation applied I_4 - I_3 + paddy straw mulch @ 5 t/ha at planting recorded higher number of shoots per plant (3.67) whereas, it was at par with the treatment I_3- Irrigation at 30 mm CPE (3.67) and I 4 -I_3 + paddy straw mulch @ 5 t/ha at planting (3.67). Patel and Patel (2012) [12] reported the decrease of plant height in potato when irrigation frequency was decrease. The above mentioned growth traits were also recorded by Kumar *et al.* (2004) [10]. On contrary, the number of shoots plant was not affected significantly by varied irrigation levels (Kumar *et al*., 2007) [11]. Abubaker *et al.*, 2014 [2] found that water treatment had no effect on the number of shoots in first season but the effect was significant in second season. In contrast, with these findings, Islam *et al.*, 1990 reported significant effect of irrigation water quantities on the number of shoots of the potato plant.

Number of leaves per Plant: Compound leaves perplant was significantly affected by both variety and different irrigation levels. The highest numberof leaves per plant (47.83) recorded with K. Pukhraj and I1 (54.33). On contrary the compound leaves were not affected significantly by varied irrigation levels (Kumar *et al*., 2007 and Abubaker *et al.*, 2014) [11, 2].

Yield Parameters

Tuber Yield (t/ha): It was observed from the data that the effect of the potato varieties was significant on all grades of tuber and total tuber yield (Table 5). The new variety WS/05-146produced significantly more total tuber 0-25 g grade and large size (>75g) in comparison to advance hybrid K. Pukhraj. Data revealed that the effect of irrigation level was also found significant on all grades of tubers and total tuber yield. The highest total tuber yield (23.38 t/ha) was obtained from I2 followed by I4 (21.41 t/ha), I3 (20.71 t/ha) and I1 (14.38 t/ha) indicating that both excess and deficit water had adverse effect on yield. This result was supported by the Abubaker *et al*., 2014 [2]. Thus the moderate water quantity (I2-Irrigation at 25 mm) was the optimum. Kumar *et al*., 2007 [11] also reported continuous decrease in processing grade tuber yield and total tuber yield with increase in irrigation levels from 15 mm CPE to 35 mm CPE and found that 20 mm CPE irrigation can be scheduled in stress condition.

Table 4: Percent plant emergence, plant vigor, number of shoots per plant, number of leaves per plant, yield of graded tuber (t/ha) and total tuber yield (t/ha) for different treatments on potato

Hybrid/ Variety	Percent plant emergence at 30 DAP	Plant Vigor	No. of Shoots/plant	No. of leaves/plant	Yield of graded tuber (t/ha)				Total tuber yield (t/ha)
					0-25 g	25 – 75g	>75 g	0-25 g	
V1	82.92	44.54	3.53	47.83	3.66	9.79	3.33	3.66	19.20
V2	83.08	46.16	3.63	43.83	4.82	8.85	3.87	4.82	20.73
CD	8.95	2.98	0.64	16.27	0.27	0.35	0.34	0.27	0.80
I_1	84.67	42.23	3.27	54.33	3.88	6.97	1.59	3.88	14.38
I_2	84.33	46.07	3.57	37.17	5.89	8.44	4.99	5.89	23.35
I_3	76.00	47.21	3.67	46.50	3.15	11.08	4.33	3.15	20.71
I_4	87.00	45.89	3.83	45.33	4.05	10.77	3.50	4.05	21.41
CD	4.96	3.66	0.42	17.10	0.13	0.35	0.14	0.13	0.51

Table 5: Number of graded tuber (t/ha), total numbertubers (t/ha) and Water Use Efficiency for different treatments on potato

Hybrid/ Variety	No. of graded tuber (000ˆ/ha)			Total No.of tubers (000ˆ/ha)	Water Use Efficiency
	0-25 g	25-75g	>75 g		
V_1	219.92	202.92	31.58	492.08	59.09
V_2	232.83	213.50	38.33	525.08	63.06
CD	5.40	19.13	5.26	20.02	2.60
I_1	269.50	147.17	16.83	462.83	33.30
I_2	291.17	232.67	47.50	611.50	64.86
I_3	150.83	215.17	40.50	442.83	71.80
I_4	194.00	237.83	35.00	517.17	74.34
CD	2.50	5.17	2.70	5.21	2.12

V1 -K. Pukhraj, V2 - WS/05-146

Number of tubers per ha: From the experiment it is observed that the effect of potato varieties was significant on graded tuber and total tuber numbers. The local variety K. Pukhraj V2 produced significantly higher number processing grade tuber (>75 g) 38.33 thousand per ha, 25-75 g grade tuber 213.50 thousand per hectare as well as total tuber number per hectare (528.08 thousand) as comparison to advance hybrid. This was because of lower tuber setting and tuber number per plant in advance hybrid.

Data revealed that the effect of irrigation level was significant on graded number of tuber and total tuber number. The irrigation applied at Irrigation at 25 mm CPE *i.e.* 5 sub-optimal irrigations produced significantly higher number of graded number of tuber and total tuber number per hectare.

Water use efficiency: It is clear from the Table No. 6 that WS/05-146 (63.06 kg tuber ha-mm^{-1}) had higher WUE than K. Pukhraj (59.09 kg tuber ha-mm^{-1}). The lower value of WUE inK. Pukhraj showed that K. Pukhrajis less efficient user of water than hybrid WS/05-146. The lower efficiency of water use for K. Pukhraj was due to the fact that much more applied water was used in the development of vegetative parts at the expense of tuber development.

Table 6: Interaction effect of varieties and irrigation levels on total tuber yield (t/ha), total number of tubers (000'/ha) and Water Use Efficiency on potato

Irrigation levels →	Total tuber yield (t/ha)				Total number of tubers (000'/ha)				Water Use Efficiency			
Variety ↓	I_1	I_2	I_3	I_4	I_1	I_2	I_3	I_4	I_1	I_2	I_3	I_4
V1	13.03	21.60	22.90	19.27	387.3	584.0	459.6	537.3	30.17	60.00	79.26	66.94
V2	15.74	25.10	18.53	23.54	538.3	639.0	426.0	497.0	36.43	69.71	64.34	81.75
CD (P=0.05)	1.02				10.41				3.60			

Table 7: Meteorological Data during the cropping period

Nov 05-11	30.2	15.7	0.0	0	88	29	12.7	8.8	1.9	25.2	8.5
12-18	29.0	14.4	0.0	0	89	35	12.2	10.5	1.5	20.7	7.8
19-25	30.0	11.3	0.0	0	89	25	9.7	7.7	0.9	21.2	8.5
26-02	30.7	13.0	0.0	0	88	27	11.0	8.5	1.2	22.6	8.5
Dec 03-09	28.9	14.3	0.0	0	90	39	11.3	11.2	1.5	25.1	7.4
10-16	28.8	11.9	0.0	0	83	29	9.5	8.3	2.0	57	8.1
17-23	27.5	8.6	0.0	0	87	24	7.9	6.1	1.5	37.1	8.5
24-31	28.2	9.9	0.0	0	86	26	8.3	7.4	1.1	22.5	7.4
Jan 01-07	28.6	12.2	0.0	0	90	32	10.0	8.8	1.5	19.9	6.4
08-14	27.2	11.9	5.6	1	85	35	9.5	8.5	2.6	17.2	6.5
15-21	28.9	11.8	0.0	0	85	27	9.3	8.0	1.2	21.5	8.0
22-28	29.9	14.3	0.0	0	83	29	10.9	8.7	1.9	25.3	7.7
29-04	30.4	12.0	0.0	0	80	26	9.9	8.2	1.6	27.0	9.4
Feb 05-11	32.2	14.1	0.0	0	81	26	10.3	8.9	1.8	30.0	9.3
12-18	31.0	15.8	0.0	0	80	31	11.3	9.2	2.6	30.9	6.8
19-25	34.1	15.5	0.0	0	68	17	9.9	6.5	2.6	41.7	10.1
26-04	34.3	15.8	0.0	0	73	15	10.7	6.3	2.2	40.4	9.7
Mar 05-11	33.0	19.2	5.5	1	69	36	12.5	12.3	3.3	36.5	6.7
12-18	32.9	17.0	0.0	0	58	18	9.7	6.7	3.3	43.5	8.9
19-25	36.5	19.7	0.0	0	63	15	12.1	7.0	2.9	50.0	9.2
26-01	35.9	23.0	0.0	0	58	13	13.3	7.4	2.7	58.5	8.9
Apr 02-08	41.4	26.6	0.0	0	45	17	14.4	9.6	5.1	66.7	8.3
09-15	40.7	22.0	0.0	0	36	9	9.1	5.2	3.2	69.6	9.4
16-22	42.6	26.7	0.0	0	41	10	12.9	6.1	4.6	72.3	9.5
23-29	42.3	24.9	0.0	0	37	8	10.5	4.9	5.4	12.5	10.3
30-06	42.0	27.6	0.0	0	39	14	12.9	8.2	4.6	74.7	9.2

Interaction effect of varieties and irrigation levels

Application of Irrigation at 25 mm along with variety Kufri Pukhraj the highest plant emergence (89.00%), plant height (49.07 cm), 0-25 grade of tuber yield (6.88 t/ha) and total tuber yield (25.10 t/ha) as compare to other treatment. The variety WS/05-146 with irrigation level 4 *i.e.*I_3 + paddy straw mulch @ 5 t/ha at planting recorded highest number of shoots per plant (4.07).

The interaction effect of different variety and various level of irrigation found significant for graded tuber yield per hectare, graded tuber number per hectare, total tuber yield per hectatre and total number of tuber per hectatre. The highest 5.03 t/ha fresh weight of grade > 75 g found with K. Pukhraj and irrigation applied at Irrigation at 25 mm CPE which is at par with WS/05-146 with irrigation applied at Irrigation at 25 mm CPE. The highest total tuber yield per hectatre 25.10 t/ha reported with WS/05-146 with irrigation applied at Irrigation at 25 mm CPE followed by WS/05-146 with irrigation level 4 *i.e.*I_3 + paddy straw mulch @ 5 t/ha at planting (23.54 t/ha).

However, large number of tuber per ha 52.33 (> 75 g) reported under the treatment WS/05-146 with irrigation level 4 *i.e.*I_3 + paddy straw mulch @ 5 t/ha at plantingwhich is at par with WS/05-146 with irrigation applied at Irrigation at 25 mm CPE. Kumar (2007) [11] reported that in case of water scarcity irrigation can be scheduled at 20 mm CPE by saving 50-100 mm water without sacrificing processing grade and total tuber yield.

Treatment I_4 with the new hybrid WS/05-146recorded significantly higher (81.75) WUE among all the interaction treatments.

References

1. Anonymous. Faostat, 2013a. Available: http://faostat3.fao.org [Accessed 10 October 2014].
2. Abubaker BMA, Shuang-en Y, Guang-Cheng S, Alhadi M, Elsiddig A. Effect of irrigation levels on the growth, yield and quality of potato. Bulgarian J Agri. Scie. 2014; 20(2):303-309.
3. Ahuja S, Khurana DS. Effect of soil matric potential based irrigation scheduling on water use efficiency of potato. International J Food, agri. And Vet. Sciences. 2014; 4(3):120-132.
4. Ayas S, Korykcu A. Water-yield relationships in deficit irrigated potato. J. Agriculture faculty of Uludag University. 2010; 24(2):23-36.
5. Bartoszuk W. Decrease in potato yield resulting from water deficit during the growing season. Potato Abstract, 1987; 15(1) (Abstract no: 194)
6. Belanger G, Walsh JR, Richards JE, Milburn PH, Ziadi N. Yield response of two potato cultivars to supplemental irrigation and N fertilization in New Brunswick. Amer. J Potato Res. 2000; 77:11-21.
7. Gregory PJ, Simmonds LP. Water relations and growth of potatoes. In: The Potato Crop (P.M. Harris, Ed.), pp. 214-46. Chapman and Hall, London, UK, 1992.
8. Islam T, Sarker H, Alam J. Water use and yield relationship of irrigated potato Agricultural Water Management. 1990; 18(2):173-179.
9. Kumar D, Minhas JS, Singh B. Abiotic stress and potato production. In: The Potato: Production and Utilization in Sub-Tropics (S.M. Paul Khurana, J.S. Minhas and S.K.

Pandey, Eds.), Mehta Publishers, New Delhi, India. 2003, pp.314-22.
10. Kumar P, Pandey SK, Singh BP, Rawal S, Singh SV, Kumar D. Fertilizer requirements of chipping potato (*Solanum tuberosum* L.) cultivars in West-Central Plains. Potato J. 2004; 31:177-181.
11. Kumar P, Pandey SK, Singh SV, Kumar D. Irrigation requirements of chipping potato cultivars under West-Central Indian Plains. Potato J. 2007; 34(3-4):193-198.
12. Patel JC, Patel LR. Effect of irrigation and nitrogen on yield attributes in potato. J Indian Potato association. 2001; 28:285-287.