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Smita Bala Rangare
Department of Vegetable Science, CoA, IGKV, Raipur, Chhattisgarh, India

PK Sharma
Department of Vegetable Science, CoA, IGKV, Raipur, Chhattisgarh, India

J Trivedi
Department of Vegetable Science, CoA, IGKV, Raipur, Chhattisgarh, India

NR Rangare
Department of Genetics and Plant Breeding, CoA, IGKV, Raipur, Chhattisgarh, India

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

Effects of different irrigation regimes and genotypes on growth and yield of potato (*Solanum tuberosum* L.) under Chhattisgarh plains

Smita Bala Rangare, PK Sharma, J Trivedi and NR Rangare

Abstract
In Chhattisgarh plains potato crop grown as a rabi crop. The crop requires high water for its proper growth and good yield. On other hand, excess water reduces yield. Low and high available soil moisture both affect badly the crops. The present investigation conducted to evaluate of different irrigation regimes and genotypes for potato growth and yield. At 75 DAP and 90 DAP, the various yield and yield attributing characters were significantly affected by the different irrigation regimes except plant emergence at 75 DAP and number of shoots plant^{-1} at 90 DAP. On other hand, potato genotypes were differing non-significantly. Plant emergence at 90 DAP, plant height (cm), number of shoots plant^{-1} at 75 DAP, number of compound leaves plant^{-1}, fresh and dry weight of shoots plant^{-1} (g), total tuber yield (t ha^{-1}) and marketable tuber yield (t ha^{-1}) significantly affected by the different irrigation regimes and potato genotypes. The water deficit condition imposed by the irrigation at 25 mm CPE reported for the maximum total tuber yield (21.89 t ha^{-1} and 25.07 t ha^{-1}) and marketable tuber yield (19.75 t ha^{-1} and 23.74 t ha^{-1}) for 75 DAP and 90 DAP, respectively. The potato genotype AICRP-P-38 gave the highest total tuber yield (25.97 t ha^{-1} and 29.15 t ha^{-1}) and marketable tuber yield (23.76 t ha^{-1} and 27.42 t ha^{-1}) for 75 DAP and 90 DAP, respectively.

Keywords: potato, irrigation regimes, genotypes, vegetative growth, total tuber yield, marketable tuber yield

Introduction
The world population is increasing both in developed and developing countries. The present population of the world 7,766 millions upto June 2021 and the average annual rate of population change with 1.1 % from 2015 to 2020 (Anon, 2021) [2]. With the increasing rate of population, the other next big problem is to feed these much huge population. This is not a big deal for the developed countries but for the countries that is developing till now the hungriness is emerging as a big issue. The lands are limited and there is not any possibility to increase land areas. So the main issue is how to feed the huge population? The one and only answer is by increasing the production of food in these limit land areas.
The fourth most important food source of the world is potato after the cereal crop which is also called "Staple Food". Potato has been established as an important food crop in developed countries. It is cultivated as a rain fed and also as irrigated crop. Mostly in hilly areas potato is grown as rainfed crop during kharif season and irrigate when needed.
Availability of soil water is a major factor that determines yields and quality of potato tuber. Too low water decreases the tuber yields, induces malformation of tuber and also increases the severity of various diseases and insect pest. Potato crop requirement which constitute the amount of water required to mature the crop irrespective of the source of water supply requires 25-26 ha cm water which should be well spread throughout the growing period (Das, 2014) [4]. The critical stages of irrigation are pre-emergence stage, stolonization stage, tuberization stage and bulking stage (Das, 2014) [6]. The irrigation scheduling depends on moisture retention capacity of soil, stage of crop growth, atmospheric factors and genetic pattern of cultivar.

Material and Methods
Site Description
The experiment was conducted under the AICRP on Potato at Department of vegetable science, IGKV, Raipur (C.G.) during the rabi season of 18th November, 2018-19. The experiment consists of two factors *i.e.* four level of irrigation regimes and four potato genotypes under split plot design with three replication.

Treatment and Experimental Design

The experiment was laid out in split plot design and each treatment replicated three times for both 75 DAP and 90 DAP. The soil of experimental field was sandy loam 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^{-1}, respectively. The half dose of nitrogen (75 kg N ha^{-1}) through urea along with full dose of phosphorus (100 kg P ha^{-1}) and potash (100 kg K ha^{-1}) 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 attaining 10-12 cm high of crop was 90 days. Irrigation levels were assigned in main plot, while, the varieties were assigned in the subplot. The amount of water was calculated by taking weekly weather data obtained from Department of Agro-meteorology, IGKV, Raipur, (C.G.).

Scheduling of Irrigation

Pre–planting irrigation was given to create uniform moisture condition in field soil. In and two post-planting irrigations were also applied evenly to all treatments to ensure uniform emergence. Irrigation was applied through furrow irrigation which is also called conventional method of irrigation. In each and every irrigation, 50 mm water was applied. Open pan evaporation was measured in mm per day from USWB class 'A' open pan evaporimeter. As the volume of water evaporated from cropped field, irrigation applied. The schedule of irrigation was done on the basis of different CPE given as treatments. On the basis of CPE the treatments were received following amount and number of irrigations.

Table 1: Number of irrigation and total water given at 75 DAP and 90 DAP during Crop Growth Period of 2018-19.

Irrigation	75 DAP		90 DAP	
	No. of Irrigation	Total water given (mm)	No. of Irrigation	Total water given (mm)
I1- Irrigation at 20 mm CPE	5	250	7	350
I2- Irrigation at 25 mm CPE	4	200	5	250
I3- Irrigation at 30 mm CPE	3	150	4	200
I4- Irrigation at 30 mm CPE + paddy straw mulching @ 5 t ha^{-1}	3	150	4	200

Cultural Practices and Harvesting

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.

Haulm cuttings of potato crop were scheduled at 75 and 90 DAP. The haulm cutting was done at 2nd February and 18th February for 75 Days and 90 Days crop, respectively. Total rainfall received during crop season (planting to haulm cutting) was 70.8 mm upto 90 DAP in the year of 2018-19.

Data Recorded

Data recorded on the final emergence count which was taken at 30 DAP; while observations on plant height (cm), number of shoots plant^{-1}, number of leaves plant^{-1}, fresh weight of plant, dry weight of plant total, tuber yield (t ha^{-1}) and marketable tuber yield (t ha^{-1}) taken before harvesting.

Results and Discussion

Growth Attributing Characters

1. Plant Emergence (%): Among the different treatment of irrigation regimes the non- significant effects were recorded at 75 DAP but it was found significant at 90 DAP. The maximum plant stand was reported when irrigation applied at 20 mm CPE for both 75 DAP and 90 DAP (90.91 % and 90.57 %, respectively) followed by irrigation application at 25 mm CPE (89.72 % and 89.38 %) for both condition *i.e.* upto 75 DAP and 90 DAP, respectively.

However, in case of different potato genotypes, there were no significant differences found for 75 DAP and 90 DAP. The maximum plant emergence counted in Kufri Sundhuri (90.67 %) for 75 DAP and 89.18 % for 90 DAP. The uniform emergence of potato plant was due to one pre-planting and two post-planting irrigation which results the uniform crop emergence. This result of present investigation is supported by the Kumar *et al*, 2007 [9].

2. Plant height (cm): The effect different irrigation regimes on plant height (cm) at 75 DAP and 90 DAP are shown in table 2. The treatment I_1 *i.e.* irrigation applied at 20 mm CPE (50.9 cm and 56.1 cm) recorded the maximum value for plant height followed by I_4: 30 mm CPE + paddy straw mulching @ 5 t ha^{-1} (46.6 cm and 51.7 cm) which were found statistically *at par* with the I_2 *i.e.* irrigation applied at 25 mm CPE (45.9 cm and 51.0 cm) for 75 DAP and 90 DAP, respectively. However, the lowest value (40.8 cm and 45.3 cm) for plant height was recorded under higher stress condition *i.e.* irrigation at 30 mm CPE for 75 DAP and 90 DAP, respectively. The plant height reduced in response to water stress at higher CPE levels. Patel and Patel, 2001 [10]; Kumar *et al*, 2007 [9] also reported decreasing of plant height in crop when frequency of irrigation decreased.

Concerning with the performance of potato genotypes, the higher plant height (54.5 cm and 60.4 cm) was reported in AICRP-P-32 which was statistically *at par* with Kufri Sindhuri (54.4 cm and 60.4 cm) followed by in genotype AICRP-P-21 (39.8 cm and 44.2 cm) at both 75 DAP and 90 DAP, respectively. The lowest plant height was measured in the genotype AICRP-P-38 (35.6 cm and 39.1cm) at 75 DAP and 90 DAP, respectively. Similar findings have also been reported by Kumar *et al*, 2004 [8] and Kumar *et al*, 2007 [9].

Number of shoots plant^{-1}: Number of stem plant^{-1} was affected significantly at 75 DAP while for the 90 DAP it was not differed significantly by different irrigation regimes. The highest number of stem plant^{-1} (3.6 and 4.4) was counted with I_1 when water was applied at 20 mm CPE followed by when irrigation applied at 25 mm CPE (3.3 and 4.1) for 75 DAP and 90 DAP, respectively. The number of shoots plant^{-1} decreases as the amount of irrigation water decreases. This result is supported by Kumar *et al*, 2004 [8]; Kumar *et al*, 2007 [9] and Dash *et al*, 2018 [6].

The above mention growth parameter was significantly higher (4.0 and 5.0) for the variety AICRP-P-21 upto 75 DAP and 90 DAP, respectively as compared to other varieties. The minimum number of shoots plant^{-1} was recorded in AICRP-P-32 for 75 DAP and 90 DAP (2.5 and 3.2, respectively). This

may be due to their genetic differences that showed, the distance between nodes and number of nodes in stem (Wurr *et al*, 1993; Dey and Ray, 2017) [12, 5].

Number of compound leaves plant^{-1}: Number of compound leaves plant^{-1} was affected significantly by the various levels of irrigation and different potato genotypes for both harvesting time *i.e.* 75 DAP and 90 DAP. The highest number of compound leaves plant^{-1} (64.1 and 79.3) was counted with I_1 – irrigation at 20 mm CPE followed by when irrigation applied at 25 mm CPE (61.0 and 77.7) for 75 DA and 90 DAP, respectively. Literature revealed that the limitation in soil moisture available in different growth stages of potato plant results in earlier crop maturity and decreases in plant growth (Yuan *et al*, 2003; Dey and Ray, 2017; Dash *et al*, 2018) [13, 5, 6].
The variety Kufri Sindhuri produced more number of compound leaves plant^{-1} (67.7 and 86.0) followed by AICRP-P-32 (67.4 and 83.2) for 75 DAP and 90 DAP, respectively. The minimum number of compound leaves plant^{-1} was counted in potato genotype AICRP-P-38 (55.2 and 69.0). Kumar *et al*., (2007) [9] suggested that these results might be due to the genetic characters of varieties.

Fresh weight of plant (g): Perusal of the data in Table 2 revealed that the fresh weight of plant reported maximum (214.0 g and 240.0 g) when plant was irrigated at 30 mm CPE followed by treatment I_4: irrigation at 30 mm CPE + paddy straw mulch @ 5 t/ha at planting for (201.0 g and 225.1 g) for 75 DAP and 90 DAP, respectively. The minimum fresh weights were recorded at irrigation regimes 30 mm CPE (147.4 g and 165.2 g) at 75 DAP and 90 DAP, respectively.
The effect of varietal treatment found significant. The maximum fresh weight of plant recorded in variety AICRP-P-32 (283.3 g and 317.4 g) followed by in Kufri Sindhuri (194.4 g and 218.0 g) for 75 DAP as well as for 90 DAP, respectively. At early stage of plant growth most of the dry matter was in leaf and stem and from tuber initiation to tuber bulking stage, it was accumulated in stolon. At maturity stage and onwards stem and leaf fresh and dry weight decreased, this is due to transfer of photosynthetes from leaf and stem to tuber (Dey and Ray, 2017) [5]. The varieties which stored or assimilated more photosynthetes reported increase on dry matter accumulation in plant. Sometimes performance of variety is the genetic characters (Kormondy, 1996) [7].

Dry weight of plant (g): Concerning the data in Table 2 it is revealed that the dry weight of plant reported maximum (32.1 g and 42.5 g) when plant was irrigated at 25 mm CPE followed by treatment I_4: irrigation at 30 mm CPE + paddy straw mulch @ 5 t/ha at planting for (30.2 g and 40.8 g) for 75 DAP and 90 DAP, respectively. The minimum dry weights were recorded at irrigation regimes 30 mm CPE (22.1 g and 31.2 g) at 75 DAP and 90 DAP, respectively.
The effect of potato genotypes were found significant. The maximum dry weight of plant recorded in variety AICRP-P-32 (42.5 g and 48.3 g) followed by in Kufri Sindhuri (29.2 g and 39.7 g) for 75 DAP as well as for 90 DAP, respectively. At early stage of plant growth most of the dry matter was in leaf and stem and from tuber initiation to tuber bulking stage, it was accumulated in stolon. At maturity stage and onwards stem and leaf fresh and dry weight decreased, this is due to transfer of photosynthetes from leaf and stem to tuber (Dey and Ray, 2017) [5]. The varieties which stored or assimilated more photosynthetes reported increase on dry matter accumulation in plant. Sometimes performance of variety is the genetic characters (Kormondy, 1996) [7].

Total Tuber Yield (t ha^{-1}): Data presented in the table 2 revealed that there are significant differences exhibited among the various irrigation treatments for total tuber yield per hectare. Perusal of data indicates a continual decrease in the total tuber yield ha^{-1} with increasing in stress condition. The highest total tuber yield (26.31 t ha^{-1} and 28.88 t ha^{-1}) reported when the irrigation given at 20 mm CPE followed by irrigation at 25 mm CPE (21.89 ha^{-1} and 25.08 ha^{-1} for 75 DAP and 90 DAP, respectively. This result is supported by Kumar *et al*, 2007 [9]; Ati *et al*, 2012; Dey and Ray, 2017 [5].
In case of varietal treatment genotype AICRP-P-38, AICRP-P-32 and Kufri Sindhuri reported significant differences for total tuber yield (t ha^{-1}). The highest total tuber yield was reported in genotype AICRP-P-38 (25.97 t ha^{-1} and 29.15 t ha^{-1}) followed by AICRP-P-32 (22.64 ha^{-1} and 26.62 ha^{-1}). According to Sadarwat *et al*., 2013 the total tuber yield were recorded for various irrigation regimes, irrigation at 20 m CPE resulted in higher total tuber yield in first year, second year as well as in the pooled mean rather than other scheduled treatment.

Marketable Tuber Yield (t ha^{-1}): Data presented in the table 2 revealed that there are significant differences exhibited among the various irrigation treatments for marketable tuber yield per hectare. The data indicates a continual decrease in the marketable tuber yield ha^{-1} due to increasing in stress condition. The highest marketable tuber yield (25.14 ha^{-1} and 27.48 ha^{-1}) reported when the irrigation given at 20 mm CPE followed by irrigation at 25 mm CPE (19.76 ha^{-1} and 23.74 ha^{-1}), which was found *at par* with I_4 *i.e.* irrigation at 30 mm CPE+ paddy straw mulch @ 5 t/ha at planting (18.56 ha^{-1} and 22.92 ha^{-1}) both at 75 DAP and 90 DAP, respectively. Thus in case of water scarcity, irrigation can be scheduled at 30 mm CPE with paddy straw mulch by saving 50-75 mm water without sacrificing the marketable tuber yield (t ha^{-1}). This result is supported by Kumar *et al*, 2007 [9]; Ati *et al*, 2012; Dey and Ray, 2017 [5].
Concerning with varietal treatment, genotype AICRP-P-38 showed the significantly higher marketable tuber yield (23.77 t ha^{-1} and 27.42 t ha^{-1}) followed by AICRP-P-32 (20.62 t ha^{-1} and 24.97 t ha^{-1}) for 75 DAP and 90 DAP, respectively. Previous study stated that the soil water limitation at different stages of growth results in earlier crop maturity, less tuber yield, reduced number of tuber plant^{-1}, decreased size of tubers as well as the quality of tuber (Dalla Costa *et al*, 1997; Yuan *et al*, 2003, Dey and Ray, 2017; Dash *et al*, 2018) [13, 5, 6].

Table 2: Effects of different irrigation regimes and potato genotypes on yield and yield attributing parameters of potato during 2018-19.

Parameters	Plant Emergence (%)		Plant Height (cm)		No. of shoots plant^{-1}		No. of compound leaves plant^{-1}		Fresh weight of plant (g plant^{-1})		Dry weight of plant (g plant^{-1})		Total tuber yield (t ha^{-1})		Marketable tuber yield (t ha^{-1})	
Main Plot level of Irrigation Regimes (I)																
	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP	75 DAP	90 DAP
I_1	90.91	90.57	50.9	56.1	3.6	4.4	64.1	79.3	199.1	222.2	29.9	33.0	26.31	28.88	25.14	27.48
I_2	89.72	89.38	45.9	51.0	3.3	4.1	61.0	77.7	147.4	165.2	32.1	42.5	21.89	25.08	19.76	23.74
I_3	89.32	88.57	40.8	45.3	3.0	3.8	59.5	73.8	214.0	240.0	22.1	31.2	15.59	20.98	12.75	19.92
I_4	89.57	86.93	46.6	51.7	3.1	3.8	59.2	74.5	201.0	225.1	30.2	40.8	20.45	24.17	18.56	22.92
SE (m)	1.60	0.56	1.0	0.6	0.1	0.2	0.7	1.7	1.8	2.8	0.6	1.6	0.205	0.237	0.197	0.223
CD	NS	1.40	2.4	1.4	0.3	NS	1.8	4.1	4.5	7.0	1.5	4.1	0.511	0.592	0.492	0.555
Subplot levels of potato genotypes (V)																
V_1	89.70	88.33	39.8	44.2	4.0	5.0	53.5	67.0	136.5	152.0	20.5	27.4	15.184	19.84	12.66	18.53
V_2	89.52	89.18	54.5	60.4	2.5	3.2	67.4	83.2	283.3	317.4	42.5	48.3	22.639	26.62	20.62	24.97
V_3	89.64	89.17	35.6	39.1	3.5	4.3	55.2	69.0	147.3	165.1	22.1	31.9	25.972	29.15	23.77	27.42
V_4	90.67	88.76	54.4	60.4	3.0	3.7	67.7	86.0	194.4	218.0	29.2	39.7	20.449	23.50	19.15	22.39
SE (m)	1.59	0.44	0.8	0.7	0.1	0.2	0.9	1.0	1.9	2.1	0.5	0.8	0.179	0.325	0.179	0.319
CD	NS	NS	1.6	1.4	0.2	0.3	1.9	2.1	4.0	4.3	1.1	1.7	0.371	0.674	0.372	0.663

I_1- Irrigation at 20 mm CPE; I_2- Irrigation at 25 mm CPE; I_3- Irrigation at 30 mm CPE; I_4- Irrigation at 30 mm CPE + paddy straw mulching @ 5 t ha^{-1} ;
V_1- AICRP-P-21; V_2 - AICRP-P-32; V_3 - AICRP-P-38; V_4 - Kufri Sindhuri

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