International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 2714-2719

Received: 01-01-2020
Accepted: 03-02-2020

Shreya Paikra
Department of Vegetable Science, IGKV, Raipur, Chhattisgarh, India

Dr. Vijay Kumar
Department of Vegetable Science, IGKV, Raipur, Chhattisgarh, India

Dr. Pravin Kumar Sharma
Department of Vegetable Science, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Shreya Paikra
Department of Vegetable Science, IGKV, Raipur, Chhattisgarh, India

Studies on the effect of plant growth regulators and their application methods on growth, yield and quality attributes of potato (*Solanum tuberosum* L.) variety Kufri Pukhraj under agro-climatic conditions of Chhattisgarh plains

Shreya Paikra, Dr. Vijay Kumar and Dr. Pravin Kumar Sharma

DOI: https://doi.org/10.22271/chemi.2020.v8.i2ap.9160

Abstract
The present investigation entitled "Studies on the effect of plant growth regulators and their application methods on growth, yield and quality attributes of Potato (*Solanum tuberosum* L.) variety Kufri Pukhraj under agro-climatic conditions of Chhattisgarh plains." was performed at Research Cum Instructional Farm, College of Agriculture, IGKV, Raipur (C.G), during the *Rabi* season 2018-19 under ACRPT. The experiment was carried out with Factorial RBD with fourteen treatment combinations consisting of two methods of application S (Seed treatment) and F (Foliar Spray application) and seven levels of plant growth regulators viz., T_1 (Plain water), T_2 (GA_3 -15 ppm), T_3 (GA_3-25 ppm), T_4 (GA_3- 50 ppm), T_5 (IBA-100 ppm), T_6 (IBA-200 ppm) and T_7 (IBA-250 ppm) were replicated three times. The method of PGRs application significantly influenced on all growth, yield and quality parameters. The method of PGRs application non-significantly differentiate plant height, number of shoot and dry weight of shoot per plant, harvesting index, specific gravity. The interaction effect of these two components recorded significant lesser days for plant emergence under ST_3 (19 days), higher plant emergence percentage under ST_3 (95.11%), maximum height of plant at 90 DAP under ST_4 (61.78), maximum number of shoot under FT_2 (13.13), maximum number of tuber per plant under FT_7 (8.30), grade wise maximum tuber yield found that Grade B (50-75 g) tuber yield with FT_5 of 9.17 kg/plot (10.19 t/ha). However, maximum total tuber yield was recorded with ST_4that is (29.43 t/ha).

Keywords: Plant growth, application methods, growth, yield, *Solanum tuberosum*

Introduction
Potato (*Solanum tuberosum* L.) is one of the solanaceous vegetable crops which is most important in India. It belongs to family solanaceae having chromosome number 2n = 4x = 48. India is the world's third largest potato producing nation. In India, potato occupies 21.79 million hectares area with 486.05 million hectares production and 22.30 ton/ha productivity (Anonymous, 2017). In Chhattisgarh, 44,202 hectares area is under potato cultivation with 6, 80,523 metric tones production and 16.93 tones/ha productivity (Anonymous, 2017). Its tuber has multifarious use in home consumption as well as in processing industries. This crop is of significant economic importance in Chhattisgarh where it is cultivated mainly in *rabi* season in plain areas. In hilly area of Chhattisgarh *i.e.* Mainpat, it is cultivated in both rabi and *kharif* season. Potato brings economic returns to farmers within short period of time. Since the winters in plain areas of Chhattisgarh are of short period and early varieties fit well for cultivation.

It is one of the staple food crops which occupy 4th rank after rice, wheat and maize. Potato ranks 2nd position in production (tons) after china. Potato is a extremely nutritious and readily digestible food crop. It includes carbohydrate, proteins, minerals, vitamins and other nutritional fibers. A potato tuber contains 80 percent water and 20 percent dry matter consisting of edible protein (2.8 g), starch (16.3 g), total sugar (0.6 g), crude fiber (0.5 g), fat (0.14 g), carbohydrate (22.6 g), vitamin C (25 mg), mineral (0.9 g), calcium (7.7 mg), iron (0.75 mg), ash (1-1.5 percent), amylose (22-25 percent) and glycoalkaloids (< 1 mg) per 100 g of fresh anti-nutritional weight.

The significant element of potato tuber is starch, which accounts for about 70 percent of the total solids. Potato has increased dry matter production ability, which is approximately 47.6 kg / hectare / day. Potato generates the largest protein per unit region similar to egg and milk protein and superior in dietary quality to other vegetables, cereals and pulse proteins.

It is a short-lived crop capable of generating the greatest quantity of food per unit region and time. Being versatile in adaptability, it offers flexibility in harvesting with greater yields. Among several constraints in potato production, the temperature and photoperiods are major climatic factors affecting tuber yield and quality. The productivity of early potato varieties is lower due to short duration; moreover, under short periods of winters, there is lower productivity of potato in Chhattisgarh plains. The crop deserves attention with regards to development of suitable agronomic practices particularly for early and short duration potato varieties which are mainly cultivated in plain areas of Chhattisgarh. The roles of plant growth regulators under varying day length and temperature condition in potato has been reported by several workers through improvement in source and sink relationship thereby improving tuber yield and quality attribute. (Sillu *et al*., 2012; Pamukuntala *et al*., 2018) [3, 2]. Effect of PGR like gibberellic acid on plant growth, stolen development, tuberization and plant yield under varying photoperiods have been reported by Agrawal *et. al*., 1983 [4]. It is reported that gibberellic acid 50 ppm to 400 ppm enhanced shoot emergence, tuber sprouting, number of leaves and marketable tuber yields. (Khurana and Pandita, 1987; Bhatia *et al*., 1992; Pamkuntala *et al*., 2018; Kumar *et al*., 2012; Javanmardi *et al*., 2017) [8, 5, 2, 7, 6].

Material and Methods

The present investigation entitled "Studies on the effect of plant growth regulators and their application methods on growth, yield and quality attributes of Potato (*Solanum tuberosum* L.) variety Kufri Pukhraj under agro-climatic conditions of Chhattisgarh plains." was performed at Research Cum Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G), during the 2018-19 *rabi* season under All India Coordinated Potato Research Project.

The planting material (seed tubers) of potato variety Kufri Pukhraj was obtained from AICRP Potato, Department of Vegetable Science, IGKV, Raipur (C.G.). The plant growth regulators i.e., GA_3 and IBA were used at different concentrations by using different methods of application i.e., seed treatment before planting and foliar sprays (at 30 and 60 DAP). The details of treatments and their different combinations comprising of application methods and foliar spray treatments at different concentrations are given in the Table 1.

Table 1: Treatment Details

S. No.	Methods of Application	Notation	Details
1.	S (Seed Treatment)*	ST_1	Control (Plain water)
2.		ST_2	GA_3 (Gibberellic acid)15 ppm
3.		ST_3	GA_3 (Gibberellic acid) 25 ppm
4.		ST_4	GA_3 (Gibberellic acid) 50 ppm
5.		ST_5	IBA (Indole Butyric Acid) 100 ppm.
6.		ST_6	IBA (Indole Butyric Acid) 200 ppm.
7.		ST_7	IBA (Indole Butyric Acid) 250 ppm.
8.	F (Foliar Spray)**	FT_1	Control (Plain water)
9.		FT_2	GA_3 (Gibberellic acid) 15 ppm
10.		FT_3	GA_3 (Gibberellic acid) 25ppm
11.		FT_4	GA_3 (Gibberellic acid) 50 ppm
12.		FT_5	IBA (Indole Butyric Acid) 100 ppm.
13.		FT_6	IBA (Indole Butyric Acid) 200 ppm.
14.		FT_7	IBA (Indole Butyric Acid) 250 ppm.

*Seed potato tuber treatment at time of planting.
**Foliar spray at 30 and 60 days after planting (DAP).

Result and Discussion

Growth attributes

Different growth attributes of potato namely days for plant emergence and emergence per cent at 30 days after planting and plant height, number of shoots per plant and number of compound leaves per plant were recorded. The all growth attributes was statistically analysed and results were presented in table 2 and 3.

In general, among plant growth regulators Giberellic acid at all concentrations (T_2, T_3 and T_4) showed minimum days to plant emergence over control treatment (T_1), which took more number of days for plant emergence (24.5). The results were significantly different with respect to different plant growth regulators (PGR). The highest emergence percentage (92.89%) was observed in T_3 (GA_3 25ppm) followed by its lower concentration that is T_2 (GA_3 25ppm). The highest plant height (61.47 cm) was observed in T_4 (GA_3 50ppm) followed by concentration of IBA (60.65 cm) observed in T_7 (IBA 250ppm). This increase in plant height might be due to the fact that the stimulatory effect of GA3 on plant height due to cell elongation and rapid cell division in growing portion, there are number of reports showing that gibberellins promote growth of intact plants. The results observed in this investigation for plant height are similar to the findings of Naeem *et al.* (2006) [10], Chovatia *et al.* (2014) [9], Sillu *et al.* (2012) [3]. The highest number of shoot per plant (13) was observed in T_3 (GA_3 25ppm) followed by its lower concentration that is T_2 (GA_3 15ppm) i.e. (12.17). The highest number of compound leaves per plant (109.1) was observed in T_2 (GA_3 15ppm) followed by (98.9) at its lower concentration that is T_3 (GA_3 25ppm) higher. Among plant growth regulators IBA at concentrations of 100ppm T_5 showed maximum (338.60 g) fresh weight of shoots per plant which was followed by(298.75 g) in (GA_3 50ppm). Among plant growth regulators, IBA at concentrations of 100ppm showed maximum (276.20 g) dry weight of shoots per plant which was followed by (246.25g) in T_4 (GA_3 50 ppm).

Yield attributes

Different yield attributes of potato namely number of tubers plant^{-1}, grade wise number of tuber plot^{-1}, grade wise number of tuber hectare^{-1}, grade wise numbers of tuber (% by number), grade wise tuber yield plot^{-1}, grade wise tuber yield hectare^{-1}, grade wise tuber yield (% by weight), tuber yield plot^{-1}(Kg), total tuber yield (Kg/ha), fresh weight of tuber plant^{-1} (g), dry weight of tuber plant^{-1} (g), were recorded at harvest and results are presented in table 4 to 7.

The highest number of tubers per plant (7.93) was recorded in T_7 (IBA 250 ppm) followed by its lower dose. However, minimum values of numbers of tubers per plant was recorded in control treatment i.e. T_1 i.e. 6.77. The highest number of tubers per plot (626.16) was observed in T_5 (IBA 100ppm) followed by 601.37 which was recorded in treatment T_2 (GA_3 15ppm). Among plant growth regulators, IBA at concentrations of 200ppm i.e. T_6 showed maximum (337.81 g) fresh weight of tuber per plant which was followed by 320.30g in T_7 (IBA250ppm). Among plant growth regulators, IBA at concentrations of 200ppm showed maximum (266.92 g) dry weight of tuber per plant which was followed by 259.80 g in T_7 (IBA 250ppm). Among plant growth regulators, IBA at concentrations of 200ppm showed maximum (57.92g) average weight of tuber which was followed by 53.96 g in T_4 i.e. $GA_3$50 ppm. All the concentrations of IBA i.e. 100, 200 and 250 ppm produced greater number of Grade A tubers being maximum (92.53) at 200 ppm followed by 87.72 at lower dose (100ppm). The maximum (15.19) being in IBA 200ppm (T_6) followed by its lower doses (T_5) i.e. 14.05 Control treatment (T_1) produced minimum A grade percentage of tubers. It was revealed from data that the grade wise tuber yield per plot was observed maximum in treatment T_6 (IBA 200ppm) of Grade B i.e. 25-50g (8.81 kg) followed by the Grade C (8.20 kg) of same treatment. The tuber yield per hectare was noted maximum (9794.25 kg) in treatment T_6 (IBA200ppm) of Grade B followed by the Grade C (9112.05kg) in same treatment. Plant growth regulators significantly inspired grade B to the percentage and the maximum (34.80) being in IBA 200ppm (T_6) followed by GA_3 50ppm (T_4) i.e. 34.45 of grade B. It was revealed from data that the tuber yield per plot was observed maximum in treatment T_6 (IBA 200ppm) i.e. (25.33kg) followed by 24.02 kg in treatment T_7 (IBA 250ppm). Maximum tuber yield per hectare (29434.25 kg) was noted in treatment combinations of foliar spray application (F) and IBA 200ppm (FT_6) and followed by (FT_7) i.e.,(28131.85).

Table 2: Effects of PGR's on Days for Plant Emergence, Emergence % and Plant height, Number of Shoots and Compound leaves at 50, 75 and 90 DAP

Treatments		Days for Plant Emergence	Emergence percentage (%)	Plant height (cm)	Number of shoots/Plant	Number of compound leaves /Plant
Methods						
S	Seed treatment	21.43	91.87	57.48	11.00	89.68
F	Foliar spray	24.29	90.54	57.43	10.86	92.66
SE(m)±		0.25	0.32	0.16	0.16	0.09
CD(P=0.05)		0.73	0.93	NA	N/A	0.27
Treatments						
T_1	Plain water	24.50	90.89	54.48	9.67	76.60
T_2	GA3 (15ppm)	21.50	92.44	55.50	13.00	109.08
T_3	GA3(25ppm)	22.00	92.89	57.42	12.17	98.86
T_4	GA3 (50ppm)	21.50	90.45	61.47	11.30	91.22
T_5	IBA (100 ppm)	24.00	90.22	55.61	9.83	86.29
T_6	IBA (200 ppm)	22.50	90.45	57.06	10.00	87.30
T_7	IBA (250 ppm)	24.00	91.11	60.66	10.50	88.87
SE(m)±		0.46	0.60	0.29	0.31	0.17
CD(P=0.05)		1.36	1.74	0.86	0.89	0.51
Methods × Treatments						
ST_1	Plain water	24.00	90.22	54.33	9.33	76.60
ST_2	GA3 (15ppm)	20.00	94.67	55.80	12.87	107.27
ST_3	GA3(25ppm)	19.00	95.11	58.00	11.97	96.87
ST_4	GA3 (50ppm)	20.00	90.67	61.78	11.67	90.90
ST_5	IBA (100 ppm)	22.00	90.22	55.82	10.43	83.64
ST_6	IBA (200 ppm)	22.00	90.67	55.91	10.37	84.80
ST_7	IBA (250 ppm)	23.00	91.56	60.72	10.67	87.73
FT_1	plain water	25.00	91.56	54.63	9.93	78.60
FT_2	GA3 (15ppm)	24.00	90.22	55.20	13.13	110.88
FT_3	GA3 (25ppm)	25.00	90.67	56.84	12.30	100.85
FT_4	GA3 (50ppm)	23.00	90.22	61.16	11.00	91.57
FT_5	IBA (100 ppm)	26.00	90.22	55.40	9.50	88.93
FT_6	IBA (200 ppm)	24.00	90.22	58.20	9.76	89.80
FT_7	IBA (250 ppm)	25.00	90.67	60.60	10.36	90.00
SE(m)±		0.66	0.84	0.42	0.43	0.25
CD(P=0.05)		1.92	2.47	1.21	N/A	0.72

Table 3: Effect of PGR's on Fresh and Dry weight of shoots and tubers per plant (g) with dry matter content percentage.

Treatments		Fresh weight per plant(g)		Dry weight per plant(g)		Dry matter content (%)	
		Shoot	Tuber	Shoot	Tuber	Shoot	Tuber
Methods							
S	Seed treatment	251.44	281.79	208.93	227.88	16.86	19.01
F	Foliar spray	304.04	298.61	249.49	235.60	17.82	21.01
SE(m)±		0.24	0.57	0.22	0.57	0.06	0.04
CD(P=0.05)		0.69	1.66	0.63	1.66	0.18	0.11
Treatments							
T_1	Plain water	232.60	243.45	195.90	205.16	15.76	15.25
T_2	GA3 (15ppm)	236.15	257.53	195.75	206.32	17.10	20.32
T_3	GA3(25ppm)	261.25	284.61	215.82	230.29	17.35	19.12
T_4	GA3 (50ppm)	298.75	281.09	246.25	215.55	17.54	23.28
T_5	IBA (100 ppm)	338.60	306.62	276.20	238.15	18.25	22.30
T_6	IBA (200 ppm)	287.70	337.81	236.00	266.92	17.94	20.94
T_7	IBA (250 ppm)	289.15	320.30	238.55	259.80	17.46	18.87
SE(m)±		0.44	1.07	0.40	1.06	0.12	0.07
CD(P=0.05)		1.30	3.12	1.18	3.11	0.34	0.21
Methods × Treatments							
ST_1	Plain water	214.00	241.00	180.80	203.75	15.51	14.42
ST_2	GA3 (15ppm)	232.10	254.42	193.30	206.56	16.72	18.81
ST_3	GA3(25ppm)	238.20	275.01	197.94	219.99	16.90	20.01
ST_4	GA3 (50ppm)	269.40	277.54	223.10	221.44	17.19	20.22
ST_5	IBA (100 ppm)	273.50	299.15	226.20	235.69	17.29	21.21
ST_6	IBA (200 ppm)	272.50	322.41	225.10	258.07	17.39	19.96
ST_7	IBA (250 ppm)	260.40	303.01	216.10	247.14	17.01	18.44
FT1	plain water	251.20	245.89	211.00	206.25	16.00	16.07
FT_2	GA3 (15ppm)	240.20	260.63	198.20	206.39	17.48	21.82
FT_3	GA3 (25ppm)	284.30	294.21	233.70	240.59	17.80	18.22
FT_4	GA3 (50ppm)	328.10	284.63	269.40	209.66	17.89	26.34
FT_5	IBA (100 ppm)	403.70	314.09	326.20	240.60	19.20	23.40
FT_6	IBA (200 ppm)	302.90	353.21	246.90	275.77	18.49	21.92
FT_7	IBA (250 ppm)	317.90	337.58	261.00	272.45	17.90	19.29
SE(m)±		0.63	1.51	0.57	1.50	0.17	0.10
CD(P=0.05)		1.83	4.41	1.67	4.40	0.48	0.297

Table 4: Effect of PGRs in number of tuber per plant and in total number of tuber per plot.

Treatments		Number of tuber/plant	Total number of tuber /plot	Average weight of tuber
Methods				
S	Seed treatment	7.08	579.11	49.14
F	Foliar spray	7.62	590.25	49.97
SE(m)±		0.06	3.21	0.45
CD(P=0.05)		0.17	9.37	N/A
Treatments				
T_1	Plain water	6.77	535.01	37.03
T_2	GA3 (15ppm)	7.45	601.37	45.92
T_3	GA3(25ppm)	7.07	584.01	49.85
T_4	GA3 (50ppm)	7.60	592.00	53.96
T_5	IBA (100 ppm)	7.52	626.16	53.80
T_6	IBA (200 ppm)	7.10	585.36	57.92
T_7	IBA (250 ppm)	7.93	568.84	48.38
SE(m)±		0.11	6.00	0.85
CD(P=0.05)		0.32	17.53	2.48
Methods × Treatments				
ST_1	Plain water	6.47	529.68	37.18
ST_2	GA3 (15ppm)	7.37	579.34	43.73
ST_3	GA3(25ppm)	7.00	566.33	52.19
ST_4	GA3 (50ppm)	7.40	592.33	49.66
ST_5	IBA (100 ppm)	6.93	648.36	54.84
ST_6	IBA (200 ppm)	6.80	597.33	56.04
ST_7	IBA (250 ppm)	7.57	540.35	50.31
FT_1	plain water	7.07	540.33	36.88
FT_2	GA3 (15ppm)	7.53	623.39	48.12
FT_3	GA3 (25ppm)	7.13	601.69	47.53
FT_4	GA3 (50ppm)	7.80	591.67	58.26
FT_5	IBA (100 ppm)	8.10	603.95	52.77
FT_6	IBA (200 ppm)	7.40	573.39	59.81
FT_7	IBA (250 ppm)	8.30	597.33	46.45

SE(m)±	0.15	8.48	1.20
CD(P=0.05)	0.45	24.79	3.51

Table 5: Effect of PGRs in number of tubers of different grades

Treatments		Grade wise number of tuber											
		Grade wise number of tuber per plot				Grade wise number of tuber (in thousands per hectare)				Grade wise number of tuber (% by number)			
Grades		Grade A (>75g)	Grade B (50-75g)	Grade C (25-50g)	Grade D (0-25g)	Grade A (>75g)	Grade B (50-75g)	Grade C (25-50g)	Grade D (0-25g)	Grade A (>75g)	Grade B (50-75g)	Grade C (25-50g)	Grade D (0-25g)
Methods													
S	Seed treatment	77.622	161.355	248.263	84.91	86.248	179.282	275.846	94.35	13.56	28.149	43.448	14.844
F	Foliar spray	85.817	185.975	245.805	83.46	95.353	206.639	273.117	92.73	14.238	30.963	40.913	13.888
SE(m)±		0.537	0.381	0.326	0.406	0.597	0.424	0.362	0.451	0.084	0.154	0.309	0.109
CD(P=0.05)		1.571	1.115	0.952	1.187	1.745	1.24	1.059	1.318	0.245	0.449	0.904	0.318
Treatments													
T1	Plain water	67.327	164.85	225.437	77.407	74.807	183.165	250.485	86.005	12.585	30.792	42.158	14.465
T2	GA3 (15ppm)	75.468	177.625	254.36	84.55	83.855	197.36	282.622	93.945	12.747	30.003	42.968	14.282
T3	GA3(25ppm)	77.598	163.29	255.832	85.615	86.22	181.435	284.257	95.13	13.308	27.993	43.98	14.718
T4	GA3 (50ppm)	84.252	139.76	278.45	92.393	93.615	155.288	309.397	102.66	14.193	23.245	46.952	15.618
T5	IBA (100 ppm)	87.72	173.652	248.96	78.335	97.468	192.945	276.627	87.038	14.887	29.49	42.305	13.32
T6	IBA (200 ppm)	92.532	203.155	235.21	91.943	102.815	255.727	261.35	102.158	14.825	32.623	37.797	14.757
T7	IBA (250 ppm)	87.142	193.322	230.97	79.082	96.822	214.802	256.633	87.868	14.748	32.747	39.103	13.403
SE(m)±		1.005	0.713	0.609	0.76	1.117	0.794	0.678	0.844	0.157	0.287	0.579	0.204
CD(P=0.05)		2.939	2.085	1.78	2.221	3.265	2.32	1.981	2.466	0.458	0.84	1.692	0.595
Methods × Treatments													
ST1	Plain water	67.32	152.49	234.34	75.53	74.8	169.43	260.38	83.92	12.71	28.79	44.24	14.26
ST2	GA3 (15ppm)	71.5	171.81	262.93	85.43	79.45	190.9	292.14	94.92	12.08	29.04	44.44	14.44
ST3	GA3(25ppm)	71.51	148.58	259.6	87.65	79.45	165.09	288.44	97.39	12.6	26.19	45.76	15.45
ST4	GA3 (50ppm)	83.84	101.81	282.2	98.49	93.16	113.12	313.55	109.43	14.8	17.98	49.83	17.39
ST5	IBA (100 ppm)	82.24	166.97	245.18	79	91.38	185.52	272.42	87.78	14.34	29.12	42.76	13.78
ST6	IBA (200 ppm)	84.06	195.58	230.33	87.36	93.4	217.31	255.92	97.07	14.07	32.74	38.56	14.63
ST7	IBA (250 ppm)	82.89	192.24	223.26	80.95	92.1	213.6	248.07	89.94	14.31	33.18	38.54	13.97
FT1	plain water	67.33	177.21	216.53	79.28	74.81	196.9	240.59	88.09	12.46	32.8	40.07	14.67
FT2	GA3 (15ppm)	79.43	183.44	245.79	83.67	88.26	203.82	273.1	92.97	13.41	30.97	41.5	14.13
FT3	GA3 (25ppm)	83.69	178	252.06	83.58	92.99	197.78	280.07	92.87	14.01	29.8	42.2	13.99
FT4	GA3 (50ppm)	84.66	177.71	274.72	86.3	94.07	197.46	305.24	95.89	13.58	28.51	44.07	13.84
FT5	IBA (100 ppm)	93.2	180.33	252.75	77.67	103.56	200.37	280.83	86.3	15.43	29.86	41.85	12.86
FT6	IBA (200 ppm)	101.01	210.73	240.1	96.53	112.23	234.14	266.78	107.25	15.58	32.5	37.03	14.89
FT7	IBA (250 ppm)	91.4	194.4	238.68	77.22	101.55	216	265.2	85.8	15.19	32.31	39.67	12.83
SE(m)±		1.42	1.01	0.86	1.07	1.58	1.12	0.96	1.19	0.22	0.41	0.82	0.29
CD(P=0.05)		4.16	2.95	2.52	3.14	4.62	3.28	2.8	3.49	0.65	1.19	2.39	0.84

Table 6: Effect of PGRs on tuber yield of different grades

Treatments		Gradewise tuber yield kg /plot				Gradewise tuber yield kg /hectare				Gradewise tuber yield (% by weight)			
		Grade A 75g <	Grade B 50-75g	Grade C 25-50g	Grade D 0-25 g	Grade A 75g <	Grade B 50-75g	Grade C 25-50g	Grade D 0-25 g	Grade A 75g <	Grade B 50-75g	Grade C 25-50g	Grade D 0-25 g
Methods													
S	Seed treatment	6.75	7.23	6.75	0.40	7501.66	8036.43	7497.60	447.00	31.97	34.23	31.78	1.89
F	Foliar spray	7.03	7.65	7.24	0.46	7815.72	8506.87	8048.70	512.63	31.45	34.18	32.34	2.03
SE(m)±		0.01	0.02	0.04	0.00	5.90	22.34	42.96	3.06	0.02	0.00	0.00	0.01
CD(P=0.05)		0.02	0.06	0.11	0.01	17.25	65.29	125.58	8.94	0.07	0.01	0.01	0.04
Treatments													
T_1	Plain water	5.78	6.29	5.90	0.29	6424.44	6988.77	6553.16	320.75	31.67	34.10	31.80	1.58
T_2	GA3 (15ppm)	6.19	6.59	6.19	0.35	6875.44	7318.47	6873.05	393.39	32.04	34.41	32.03	1.83
T_3	GA3(25ppm)	6.86	7.27	6.83	0.39	7622.89	8074.57	7584.91	435.43	32.14	34.06	31.97	1.84
T_4	GA3 (50ppm)	6.73	7.25	6.72	0.39	7473.94	8059.33	7464.73	425.88	31.91	34.45	31.87	1.82
T_5	IBA (100 ppm)	7.36	7.73	7.43	0.49	8172.85	8590.05	8253.25	535.69	32.00	33.62	32.30	2.10
T_6	IBA (200 ppm)	7.73	8.81	8.20	0.59	8590.02	9794.25	9112.05	654.39	30.53	34.80	32.36	2.32
T_7	IBA (250 ppm)	7.61	8.17	7.71	0.53	8451.25	9076.09	8570.90	593.20	31.69	33.99	32.11	2.22
SE(m)±		0.01	0.04	0.07	0.01	11.04	41.79	80.37	5.72	0.04	0.01	0.01	0.03
CD(P=0.05)		0.03	0.11	0.21	0.02	32.26	122.15	234.93	16.73	0.12	0.02	0.02	0.07
Methods × Treatments													
ST_1	Plain water	5.77	6.22	5.82	0.27	6412.17	6912.66	6462.85	295.91	31.93	34.42	31.18	1.47
ST_2	GA3 (15ppm)	6.16	6.50	6.07	0.35	6840.60	7226.00	6745.96	388.80	32.26	34.08	31.83	1.83
ST_3	GA3(25ppm)	6.60	7.15	6.50	0.38	7334.54	7940.61	7224.46	418.28	32.00	34.65	31.52	1.83
ST_4	GA3 (50ppm)	6.68	7.17	6.58	0.38	7426.49	7967.63	7314.86	419.28	32.11	34.45	31.63	1.81
ST_5	IBA (100 ppm)	7.27	7.48	7.23	0.46	8079.04	8310.53	8033.51	506.47	32.41	33.34	32.22	2.03
ST_6	IBA (200 ppm)	7.46	8.45	7.75	0.51	8291.05	9394.38	8614.81	566.93	30.86	34.97	32.06	2.11

ST_7	IBA (250 ppm)	7.31	7.65	7.28	0.48	8127.74	8503.19	8086.76	533.31	32.19	33.67	32.03	2.11
FT1	plain water	5.79	6.36	5.98	0.31	6436.72	7064.88	6643.48	345.58	31.41	34.48	32.42	1.69
FT_2	GA3 (15ppm)	6.22	6.67	6.30	0.36	6910.27	7410.94	7000.15	397.98	31.82	34.12	32.23	1.83
FT_3	GA3 (25ppm)	7.12	7.39	7.15	0.41	7911.24	8208.54	7945.37	452.57	32.27	33.48	32.41	1.85
FT_4	GA3 (50ppm)	6.77	7.34	6.85	0.39	7521.38	8151.04	7614.60	432.47	31.71	34.36	32.10	1.82
FT_5	IBA (100 ppm)	7.44	7.98	7.63	0.51	8266.65	8869.57	8472.98	564.91	31.58	33.89	32.37	2.16
FT_6	IBA (200 ppm)	8.00	9.17	8.65	0.67	8889.00	10194.12	9609.30	741.84	30.20	34.63	32.21	2.52
FT_7	IBA (250 ppm)	7.90	8.68	8.15	0.59	8774.75	9648.99	9055.03	653.09	31.19	34.30	32.19	2.32
SE(m)±		0.01	0.05	0.10	0.01	15.61	59.10	113.66	8.09	0.06	0.01	0.01	0.04
CD(P=0.05)		0.04	0.15	0.30	0.02	45.63	172.74	332.25	23.65	0.17	0.02	0.03	0.10

Table 7: Effect of PGR on total tuber yield

Treatments		Total yield /Plot (Kg)	Total yield /ha (Kg/ha)
Methods			
S	Seed treatment	21.13	23482.69
F	Foliar spray	22.40	24883.92
SE(m)±		0.04	47.49
CD(P=0.05)		0.13	138.83
Treatments			
T_1	Plain water	18.25	20287.13
T_2	GA3 (15ppm)	19.31	21460.35
T_3	GA3(25ppm)	21.35	23717.81
T_4	GA3 (50ppm)	21.08	23423.87
T_5	IBA (100 ppm)	23.00	25551.83
T_6	IBA (200 ppm)	25.33	28150.71
T_7	IBA (250 ppm)	24.02	26691.42
SE(m)±		0.08	88.85
CD(P=0.05)		0.23	259.72
Methods × Treatments			
ST_1	Plain water	18.08	20083.59
ST_2	GA3 (15ppm)	19.08	21201.36
ST_3	GA3(25ppm)	20.63	22917.90
ST_4	GA3 (50ppm)	20.82	23128.25
ST_5	IBA (100 ppm)	22.44	24929.55
ST_6	IBA (200 ppm)	24.18	26867.17
ST_7	IBA (250 ppm)	22.73	25251.00
FT_1	plain water	18.44	20490.66
FT_2	GA3 (15ppm)	19.55	21719.34
FT_3	GA3 (25ppm)	22.07	24517.72
FT_4	GA3 (50ppm)	21.35	23719.50
FT_5	IBA (100 ppm)	23.56	26174.10
FT_6	IBA (200 ppm)	26.49	29434.25
FT_7	IBA (250 ppm)	25.32	28131.85
SE(m)±		0.11	125.66
CD(P=0.05)		0.33	367.30

Conclusion

The results obtained during the present investigation reveals that the effective concentration of undertaken plant growth regulators and application method can be used to improve the growth and yield parameters of potato. In the view of the results obtained from this investigation, it could be concluded that the growth parameters were positively influenced by seed treatment of GA_3 (at all concentration). However, yield parameters were positively influenced by foliar treatment of IBA 200ppm.

Acknowledgment

The authors are thankful to the Department of Vegetable Science, Indira Gandhi Krishi Vishwavidhyalaya, Raipur (C.G.).

References

1. National Horticulture Board. Horticultural Statistics at a Glance 2017, Horticulture Statistics Division Department of Agriculture, Cooperation & Farmers Welfare Ministry of Agriculture & Farmers Welfare Government of India. Government of India Controller of Publication, 2017.
2. Pamukuntla M, Sharma PK. Studies on effect of plant growth regulators on growth, yield and quality of Potato (*Solanum tuberosum* L.). Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, 2018.
3. Sillu M, Patel NM, Bhadoria HS, Wankhade VR. Effect of plant growth regulator on growth and yield of potato (*Solanum tuberosum* L.).Advanced Research Journal of Improvement. 2012; 3:144-147.
4. Agarwal AK, Kumar P, Alka. Influence of morphactin and gibberellic acid on plant growth, stolon development, tuberization and yield in potato exposed to varying photoperiods. Indian Journal of Plant Physiology. 1983; 24(3):285-291.
5. Bhatia AK, Pandita ML, Khurana SC. Effect of plant growth substances and sprouting conditions on sprout growth. Journal of Indian Potato Association. 1991; 18(3-4):151-154.
6. Javanmardi J, Rasuli F. Potato yield and tuber quality as affected by gibberellic acid and zinc sulphate. Iran Agricultural Research. 2017; 36(2):7-12.
7. Kumar A, Singh BP, Katiyar H. Effect of foliar application of plant growth regulator on potato (*Solanum tuberosum* L.). tuber quality. Progressive Horticulture. 2012; 44(2):299-303.
8. Khurana SC, Pandita ML. A note on the, effect of gibberellic acid on growth and deve1oprnent of two commercial potato varieties. Haryana Journal of Horticultural Science. 1987; 16(1-2):151-53.
9. Chovatia RS, Desai SS, Virendra Singh. Effect of different plant growth regulators and micronutrients on fruit quality and plant micronutrient content of tomato. International Journal of Agricultural Sciences. 2014. 10(1):130-133.
10. Naeem M, Khan MMA Champa Gautam Firoz Mohammad Siddiqui MH, Khan MN. Effect of gibberellic acid spray on performance of tomato.Turkish Journal of Biology. 2006; 30(1):11-16. 39 ref.
11. Olsen SR, Cole CV, Watanble FS, Dean LA. Estimation of available phosphorous in soil by extraction with sodium bicarbonate. Circ. US. Dep. Agric. 1954, 939.