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Effect of growth retardants and methods of application on growth and yield of potato

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ABSTRACT

Effect of growth retardants and methods of application on growth and yield of potato crop was investigated in cultivar Kufri Pukhraj during 2003-04 and 2004-05. Three growth retardants *viz.,* TIBA @ 100 ppm, Mepiquat Chloride @ 100 ppm and Cycocel @ 750 ppm along with a control were used with four application methods *viz.,* tuber dipping, foliar spray at 30 days after planting, foliar spray at 45 days after planting, foliar spray at 30 and 45 days after planting and a control treatment. Although, all the growth retardants tried, improved establishment and growth measured interms of plant height, number of stems, leaf area and total dry weight. Mepiquat Chloride @ 100 ppm foliar sprayed at 30 and 45 days after planting proved to be most effective followed by CCC @ 750 ppm. The tuber yield under this treatment was significantly superior over control (water dip). This suggested that Mapiquat Chloride @ 100 ppm foliar sprayed at 30 and 45 days after planting helped best in obtaining the higher growth, yield and quality parameters.

Key words: Mepiquat Chloride, TIBA, CCC, potato, seed, tuber, photosynthesis.

INTRODUCTION

Growth retardants are the new generation of organic chemicals, which retard stem elongation, increase green colour of the leaves and indirectly affect the flowering. According to Cathey (3), growth retardant is a chemical that slows down cell division and cell elongation in shoot tissues and regulate plant height. Growth retardants are considered as anti-metabolites rather than anti-gibberellins or anti-auxins (Cathey, 3). They cause the inhibition of cell division in sub apical meristem. The effect of growth retardants varies with plant species, variety, concentration used, method of application, frequency of application and various other factors which influence the uptake and translocation of the chemicals. Therefore, an experiment was carried out to find out the best growth retardant and also best method and stage of application on growth and tuber yield of potato crop under rainfed conditions of Northern Karnakata.

MATERIALS AND METHODS

The field experiment was carried out at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad under rainfed conditions during *Kharif* season of 2003 and 2004. The soil was typical vertisol having available N of 265.0 kg/ha, P_2O_5 of 10.80 kg/ha and K_2O of 245.0 kg/ha. The soil pH was 6.7. The experiment consisted of 20 treatment combinations comprising of four growth retardants (G_0: Control (water), G_1: TIBA @ 100 ppm, G_2: Mepiquat Chloride @ 100 ppm, G_3: Cycocel (CCC) @ 750 ppm) and five methods of application (A_0: No dipping of tuber (Control), A_1: Dipping of tuber (Soaking), A_2: Foliar spray at 30 days after planting (DAP), A_3: Foliar spray at 45 DAP and A_4: Foliar spray at 30 and 45 DAP). The treatments were imposed by dipping the seed tubers in each growth retardant solution for 30 minutes one day prior to sowing. The treated seed tubers were spread on the floor and air-dried overnight before planting. Foliar application of growth retardants at different concentrations was done at 30 DAP, 45 DAP and at 30 and 45 DAP. The experiment was laid out with randomized block design in factorial concept with 3 replications. The plot size was 16.8 m^2 (4.2 m x 4.0 m). Seed tubers were planted at 60 cm x 20 cm spacing in the month of June immediately after the showers. Half of the recommended dose of N and 100% recommended dose of P_2O_5 and K_2O (100:75:100 kg/ha) was applied in the form of Ammonium sulphate, Single super phosphate and Muriate of potash at the time of planting. Whereas, remaining 50% N was applied at the time of hoeing and earthing up in the form of Urea. Five plants were tagged

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at random from net plot area for recording observations on various growth and yield parameters. Leaf area was determined at 45 and 60 days after planting by using leaf disc method. Twenty leaf discs having known diameter were collected randomly from top 4-6 fully expanded leaves of the plant. The discs thus collected and rest of the leaves was dried separately in hot air oven at 80^0 C for 72 hours. The dry weight of leaf discs and rest of leaves was recorded and the leaf area was calculated by using the formula (Vivekananda *et al.,* 1972). The haulms were cut at 80 DAP and harvesting was done at 15 days after haulm cutting. The data pooled were statistically analyzed using factorial RBD design.

RESULTS AND DISCUSSION

It was observed in the present study that at 45 and 60 days after planting (Table 1) the growth retardants checked the plant height significantly over control and the extent of reduction was more with Mepiquat Chloride @100 ppm (34.5 and 48.5 cm), which was at par with TIBA @ 100 ppm (34.7 and 49.6 cm) and CCC @ 750 ppm (34.8 and 48.7 cm). The mechanism of reduction in plant height appears to be due to reduction in cell division and cell elongation because of the inhibitory action of growth retardants in the biosynthetic pathway of gibberellins. Moore (1980) reported that Cycocel and Mepiquat Chloride are anti-gibberellin dwarfing agents leading to a deficiency of gibberellic acid in plants and reduced growth, which is blocking the conversion of geranyl geranoil pyrophosphate to copalyl pyrophosphate.

The application of growth retardants significantly increased the number of stems/hill (Table 1) and increase was more pronounced with Mepiquat Chloride followed by cycocel and TIBA at 45 and 60 days after planting over control. This could be due to suppression of apical dominance as a result of increase in the auxin activity when growth retardants were applied there by diverting the polar transport of auxins towards the basal buds leading to increased stems. These results are in agreement with the findings of Madalgeri and Ganiger (1993). They reported that the application of Mepiquat Chloride @ 150 ppm and cycocel @ 750 ppm increased the number of stems/hill in potato.

Like number stems, Mepiquat Chloride @100 ppm maintained its superiority over other growth retardants for leaf area also. The per cent increase in leaf area increased with different growth retardants. The extent of increase was more with Mepiquat Chloride (36.0 and 55.3 cm^2) followed by CCC (34.9 and 53.4 cm^2) and TIBA (34.5 and 52.0 cm^2) over control at 45 and 60 days after planting, respectively. Increase in the leaf area of treated plants increased the efficiency of plants to produce more photosynthates and transporting it in to sinks.

All the growth retardants improved dry weight of foliage over control. Since Mepiquat Chloride @100 ppm recorded its superiority over remaining growth retardants for number of stems and leaf area, therefore, it resulted in highest total dry matter production/plant (Table 1) over control (water soaked) at 45 and 60 days after planting. It was followed by Cycocel @ 750 ppm over control. These results are in corroborative with the findings of Bama *et al*. (2).

The growth retardants significantly increased the number, size of tuber and tuber yield. Among the growth retardants, the per cent increase in number of tubers/ plant was maximum with Mepiquat Chloride compared to control. Mepiquat Chloride recorded less (1.85) number of small size tubers (Grade <20 g) and more number (3.23) of seed size (Grade 21-50 g) tubers followed by CCC and TIBA (Table 2). Mepiquat Chloride also recorded significantly higher total number of tubers/plant over control. This increase was mainly due to the plants sprayed with growth retarding chemicals like Mepiquat Chloride and CCC increased the sink capacity of the plants interms of the number of tuber/plant. Thereby, accommodating all photosynthates produced by the plant which might have helped in significantly increasing the weight of tubers particularly the seed size tubers, which are of great value from the point of seed technology, thus increasing the total yield per plot and per hectare. The beneficial effect of these growth retardants was also reported by Sarkar and Singh (9) in potato. The significant increase (39.4% of total tuber yield/plant) of seed size tuber (Grade 21-50 g) was recorded when Mepiquat Chloride was applied to the plants followed by CCC (Table 2). This was mainly due to increase in the chlorophyll content and nitrate reductase activity after the application of growth retardants and simultaneously it might have contributed for increase in the size and number of tubers/ plant.

As regards the quality of tuber, application of growth retardants significantly increased the reducing sugar content in tuber (0.52%), especially with Mepiquat Chloride and CCC over control. Similar results were also reported by Pandita and Hooda (7), who recorded significant differences between the treated and untreated plants with respect to total sugars in potato tuber.

Seed tuber treatment and single spray of growth retardants at early stage of growth (30 DAP) was less effective compared to two sprays at early and mid growth phase (30 and 45 DAP) in modifying the growth morphology interms of plant height, number of stems, leaf area and dry matter production (Table 1). The multiple sprays of growth retardants at 30 and 45 days after

Table 1. Effect of growth retardants and method of application on growth parameters of potato.

Treatment	Plant height at		Stems/hill at		Leaf area (cm^2) at		Dry matter/plant (g) at	
	45 DAP	60 DAP	45 DAP	60 DAP	45 DAP	60 DAP	45 DAP	60 DAP
Growth retardants (G)								
G_0	37.8	56.0	2.14	3.33	31.1	47.0	11.6	53.9
G_1	34.7	49.6	2.91	4.82	34.5	52.0	13.2	58.6
G_2	34.5	48.5	3.06	5.14	36.0	55.3	13.9	62.0
G_3	34.8	48.7	2.85	4.94	34.9	53.4	13.4	60.1
P = 0.05	0.76	0.91	0.23	0.19	1.31	1.00	0.47	0.74
Method of application (A)								
A_0	37.0	54.7	2.16	3.30	31.8	46.9	11.5	53.4
A_1	35.2	51.0	2.88	4.50	34.8	51.3	13.0	57.6
A_2	34.3	49.5	3.08	4.82	35.9	52.7	13.5	59.1
A_3	36.3	50.5	2.41	4.93	32.4	53.5	12.7	60.8
A_4	34.4	47.8	3.17	5.23	35.7	55.2	14.5	62.4
P = 0.05	0.85	1.02	0.25	0.21	1.47	1.10	0.52	0.82
Interaction of Growth retardants (G) x Method of application (A)								
$G_0 \times A_0$	37.1	56.3	2.13	3.33	31.9	46.7	11.5	53.6
$G_0 \times A_1$	37.7	55.4	2.00	3.30	30.3	47.5	11.8	53.6
$G_0 \times A_2$	37.4	55.6	2.30	3.33	30.8	47.9	11.4	54.1
$G_0 \times A_3$	38.7	56.7	2.07	3.37	32.2	46.6	11.7	54.3
$G_0 \times A_4$	38.1	56.0	2.20	3.30	30.5	46.4	11.8	53.8
$G_1 \times A_0$	36.9	54.4	2.23	3.23	31.4	47.7	11.3	52.4
$G_1 \times A_1$	34.2	50.4	3.13	4.73	35.1	50.7	11.1	57.4
$G_1 \times A_2$	33.4	48.3	3.30	5.13	36.7	52.6	13.6	59.0
$G_1 \times A_3$	35.7	48.8	2.50	5.37	32.5	53.7	13.1	61.1
$G_1 \times A_4$	33.5	46.0	3.37	5.63	36.7	55.1	14.8	63.1
$G_2 \times A_0$	36.5	54.2	2.13	3.30	32.2	46.3	11.8	54.2
$G_2 \times A_1$	34.3	49.2	3.37	5.03	37.4	54.3	14.0	60.3
$G_2 \times A_2$	33.0	46.5	3.57	5.57	38.8	55.9	14.7	62.6
$G_2 \times A_3$	35.7	48.1	2.50	5.63	32.8	58.4	13.2	64.8
$G_2 \times A_4$	33.0	44.5	3.73	6.17	38.6	61.4	15.9	68.3
$G_3 \times A_0$	37.6	53.8	2.13	3.33	31.9	46.9	11.4	53.6
$G_3 \times A_1$	34.6	49.1	3.00	4.93	36.2	52.8	13.2	59.2
$G_3 \times A_2$	33.3	47.4	3.17	5.23	37.4	54.4	14.0	60.6
$G_3 \times A_3$	35.2	48.3	2.57	5.36	32.3	55.2	13.0	63.0
$G_3 \times A_4$	33.2	44.9	3.37	5.83	36.9	57.7	15.3	64.3
CD (*P* = 0.05)	1.70	2.03	0.51	0.42	2.93	2.23	1.05	1.65

Growth retardants: G_0: Control, G_1: TIBA @ 100 ppm, G_2: Mepiquat Chloride @ 100 ppm and G_3: Cycocel (CCC) @750 ppm; **Method of application:** A_0: No dipping of tubers, A_1: Dipping of tubers (Soaking), A_2: Foliar spray at 30 DAP, A_3: Foliar spray at 45 DAP & A_4: Foliar spray at 30 and 45 DAP

planting registered significantly lower plant height (34.4 and 47.8 cm), more number of stems/hill (3.17 and 5.23), higher leaf area (35.7 and 55.2 cm^2) and higher dry matter (leaf, stem and tuber) production/plant (14.5 and 62.4 g). The reduced plant height might be due to reduction in growth of the important sinks namely all auxillary buds and therefore, might have changed the distribution of pattern of assimilates. Bama *et al.* (2) found that CCC treatment to potato plants retarded the growth but increased the leaf area and tuber formation.

Different methods of growth retardant application significantly influenced on number of tubers/plant. It has been observed that all the growth retardants improved multiplication ratio, especially the seed size and large size tubers/plant over control (Table 2). Two sprayings of growth retardant at 30 and 45 days after planting

Table 2. Effect of growth retardants and method of application on yield parameters of potato

Treatment	No of tubers /plant (Grade<20 g)	No. of tubers /plant (Grade 21-50 g)	No. of tubers /plant (Grade >50 g)	Total No. of tubers /plant	Tuber yield/plant (Grade <20 g)	Tuber yield/plant (Grade 21-50 g)	Tuber yield/plant (Grade >50 g)	Total tuber yield/plant (g)	Total tuber yield/ha (t)	Reducing sugar content (%)
Growth retardants (G)										
G_0	2.49	2.09	1.61	6.18	53.3 (15.9)	123.0 (38.7)	158.4 (47.3)	335	17.5	0.36
G_1	2.10	2.80	2.06	6.96	47.0 (12.7)	140.2 (38.0)	182.0 (49.3)	369	19.6	0.40
G_2	1.85	3.23	2.77	7.86	37.1 (9.7)	151.1 (39.4)	195.5 (50.9)	384	20.4	0.52
G_3	1.97	2.89	2.25	7.11	42.6 (11.4)	143.6 (38.5)	186.4 (50.0)	373	19.8	0.41
P = 0.05	0.10	0.11	0.14	0.18	1.50	2.68	4.47	5.00	0.40	0.029
Method of application (A)										
A_0	2.46	2.12	1.56	6.14	53.0 (15.6)	124.7 (36.7)	161.7 (47.6)	339	17.9	0.36
A_1	2.31	2.60	1.98	6.89	45.3 (12.4)	138.9 (38.1)	180.6 (49.5)	365	19.3	0.42
A_2	2.10	2.86	2.04	7.00	43.2 (11.8)	141.4 (38.5)	182.4 (49.7)	367	19.4	0.41
A_3	1.94	2.98	2.43	7.36	42.2 (11.4)	145.1 (39.1)	183.6 (49.5)	371	19.7	0.45
A_4	1.71	3.19	2.85	7.75	41.3 (10.8)	147.3 (38.5)	194.5 (50.8)	383	20.2	0.48
P = 0.05	0.11	0.12	0.16	0.20	1.67	2.99	5.00	5.59	0.44	0.032
Interaction of Growth retardants (G) x Method of application (A)										
$G_0 \times A_0$	2.37	2.00	1.50	5.87	52.4 (15.5)	123.9 (36.6)	162.2 (47.9)	339	17.5	0.36
$G_0 \times A_1$	2.63	2.10	1.63	6.37	54.3 (16.2)	121.4 (36.3)	158.7 (47.5)	334	17.6	0.37
$G_0 \times A_2$	2.47	2.27	1.70	6.43	52.6 (15.9)	123.4 (37.4)	154.0 (46.7)	330	17.2	0.36
$G_0 \times A_3$	2.57	2.10	1.60	6.27	52.2 (15.7)	126.1 (38.0)	153.2 (46.2)	332	17.4	0.35
$G_0 \times A_4$	2.40	1.97	1.60	5.97	54.8 (16.2)	120.3 (35.5)	164.0 (48.4)	339	17.7	0.38
$G_1 \times A_0$	2.50	2.20	1.53	6.23	54.8 (16.2)	122.2 (36.1)	161.2 (47.7)	338	18.0	0.36
$G_1 \times A_1$	2.30	2.60	1.80	6.70	47.9 (13.0)	140.1 (38.1)	179.8 (48.9)	368	19.7	0.38
$G_1 \times A_2$	2.13	2.90	2.03	7.07	45.5 (12.2)	142.7 (38.4)	183.2 (49.3)	371	19.7	0.40
$G_1 \times A_3$	1.93	3.07	2.23	7.23	44.7 (11.9)	146.3 (38.9)	184.8 (49.2)	376	20.0	0.41
$G_1 \times A_4$	1.63	3.23	2.70	7.57	42.1 (10.7)	149.8 (38.1)	200.9 (51.1)	393	20.8	0.44
$G_2 \times A_0$	2.50	2.17	1.70	6.37	52.9 (15.6)	125.1 (36.9)	160.8 (47.5)	339	17.9	0.38
$G_2 \times A_1$	2.10	3.03	2.50	7.63	35.7 (9.3)	151.7 (39.5)	196.3 (51.1)	384	20.2	0.51
$G_2 \times A_2$	1.83	3.23	2.67	7.73	33.8 (8.7)	154.2 (39.8)	198.9 (51.4)	387	20.9	0.47
$G_2 \times A_3$	1.53	3.60	3.20	8.33	32.4 (8.1)	159.1 (40.0)	205.9 (51.8)	397	21.0	0.61
$G_2 \times A_4$	1.30	4.13	3.80	9.23	31.0 (7.5)	165.2 (40.1)	215.4 (52.3)	412	21.9	0.65
$G_3 \times A_0$	2.47	2.13	1.50	6.10	52.0 (15.2)	127.6 (37.3)	162.7 (47.5)	342	18.1	0.34
$G_3 \times A_1$	2.20	2.67	2.00	6.87	43.5 (11.6)	142.6 (38.2)	187.5 (50.2)	374	19.6	0.41
$G_3 \times A_2$	1.97	3.03	1.77	6.77	40.9 (10.8)	145.1 (38.2)	193.7 (51.0)	380	20.1	0.43
$G_3 \times A_3$	1.73	3.17	2.70	7.60	39.7 (10.5)	148.8 (39.3)	190.5 (50.3)	379	20.4	0.44
$G_3 \times A_4$	1.50	3.43	3.30	8.23	37.2 (9.6)	154.0 (39.6)	197.7 (50.8)	389	20.6	0.44
CD (*P* = 0.05)	0.22	0.24	0.31	0.41	3.35	5.99	10.00	11.18	0.88	0.065

* Figures in parentheses indicate the per cent distribution of grade wise tuber yield per plant on weight basis

Growth retardants: G_0: Control, G_1: TIBA @ 100 ppm, G_2: Mepiquat Chloride @ 100 ppm and G_3: Cycocel (CCC) @ 750 ppm

Method of application: A_0: No dipping of tubers, A_1: Dipping of tubers (Soaking), A_2: Foliar spray at 30 DAP, A_3: Foliar spray at 45 DAP and A_4: Foliar spray at 30 and 45 DAP

recorded higher number of seed size tubers (3.19) of Grade 21-50 g, large size tubers (2.85) of Grade >50 g and total number of tubers/plant (7.75) followed by single spray at 45 days after planting, which recorded more number of small size tubers (2.46) of Grade <20 g. This increase in number of tubers/plant in the sprays at 30 and 45 days after planting is due to increased utilization of substances such as photosynthates and nutrients for tuber development as a result of reduction in vegetative growth.

Regarding tuber yield/plant, the spraying of growth retardants at 30 and 45 days after planting registered significantly higher percentage (50.8%) of large size, total tuber yield per plant (383 g) and per hectare (20.2 t) followed by single spray at 45 days after planting over control treatment. This increased tuber yield may be ascribed to total or partial inhibition of bud growth which might have resulted in stimulation of tuberization.

Application of growth retardant at 30 and 45 days after planting recorded significantly higher reducing sugar (%) in tuber (0.48%) followed by (0.45%) in single spray at 45 days after planting and lowest (0.36%) was in control (Table 2). This increase of reducing sugar (%) in two sprays at 30 and 45 days after planting may be due to increased sugar accumulation after the synthesis of starch. These results are in agreement with the reports of Anjanappa *et al.* (1).

The interaction of growth retardants and application methods on growth was found significant in both the years (Table 1). Application of growth retardants reduced the plant height, increased number of stems/hill and leaf area over control at 45 and 60 days after planting. The growth retardant Mepiquat Chloride sprayed at 30 and 45 days after planting recorded significantly less (33.0 and 44.50 cm) plant height followed by CCC spray (33.2 and 44.9 cm) at 30 and 45 days after planting. The number of stems/hill was also significantly more (3.73 and 6.17) in Mepiquat Chloride sprayed at 30 and 45 days after planting followed by CCC (3.37 and 5.83) over control (2.13 and 3.33). Further, the leaf area (cm^2) was also highest in Mepiquat Chloride sprayed at 30 and 45 days after planting over other growth retardants and application methods. The experimentation of previous workers (Prakash, 8) have amply proved that checking of vegetative growth through growth retardant sprays at appropriate stage have altered the plant physiology and improved the yielding ability of potato.

Significantly maximum (15.9 and 68.3 g) total dry weight of plant was recorded in Mepiquat Chloride @ 100 ppm sprayed at 30 and 45 days after planting while, the lowest (11.5 and 52.4 g) was in control. These results are in conformity with the results of Eyob and Krishnappa (1999) who recorded maximum dry matter of root, stem, tuber and total dry weight of plant when CCC was sprayed @ 1500 ppm at 45 days after planting. The increase in dry weight of all components of plant could be attributed to increased chlorophyll content in leaf which intern might have helped in increasing the photosynthetic activity and also due to intrinsic sink capacity of tuber.

A significant improvement in the seed size and large size tuber in plants sprayed with growth retardants was note worthy, which simultaneously reduced the small size tubers. Among the growth retardants, Mepiquat Chloride @ 100 ppm recorded significantly higher number of seed size (4.13) and large size (3.80) tubers followed by CCC (3.43 and 3.30) when sprayed at 30 and 45 days after planting. On the contrary, the highest number of small size (2.63) tubers was recorded in control (Table 2). Further, the total number of tubers/plant was also significantly highest (9.23) in Mepiquat Chloride @ 100 ppm sprayed at 30 and 45 days followed by single spray at 45 days after planting (8.33) compared to control (5.87).

As far as tuber yield is concerned, significantly maximum seed size and large size tuber yield was obtained when Mepiquat Chloride was sprayed at 30 and 45 days after planting followed by single spray at 45 days compared to control. Whereas, significantly higher (52.4 g) small size tuber yield was obtained by control treatment (Table 2). The total tuber yield per plant and per hectare were significantly highest in Mepiquat Chloride sprayed at 30 and 45 days after planting treatment followed by single spray at 45 days after planting. This clearly indicates that single or double spray of Mepiquat Chloride and double spray of CCC played a definite role in the physiology of potato plants to increase the seed size and large size tuber in particular and total tuber yield in general.

The reducing sugar content in the tuber was recorded significantly highest (0.65%) when the crop was sprayed with Mepiquat Chloride @ 100 ppm followed by single spray at 45 days after planting (Table 2). Similar findings have also been reported by Eyob and Krishnappa (4). The significant increase in reducing sugar content over control could be due to the increased chlorophyll content in the leaf which has helped in increasing the photosynthesis activity and sink capacity of the crop.

From the foregoing discussion it is therefore evident that the two sprayings of Mepiquat Chloride @ 100 ppm or CCC @ 750 ppm at appropriate growth stage (30 and 45 days after planting) to potato cv. Kufri Pukhraj brought favourable growth modification and helped in obtaining increased seed size as well as total tuber yield of potato.

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