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Effect of foliar application of plant growth regulators on growth and yield of potato seed tubers propagated from micro plantlets on soilless solid media in greenhouse

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ABSTRACT : In the present study, effect of foliar application of plant growth regulators on growth and yield of potato seed tubers cv. KUFRI CHIPSONA 3, grown from micro plantlets, on soil-less solid media in greenhouse conditions, were evaluated. Out of seven treatments studied, six included plant growth regulators, of which, two were plant growth enhancers (GA_3, NAA), four were plant growth retardants (Paclobutrazaol, Triacontanol, Ethrel and Chlormequat chloride-CCC) and one control (water spray). Treatments were designated, namely, T_0 control (water spray), T_1 GA_3 (0.0036 ppm), T_2 paclobutrazaol (100 ppm), T_3 triacontanol (0.5 ppm), T_4 NAA (100 ppm), T_5 ethrel (250 ppm) and T_6 CCC (500 ppm) as foliar application on 30 DAP (days after planting) old crop plants. Results indicate that the treatment with T_5 ethrel (250 ppm) was significantly effective in altering crop phenotype, chiefly, in terms of plant growth parameters like crop height (dwarf phenotype, 61.1cm vs. control, 110.2cm), main shoot diameter (5.8cm vs. 4.2cm), number of tuber per plant (3.4 vs. 2.6) and total yield of tuber [g per block] (534.6g vs. 246g in controls) in comparison to T_0 control-water spray. Application of Ethrel (250 ppm) at 30 DAP is recommended on micro plantlets generated crop plants, grown in soil-less solid media cultivation in green house condition, for increased yield of potato seed tubers.

KEY **W**ORDS : Plant growth regulator, Plant growth enhancers, Plant growth retardants, Potato seed tubers, Harvest index

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Potato is a vegetatively propagated crop. Seed potato alone accounts for about 40-50 per cent of cost of cultivation (Kumar *et al.*, 2007). The state and central seed production agencies of India were able to meet only 20-25 per cent requirement of quality seed potatoes. For bridging this wide gap, research and innovative methods (Ranalli, 1997), are needed to increase early generation seed potato (G_0) production through micro-propagation (Sharma and Singh, 2010 and Sharma *et al.*, 2010), soil-less cultivation and use of plant growth regulators at a commercial level (Pandey, 2006).

In vitro propagated (micropropagated) plantlets are commonly used in potato seed tuber (G_0) production as a source of healthy propagule (Struik, 2007). Producing

minituber (early generation seed potato) from micro plantlets allows potential yield of seed potato of about, 20-25 tubers per microplant, whereas the national average still stands at 2-3 tubers per micro-plant, due to its low multiplication ratio ranging from 1:2 to 1: 20 (Chandra *et al*., 1992). Potato is also a very high input – intensive crop (CPRI annual report, 2014-2015, website 1) available online, *www. http://cpri.ernet.in/annual_reports/CPRI_Annual_Report_2015.pdf*).

The overall performance of the crop depends upon the metabolic activities of plants, particularly at their critical growth and developmental stages. To overcome the deficit in obtaining maximum production and productivity, the role of plant growth regulators play vital role even though it is required in a very small quantity. The plant growth regulators have been reported to influence growth and play a significant role in increasing the yield by 10–15 per cent by suppressing or stimulating plant growth (Birbal *et al.*, 2009).

Hence, the present study was undertaken to investigate the effect of foliar application of various plant growth regulators on growth and yield of seed potato tubers in microplant based soilless solid media production system.

RESEARCH PROCEDURE

An experiment was conducted in an insect proof net house at MAHYCO, Jalna in 2016. The experiment was set up in a Completely Randomized Block Design (CRBD) with three replicates (R = 3). Potato 'Kufri Chipsona 3' microplant was used for the experiment. Microplants were planted at 20 cm x 10 cm in 1.2 m x 0.6 m block which fits around 25 microplants per block (N; number of plants per replicate = 25). Each block consisted of solid media substrate, Kalpeat plus *i.e.* coco peat: perlite (75:25) with pH 6.8. Fertilizers were applied at 8:6:7 g/m² as recommended by CPRI, Shimla, India in the form of ammonium sulfate, single superphosphate and muriate of potash, respectively. Half of the dose of nitrogen, full dose phosphate and potash were applied as basal dose, while the remaining half dose of nitrogen was applied in the form of urea at earthing up stage. In addition, boracol-12 micronutrient fertilizer, was applied at planting time. The experiment comprised of seven treatments; one control and six different plant growth regulators *viz*., T_0 control (water spray), T_1 GA_3 (0.0036 ppm), T_2 paclobutrazaol (100 ppm), T_3 triacontanol (0.5 ppm), T_4 NAA (100 ppm), T_5 ethrel (250 ppm) and T_6 CCC (500 ppm). A 15 litre hand sprayer was used for spraying for attaining full cover spray. It was ensured that the application of growth regulators was uniform, on both upper and lower parts of plants, drenching the plants completely. Out of six plant growth regulators, two were plant growth enhancers/simulators (GA_3, NAA) and four were commonly used plant growth retardants (Paclobutrazaol, Triacontanol, Ethrel and Chlormequat chloride-CCC). The crop was sprayed with all six plant growth regulators with their respective concentrations and water control, once in the season at 30 days after planting (DAP). For every fifteen days interval, the plants were sprayed with pesticide solutions. In one litre of water, the following chemicals were added, 9 g of dithane M 45 or 3.5 g ridomil gold MZ fungicide and 4.4 ml metasystox or 0.5 mg admir (commercial) insecticides. The solution was used half strength for the first one month, and full strength for the rest of the season. As the plants in the blocks grew, they were supported by thread and banding wire. The haulms were destroyed manually at 90 (DAP) days after planting. The pooled data were statistically analyzed by using ANOVA (analysis of variance, Fisher, F-test) for CRD at P=0.05 level of significance. Harvest index was calculated as (HI) = seed tuber yield / biological yield (seed tuber + vegetative parts).

RESEARCH ANALYSIS AND REASONING

The results obtained from the present investigation have been discussed in the following sub heads :

Plant growth parameters :

Plant growth parameters like length of main shoot/ stem (90 DAP), number of shoots per plant and main shoot or stem diameter were altered by the application of plant growth regulators. Notably T_2, T_3, T_5 and T_6 resulted in significant alteration in plant height, number of shoots per plant and main shoot or stem diameter. The treatment T_5: ethrel resulted in significantly desirable change in plant growth parameters (Fig. 1-3).

Effect on main shoot/stem length (cm) at 90 DAP :

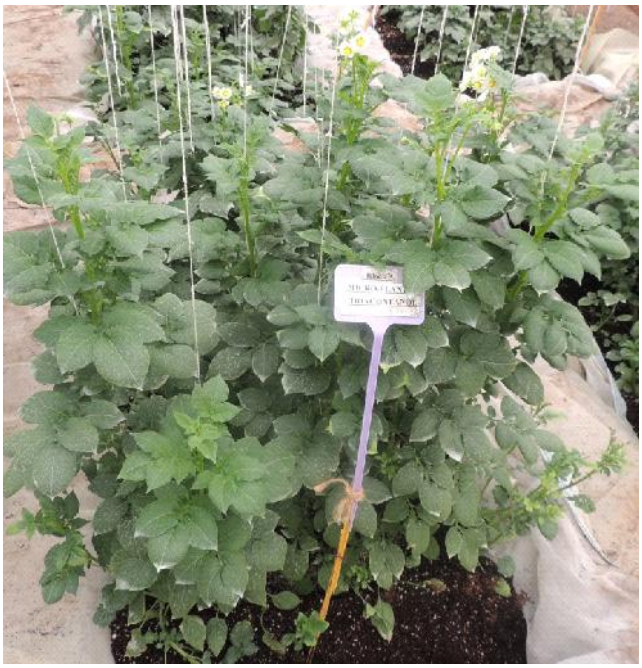
Out of six plant growth regulators studied, plant growth enhancers T_1: GA_3 and T_4: NAA treatment resulted in longer stem measuring 120.4 cm and 98.1 cm,

T_0: Control 90 DAP

T_5: Ethrel 90 DAP

Fig. 1 : T_0: Control Vs. T_5: Ethrel

T_0: Control 90 DAP



T_3: Triacontanol 90 DAP

Fig. 2 : T_0: Control Vs. T_3: Triacontanol

T_0: Control 90 DAP

T_1: GA_3 90 DAP

Fig. 3 : T_0: Control Vs. T_1: GA_3

respectively, compared with T_0: control 110.2 cm. In case of plant growth retardants, treated stem were shorter *i.e.* 47.4 cm, 70.7 cm, 61.1 cm and 75.2 cm with T_2: paclobutrazaol, T_3: triacontanol, T_5: ethrel and T_6: CCC application, respectively (Table 1). The observed effect may be due to the higher activity of GA_3 and NAA in inducing cell elongation and cell division. This ultimately translates into higher plant height as reported by Birbal *et al.* (2009). While, plant growth retardants arrested the activity of GA_3 inside plant cells (which are responsible for stem elongation), hence, reducing stem length was observed when retardants were used. GA_3 is responsible for stem elongation by increasing the internodes length (Davis *et al.*, 1991). Plant growth retardants reduce the level of GA_3 in plant cells by blocking the GA biosynthesis pathway (Bandara *et al.*, 1998).

Effect on main stem diameter (cm) :

In case of plant growth enhancers, plants stems were thinner and with plant growth retardants, stem girth was thicker as compared to controls (Table 1). In T_1: GA_3 treatment, plants had thinner stem *i.e.* 3.8 cm in diameter and T_5: ethrel treated plants had thicker stem with 5.8 cm diameter when compared to T_0: control with

Table 1: Growth parameters as influenced by foliar application of plant growth regulators

Treatments	Survival %	Main stem/plant height (cm)		Main stem diameter (cm) at 90 DAP	No. of shoots/plant
		30 DAP	90 DAP		
T_0 Control	92	18.4	110.2	4.2	2.2
T_1 GA_3 @ 0.0036ppm	92^{NS}	19.1^{S*}	120.4^{NS}	3.8^{S*}	3.1^{S*}
T_2 Paclobutrazaol @ 100 ppm	84^{S*}	18.6^{NS}	47.4^{S*}	4^{NS}	1.2^{S*}
T_3 Triacontanol @ 0.500 ppm	84^{S*}	18.2^{NS}	70.7^{S*}	5.2^{S*}	2.6^{S*}
T_4 NAA @ 100 ppm	100^{NS}	20.2^{S*}	98.1^{NS}	5.1^{S*}	2.1^{NS}
T_5 Ethrel @ 250 ppm	96^{NS}	19.4^{S*}	61.1^{S*}	5.8^{S*}	2^{NS}
T_6 CCC @ 500 ppm	92^{NS}	19.1^{S*}	75.2^{S*}	4.1^{NS}	2.8^{S*}
S.E. ±	2.21	0.25	10.14	0.28	0.23
CD/LSD (P = 0.05)	4.42	0.50	20.29	0.57	0.47
CV%	5.0	3.0	2.9	15	2.5

S= Significant NS= Non-significant * indicates significance of value at P=0.05

4.2 cm. This may be explained by the high levels of GA accumulation in plants treated with growth enhancers which, resulted in higher cell division and increase in plant height with thin stem. Plant growth retardants limit GA in plant cells and results in dwarf plants with thick stems by increasing thickness of cortex, vascular bundles and pith diameter (Tsegaw *et al.,* 2005 and Mabvongwe *et al.,* 2016).

Effect on shoot number per plant :

The data (Table 1) revealed that the effect of plant growth regulators were significant on number of shoots per plant. Treatment T_1:GA_3 resulted in higher shoots number per plant (3.1) and lowest shoot number per plants was observed with T_2: paclobutrazaol (1.2) application. The increase in the vegetative character with plant growth regulators with growth enhancer activity of T_1:GA_3 and T_4: NAA enhance cell division and quick multiplication. In contrast, decrease in vegetative growth with plant growth retardants *i.e.*T_2: paclobutrazaol, T_3: triacontanol, T_5: ethrel and T_6: CCC suppresses cell division. The above results are in consonance with those obtained by Miller *et al.* (1985); Bhatia *et al.* (1991); Asma *et al. (*2001); Alexopoulos *et al.* (2007); Ostroshy and Struik (2008); El- Helaly (2009); Sillu *et al.* (2012) and Mabvongwe *et al.* (2016).

Plant yield parameters :

Yield parameters like number of tubers per plant, tuber yield (g) per plant, mean tuber weight (g) and harvest index were significantly affected by application of plant growth regulators and greatest effect was observed with T_5: ethrel (250 ppm) treatment.

Effect on yield :

It was found that application of T_5: ethrel gave significantly higher number of tubers per plant (3.4) and tuber yield per block (534.6 g), over T_0: control with 2.6 tuber/ plant and 246g tuber yield / block followed by T_3: Triacontanol 3.3 tuber/ plant and 280g tuber yield / block (Table 2). Similar results were observed by Alexopoulos *et al.*, 2007 and Birbal *et al.*, 2009, as they reported that foliar application of plant growth regulators increase the tuber number per plant and tuber yield (kg/hill) significantly, over untreated controls.

With respect of mean tuber weight (g) and harvest index (HI), it was found higher in T_5: ethrel treatment (6.6 g and 0.77g), whereas found lowest in T_6: CCC (3 g and 0.17) as compared to T_0: control (4.1 g and 0.3). Better efficiency of ethrel treated plants is attributed to the higher number of tuber and tuber yield per plant (Table 2).

This probably is due to foliar application of plant growth regulators which might have better penetration effect on leaves and resulted in increased leaf chlorophyll content. These resulted in increase in photosynthetic rate and higher yield and yield attributes. Similar findings have also been obtained by Tomer and Rarmgiry (1997); Kang *et al.* (1997); Alexopoulos *et al.* (2007) and Sillu *et al.* (2012).

Effect on harvest index (HI) and tuber grid :

With respective of high harvest index, (HI) T_5: ethrel treated plants register significant increase in dry matter of tuber over T_0: control.

In perspective, increase in average tuber weight was observed in the present study in T_3: triacontanol and T_5: ethrel which, resulted in production of maximum seed size tubers and produced less oversized tubers, these treatments also resulted in almost no mini (small) size tubers.

Table 2: Yield parameters as influenced by foliar application of plant growth regulators

Treatments	Tuber yield (g)/plant	tuber yield (g)/ block	No. of tubers/plant	No. of tubers/block	Mean tuber wt (g)	Harvest index (HI)
T_0 Control	10.9	246	2.6	60	4.1	0.3
T_1 GA_3 @ 0.0036ppm	6.6^{NS}	151.8^{NS}	2^{NS}	46^{NS}	3.3^{NS}	0.19^{NS}
T_2 Paclobutrazaol @ 100 ppm	10.6^{NS}	238.5^{NS}	2^{NS}	45^{NS}	5.3^{S*}	0.56^{S}
T_3 Triacontanol @ 0.500 ppm	13.2^{S*}	280^{NS}	3.3^{S*}	70^{S*}	4^{NS}	0.32^{NS}
T_4 NAA @ 100 ppm	8.3^{NS}	166.4^{NS}	2.6^{S}	52^{NS}	3.2^{NS}	0.21^{NS}
T_5 Ethrel @ 250 ppm	21.7^{S*}	534.6^{S*}	3.4^{S*}	81^{S*}	6.6^{S*}	0.77^{S*}
T_6 CCC @ 500 ppm	4.8^{NS}	117^{NS}	1.6^{NS}	39^{NS}	3^{NS}	0.17^{NS}
S.E. ±	2.09	52.62	0.25	5.69	0.49	0.08
CD/LSD (P = 0.05)	4.19	105.25	0.51	11.39	0.98	0.16
CV%	4.7	5.2	2.5	2.4	2.8	5.7

S= Significant NS= Non-significant * indicates significance of value at P=0.05

Conclusion :

The results obtained from the present investigation concluded that for securing the higher growth and seed tuber yield as well as average weight of seed tuber; foliar application of growth retardant, ethrel (250 ppm) followed by triacontanol (0.5 ppm) is advocated as foliar spray in soil-less solid media for potato cultivars.

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