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Growth, chlorophyll and yield of paddy (*Oryza sativa* L.) as affected by growth regulators

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Abstract
The present investigation entitled "Growth, Chlorophyll and Yield of Paddy (*Oryza sativa* L.) As Affected by Growth Regulators" was conducted during the *kharif* season in 2011 and 2012 at Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.). The experiment was setup in Randomized Block Design (RBD) with three replications and nine treatments. Growth regulators *i.e.*, IAA (25 and 50 ppm), CCC (2000 and 4000 ppm), Alar (2000 and 3000 ppm) and Cytokinin (5 and 10 ppm) were applied on foliage at vegetative and milky stage of Rice (*Var.* PHB-71). Growth parameters was recorded at maximum maturity stage of paddy crop, while, Yield attributes were taken at the time of crop harvest. Chlorophyll Intensity (%) was recorded at pre-anthesis stage. All PGRs showed superior value in all the parameters of crop with respect to control. Growth characters *viz.*, Plant Height (cm), Number of tillers plant^{-1}, Leaf area plant^{-1} (cm^2), Total dry matter production plant^{-1} (g) were found superior with foliar application of IAA 50 ppm and Yield attributes *viz.*, Number of panicles plant^{-1}, Number of grains panicle^{-1}, Grain weight plant^{-1} (g), Grain yield (kg ha^{-1}), Test weight (g), Harvest index (%) were also maximized with foliar application of IAA 50 ppm. Chlorophyll intensity was found superior by the treatment of IAA 50 ppm.

Keywords: PGRs, paddy, growth parameters, chlorophyll, yield

Introduction
Paddy (*Oryza Sativa* L.) is one of the most important cereal crops of the world in terms of food, area and production (Niamatullah *et al*., 2010) [6]. One in every three people depends on paddy for more than half of their daily food (Khush and Virk, 2000) [4]. The crop occupies one of the world's total areas planted to cereals, providing 50-60 percent of the calories to 2.7 billion peoples (Belder *et al*., 2004) [2]. The demand of paddy is growing due to increasing population and food consumption patterns, while the land will either remain same or may decline. So, with the growing demand, it is very important to ensure the constant availability of more paddy at less cost. Therefore, the use of growth regulators not only provided the useful tool to improve the morphological but also helpful in overcoming the problem of lower yield of paddy crop. Plant growth regulators have been used in agriculture for as long as crop cultivation, their impact up to now has been relatively little detected and their application is limited to some specific objectives for example quality and quantity improvement (Pandey *et al*., 2001) [7]. PGRs play vital roles in coordination of many growth and behavioral processes in paddy, which regulates the amount, type and direction of plant growth (Rajendra and Jones Jonathan 2009; Anjum *et al.*, 2011) [1, 8]. It modifies growth and development in various ways under different growth conditions and are effective in elevating the stress effects (Razi and Sen, 1996) [9]. It plays an important role in the movement of accumulated carbohydrate to the sink. Auxins (IAA) play a dominant role in root and shoot development, leaf senescence, fruit setting and flowering (Friml, 2003) [3]. Adjustment of plant growth and development using growth reducers such as Cycocel to reduce the plant height and increase the tolerance to lodging is a technique permitting the greater amount of nitrogen to attain higher yield (Mohaghegh *et al.*, 2007) [5]. Cycocel treatment decreases the cell size and increases the cell wall thickness, thickness of the cell sap, increases the number of stem sets, decreases the length of internodes and increases the stem diameter. It decreases the plant height up to 23% and significantly increases the grain yield (Singh *et al.*, 2002) [10]. Alar is a growth retardant used to reduce the plant height, increase stem diameter, short foliage stature of the crop plant. Cytokinin is used to promote cell division in plant root and shoot, improve plant height, chlorophyll content and grain filling rate.

Materials and Methods
The experiment was conducted at Student's Instructional Farm of Chandra Shekhar Azad

University of Agriculture and Technology, Kanpur (U.P.). Geographically, Kanpur is located at 26.30^0 N Longitude, 80.15^0 E Latitude and it lies 127 meters above mean sea level in Gangatic alluvial of central Uttar Pradesh. The experimental site having sandy-loam soil with pH 7.2, Organic matter 0.46%, available nitrogen 245 kg/ha, available phosphorous 16 kg/ha and available potassium 282 kg/ha. The experiment was laid down in Randomized Block Design (RBD) with three replications. Paddy variety PHB-71 was sown in puddled bed to raise the nursery. Transplanting of twenty one days old seedlings with two seedlings per hill was done with 20 x 15 cm spacing (Plot size was 3 x 4 m^2) in each three replications. Nitrogen, Phosphorus and Potash were applied in transplanted field at the rate of 120:60:60 kg ha^{-1} in the form of urea, single super phosphate and murate of potash, respectively. Various plant growth regulators *viz.*, IAA (25 and 50 ppm), CCC (2000 and 4000 ppm), Alar (2000 and 3000 ppm) and Cytokinin (5 and 10 ppm) were used as foliar application at vegetative and milky stage.

Observations on Growth characters *viz.*, Plant Height (cm), Number of tillers $plant^{-1}$, Leaf area $plant^{-1}$ (cm^2), Total dry matter production $plant^{-1}$ (g) were recorded at maturity stage of crop and Chlorophyll intensity (%) was measured with the help of Plant Efficiency Analyzer (Model X 55/M-PEA) and the values were expressed as SPAD value and it was measured at pre-anthesis stage. Yield with its attributes *viz.*, Number of panicles $plant^{-1}$, Number of grains $panicle^{-1}$, Grain weight $plant^{-1}$ (g), Grain yield (kg ha^{-1}), Test weight (g), Harvest index (%) were taken at the time of harvesting.

Results and Discussion

A perusal of data on growth parameters presented in Table-1 revealed that application of growth regulators as foliar spray significantly influenced the plant height. The effect of IAA 50 ppm was more pronounced followed by IAA 25 ppm and both the doses of Cytokinin (5 and 10 ppm) in both years. While minimum plant height were recorded with the treatment of CCC 4000 ppm followed by CCC 2000 ppm and Alar 3000 ppm. Data regarding Number of tillers $plant^{-1}$ (Table-1) as affected by growth regulators recorded at maturity stage expressed that all the treatments significantly increased number of tillers $Plant^{-1}$. Spraying of all the plant growth regulators registered higher tillers $plant^{-1}$ as compared to control at both the years of the research work. The maximum Number of tillers $plant^{-1}$ was recorded with IAA 50 ppm followed by CCC 2000 ppm and IAA 25 ppm while minimum Number of tillers $plant^{-1}$ was recorded with Cytokinin 10 ppm. The leaf area $plant^{-1}$ is presented in Table-1 revealed that all the treatments significantly increased leaf area $plant^{-1}$ at maturity stage of the paddy crop with respect to control. The maximum leaf area $plant^{-1}$ was recorded with foliar application of IAA 50 ppm followed by IAA 25 ppm and Alar 2000 ppm and the minimum leaf area $plant^{-1}$ was recorded in case of foliar application of CCC 4000 ppm. Data pertaining to total dry matter production $plant^{-1}$ (g) as affected by foliar application of plant growth regulators are presented in Table-2 showed that foliar application of all the treatments significantly increased total dry matter production $plant^{-1}$ (g) as compared to control during both year (2012 and 2013). The effect of foliar application of IAA 50 ppm was more pronounced and significantly increased the total dry matter production $plant^{-1}$ as compared to other treatments while minimum value was recorded with CCC 2000 ppm during both years. Result on leaf chlorophyll intensity present in Table-2 showed that the growth regulators significantly accelerate the chlorophyll intensity of paddy leaf in comparison to control plant. The highest value on leaf chlorophyll was registered by the treatment of IAA 50 ppm followed by IAA 25 ppm and Cytokinin 10 ppm during both years. Increment in total chlorophyll was due to formation, maintenance and development of chloroplast by the treatment of these individual crop plants with growth regulators.

Observation with respect to yield and yield attributing characters were presented in Table-3. Regarding different treatments were concerned, IAA 50 ppm showed significantly higher number of panicles $plant^{-1}$ as compare to other treatments including control during both year. Perusal of data (Table-3) revealed that the maximum number of grains $panicle^{-1}$ was recorded with the treatment of IAA 50 ppm followed by IAA 25 ppm and Alar 2000 ppm in all the experimental year. Data pertaining to grain weight $plant^{-1}$ (Table-3) as affected by foliar application of plant growth regulators demonstrated that the maximum grain weight $plant^{-1}$ was recorded with IAA 50 ppm followed by Alar 2000 ppm and IAA 25 ppm. The data with respect to Test weight (Table-4) revealed that the maximum test weight was recorded with IAA 50 ppm which found superior over rest of the treatments including control. The effect of foliar application of IAA 50 ppm was more pronounced and increased the Grain yield (kg ha^{-1}) (Table-4) as compared to other treatments while minimum value was recorded with CCC 4000 ppm during both of the research work. It is evident from the data that maximum harvest index (Table-4) was recorded with foliar application of IAA 50 ppm followed by Cytokinin 5 ppm during 2011 and 2012.

Table 1: Effect of growth regulators on plant height (cm), number of tillers $plant^{-1}$ and leaf area $plant^{-1}$ (cm^2) of paddy at maturity stage during 2011 and 2012

Treatment	Plant height (cm)		Number of tillers $plant^{-1}$		Leaf area $plant^{-1}$ (cm^2)	
	2011	2012	2011	2012	2011	2012
T_1 - Control	83.00	82.00	7.00	6.80	1214.33	1220.20
T_2 - IAA 25 ppm	87.50	86.40	9.30	9.20	1682.66	1665.33
T_3 - IAA 50 ppm	90.86	88.50	10.30	10.00	1981.33	1898.50
T_4 - CCC 2000 ppm	78.80	77.70	9.70	9.50	1379.00	1380.00
T_5 - CCC 4000 ppm	76.30	75.40	8.30	8.60	1288.00	1270.20
T_6 - Alar 2000 ppm	81.50	80.20	9.30	9.00	1661.00	1650.00
T_7 - Alar 3000 ppm	79.60	78.30	8.70	8.60	1449.33	1443.66
T_8 - Cytokinin 5 ppm	86.20	85.10	9.00	8.90	1531.66	1510.00
T_9 - Cytokinin 10 ppm	83.00	82.10	8.30	8.00	1458.99	1445.66
SE (m)±	2.23	1.13	0.44	0.29	42.82	41.66
CD at 5%	4.93	2.40	0.93	0.60	90.78	88.31

Table 2: Effect of growth regulators on total dry matter production plant^{-1} and chlorophyll intensity (%) of paddy at maturity stage during 2011 and 2012

Treatment	Total dry matter production plant^{-1} (g)		Chlorophyll intensity (%)	
	2011	2012	2011	2012
T_1 - Control	37.45	37.35	33.50	36.20
T_2 - IAA 25 ppm	53.00	52.20	38.78	39.65
T_3 - IAA 50 ppm	55.33	55.10	40.65	41.20
T_4 - CCC 2000 ppm	42.20	42.50	36.20	36.75
T_5 - CCC 4000 ppm	45.20	44.80	36.75	37.10
T_6 - Alar 2000 ppm	52.30	51.60	36.50	36.85
T_7 - Alar 3000 ppm	49.35	49.20	37.00	37.10
T_8 - Cytokinin 5 ppm	51.90	50.80	37.10	37.25
T_9 - Cytokinin 10 ppm	49.26	48.60	37.90	37.85
SE (m)±	1.61	1.02	1.91	2.03
CD at 5%	3.42	2.17	4.05	4.30

Table 3: Effect of growth regulators on number of panicles plant^{-1}, number of grains panicle^{-1} and grain weight plant^{-1} (g) of paddy at harvesting stage during 2011 and 2012

Treatment	Number of panicles plant^{-1}		Number of grains panicle^{-1}		Grain weight plant^{-1} (g)	
	2011	2012	2011	2012	2011	2012
T_1 - Control	7.00	6.80	22.30	21.50	19.50	20.00
T_2 - IAA 25 ppm	9.00	9.00	28.40	26.40	23.50	23.00
T_3 - IAA 50 ppm	10.00	10.00	29.80	28.60	25.50	25.40
T_4 - CCC 2000 ppm	8.80	8.90	25.60	24.60	21.40	21.15
T_5 - CCC 4000 ppm	8.00	8.00	23.90	22.50	20.20	20.10
T_6 - Alar 2000 ppm	9.00	8.67	28.50	26.00	23.60	23.20
T_7 - Alar 3000 ppm	8.33	8.33	26.40	24.40	22.50	22.00
T_8 - Cytokinin 5 ppm	8.67	8.45	27.90	25.80	22.60	22.40
T_9 - Cytokinin 10 ppm	8.33	8.08	26.40	23.60	21.80	21.60
SE (m)±	0.34	0.27	1.09	0.64	0.57	0.74
CD at 5%	0.72	0.55	2.32	1.36	1.21	1.56

Table 4: Effect of growth regulators on test weight (g), grain yield (kg ha^{-1}) and harvest index (%) of paddy at harvesting stage during 2011 and 2012

Treatment	Test weight (g)		Grain yield (kg ha^{-1})		Harvest index (%)	
	2011	2012	2011	2012	2011	2012
T_1 - Control	19.60	20.00	3959.32	3940.10	31.29	31.43
T_2 - IAA 25 ppm	22.34	22.20	4324.50	4276.60	32.43	32.89
T_3 - IAA 50 ppm	23.70	23.20	4596.78	4516.70	34.30	34.74
T_4 - CCC 2000 ppm	20.58	20.40	4320.50	4228.40	32.32	32.11
T_5 - CCC 4000 ppm	20.20	20.25	4210.20	4164.83	32.00	31.03
T_6 - Alar 2000 ppm	22.86	22.65	4400.50	4292.47	32.84	32.52
T_7 - Alar 3000 ppm	21.70	21.55	4300.20	4036.20	32.66	31.20
T_8 - Cytokinin 5 ppm	21.60	21.45	4310.50	4215.58	34.27	33.63
T_9 - Cytokinin 10 ppm	20.10	20.00	4250.20	4189.96	34.00	33.51
SE (m)±	0.60	0.68	31.49	46.33	0.92	1.16
CD at 5%	1.39	1.44	66.76	98.61	1.95	2.46

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