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Exploring the Impact of Plant Growth Regulators on Growth and Physiological Responses in Hybrid Rice Cultivation

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ABSTRACT: Plant growth regulators are artificial synthetic agents used for promoting or inhibiting growth, biochemical changes, phenology, quality characters and other plant physiological processes. The present study was performed at Student Instructional Farm of C. S. Azad University of Agriculture & Technology, Kanpur to evaluate the Aftermath of plant growth regulator's foliar application on growth and Physiological characters of Rice. The experiment was conducted in randomized block design, with treatments consisting of foliar spray with IAA (25 & 50ppm), IBA (25 & 50ppm), NAA (25 & 50ppm), Ascorbic Acid (50 & 100ppm) and Kinetin (5 & 10ppm). The effect of foliar application of different concentration of plant growth regulators on Growth and physiological characters in rice were observed at tillering, anthesis, dough and at maturity stage. Growth parameters like plant height, number of tillers and leaf traits namely Total Leaf Area and Chlorophyll intensity recorded significant enhancement by the foliar application of IAA @ 50ppm. Significantly higher chlorophyll intensity in leaves were estimated at anthesis stage with the foliar spray of IAA @ 50ppm and followed by IAA @ 25ppm. Various traits of plant growth and physiology were altered under the application of Indole-3-acetic acid (*i.e.*, Plant height, number of tillers plant^{-1}, total leaf area plant^{-1} and chlorophyll intensity in leaves). According to above outcome of the experiment, it can be concluded that the foliar application of Indole Acetic Acid (IAA) is one of the most promising growth promoting hormones and it will definitely play significant role to change growth and physiological character in hybrid rice.

Keywords: Plant growth regulators, hybrid rice, growth, Physiological character.

INTRODUCTION

Rice (*Oryza sativa* L.) is a C3 crop plant that reproduces through self-pollination and belongs to the Poaceae family. The *Oryza genus* comprises 24 different species, but only two, namely *Oryza sativa* and *Oryza glaberrima*, are cultivated for commercial purposes. Rice holds immense significance as a staple food source for over 60% of the world's population. It is rich in carbohydrates and provides a moderate amount of protein for the human diet. The preference for rice as a food varies across different regions, with many favoring high-quality rice over coarser varieties. Rice primarily consists of starch, with starch content ranging from 78% to 79%, comprising both amylase and amylopectin fractions. It provides a calorific value of 32.8 and has a digestibility coefficient of 76, a biological value of 70, and a protein efficiency ratio (Kumar *et al*., 2018). Plant growth regulators (PGRs) are recognized for their ability to enhance the physiological efficiency of plants, including their photosynthetic capabilities, leading to increased crop yields. PGRs also play a vital role in improving the connection between source and sink tissues in plants, facilitating the movement of photo-assimilates and ultimately enhancing productivity. However, it is crucial to carefully plan the application and assessment of PGRs, taking into account factors such as the appropriate concentration, timing of application, specificity to particular plant species, and the season (Khan and Mazid 2018). Plant growth regulators are carbon-based compounds, whether natural or synthetic, distinct from nutrients, and they play fundamental roles in various aspects of a plant's life cycle, including altering or restoring growth patterns (Davies, 2013). These hormones have a significant impact on the activation or deactivation of gene expressions in plants, thereby influencing growth, development, and metabolism. In essence, the availability of exogenous growth regulators presents a valuable opportunity for modifying plant growth. Additionally, their high activity at low concentrations makes them economically advantageous for use.

MATERIAL AND METHODS

In order to accomplish the objectives of the present study entitled **"**Modification of morpho-physiological traits, quality and yield of rice (*Oryza sativa* L.) by Plant Growth Regulators**"** was carried out during *Kharif* season of 2021-2022 and 2022-2023. All investigations related to field experiments were conducted at Student Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. Experimental field was well leveled and assured irrigation facilities. The experiment was laid out in randomized block design with three replications. The experimental field was properly leveled followed by preparatory irrigation afterward at optimum tilth, the field was ploughed and layout was done as per programme.

A. Plant height

Plant height of main shoot was measured with the help of meter scale and recorded at tillering, anthesis, dough and maturity stage in randomly five tagged plants in each plot of all three replications. The plant height was measured from base of the plant to the top leaf of the main shoot in early stage of the growth while after panicle emergence, the plant height of main shoot measured from base of the plant to the joint of panicle in cm and mean values were calculated.

B. Number of tillers plant^{-1}

Simultaneously with height measurement number of tillers were also counted and recorded on tagged plants including the main shoot. All axillary tillers (including main shoot) was counted in number and recorded in each treatment.

C. Total Leaf Area plant^{-1} at different growth stages (cm^{-2})

Leaf area plant^{-1} was calculated with the help of formula given by Tsunoda (1964).

Total Leaf Area = Length of the leaf × Breadth of Leaf × Correction Factor (0.725) × Number of leaves plant^{-1}.

D. Chlorophyll intensity in leaves (%)

Chlorophyll intensity was measured as SPAD value during tillering, anthesis and dough stages as SPAD unit from the electronic instrument chlorophyll meter. Chlorophyll intensity in leaves was measured in between 9:30 to 10:00am on clear sky day. The SPAD values were recorded from top most fully development five random leaf.

RESULT AND DISCUSSION

Data pertaining to various growth and physiological parameters as affected by various concentrations of plant growth regulators have been presented in the following table.

A. Plant height

Data of Table 1 and Fig. 1 showed that plant height progressively increased with the increase of the plant age during both the years. All the treatments registered significant increase in plant height over control at all the stages of observations up to the maturity. All the treatments were found significant increase over control. At tillering, anthesis, dough and maturity stage showed maximum increase in plant height by the foliar spray of IAA @ 50ppm during both the years of cropping, while lowest increase in plant height was observed in control. The best treatment was found IAA @ 50 ppm and followed by IAA @ 25 ppm. Findings were supported by Pandey *et al*. (2001); Eifediyi and Remison (2015); Kumar *et al.* (2018); Prajapati *et al.* (2020).

Table 1: Effect of plant growth regulators on Plant height (cm) in hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Sr. No.	Treatments	Plant height (cm)							
		Tillering		Anthesis		Dough		Maturity	
		2021	2022	2021	2022	2021	2022	2021	2022
1.	T_1 – Control	29.23	30.90	60.00	60.85	91.00	91.50	100.43	100.89
2.	T_2 – IBA 25ppm	31.00	32.39	62.33	62.95	94.06	95.11	103.60	103.80
3.	T_3 – IBA 50ppm	31.26	32.72	63.76	64.87	94.56	95.89	104.93	105.00
4.	T_4 – IAA 25ppm	35.86	36.48	71.23	72.34	103.16	104.19	111.60	112.05
5.	T_5 – IAA 50ppm	36.26	37.54	72.86	74.50	104.00	105.20	112.06	113.23
6.	T_6 – NAA 25ppm	34.16	35.53	70.06	71.10	101.33	102.30	109.23	110.00
7.	T_7 – NAA 50ppm	34.80	36.00	70.56	72.19	101.66	102.78	109.66	110.85
8.	T_8 – AsA 50ppm	32.03	31.66	68.30	68.79	98.83	99.25	107.00	107.50
9.	T_9 – AsA 100ppm	32.43	32.00	68.53	69.14	99.10	99.93	107.80	108.10
10.	T_{10} – Kinetin 5ppm	33.66	34.50	69.00	69.81	100.20	101.39	108.30	109.20
11.	T_{11} - Kinetin 10ppm	33.83	34.95	69.50	70.15	100.76	102.10	108.83	109.79
	SE(d)	**0.64**	**0.37**	**1.38**	**1.47**	**1.45**	**2.31**	**1.90**	**2.52**
	CD at 5%	**1.35**	**0.78**	**2.89**	**3.08**	**3.02**	**4.83**	**3.96**	**5.25**

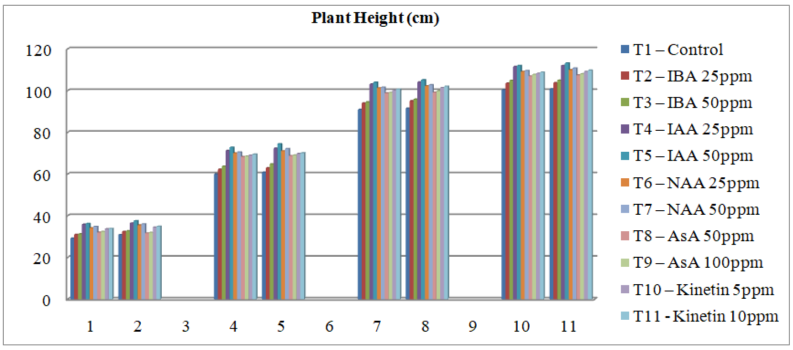

Fig. 1. Effect of plant growth regulators on Plant height (cm) in hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Table 2: Effect of plant growth regulators on Number of tillers plant^{-1} in hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Sr. No.	Treatments	Number of tillers plant^{-1}							
		Tillering		Anthesis		Dough		Maturity	
		2021	2022	2021	2022	2021	2022	2021	2022
1.	T_1 – Control	3.19	3.42	6.50	6.80	8.07	8.27	8.65	8.75
2.	T_2 – IBA 25ppm	3.43	3.52	7.34	7.53	8.35	8.48	8.95	9.10
3.	T_3 – IBA 50ppm	3.50	3.60	7.48	7.62	8.40	8.57	9.00	9.20
4.	T_4 – IAA 25ppm	4.16	4.60	8.89	9.39	10.11	10.29	10.90	11.02
5.	T_5 – IAA 50ppm	4.30	5.00	9.05	9.74	10.25	10.50	11.00	11.20
6.	T_6 – NAA 25ppm	4.00	4.32	8.70	8.96	9.96	10.05	10.80	10.88
7.	T_7 – NAA 50ppm	4.11	4.45	8.81	9.20	10.08	10.19	10.87	10.95
8.	T_8 – AsA 50ppm	3.69	3.78	7.53	7.72	9.22	9.36	10.38	10.46
9.	T_9 – AsA 100ppm	3.72	3.86	7.60	7.88	9.27	9.42	10.45	10.54
10.	T_{10} – Kinetin 5ppm	3.87	3.98	8.55	8.67	9.81	9.89	10.60	10.68
11.	T_{11} - Kinetin 10ppm	3.94	4.10	8.69	8.78	9.90	9.95	10.66	10.75
	SE(d)	**0.07**	**0.10**	**0.12**	**0.19**	**0.25**	**0.20**	**0.22**	**0.16**
	CD at 5%	**0.14**	**0.21**	**0.26**	**0.39**	**0.53**	**0.42**	**0.47**	**0.34**

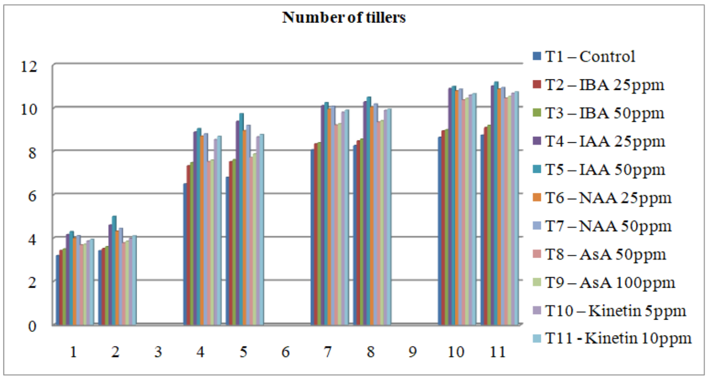

Fig. 2. Effect of plant growth regulators on Number of tillers plant^{-1} in hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Table 3: Effect of plant growth regulators on Total leaf area plant^{-1} in hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Sr. No.	Treatments	Total Leaf Area plant^{-1} (cm^2)					
		Tillering		Anthesis		Dough	
		2021	2022	2021	2022	2021	2022
1.	T_1 – Control	468.32	472.22	1250.10	1260.15	1550.40	1548.19
2.	T_2 – IBA 25ppm	475.81	476.50	1287.59	1290.64	1567.37	1569.40
3.	T_3 – IBA 50ppm	484.82	486.25	1330.09	1350.00	1588.78	1585.66
4.	T_4 – IAA 25ppm	682.10	685.00	1500.24	1515.52	1740.94	1750.54
5.	T_5 – IAA 50ppm	779.64	790.34	1538.32	1568.40	1799.84	1805.35
6.	T_6 – NAA 25ppm	554.96	559.45	1431.90	1439.10	1672.23	1675.10
7.	T_7 – NAA 50ppm	559.39	563.24	1438.89	1446.25	1676.93	1680.29
8.	T_8 – AsA 50ppm	501.53	505.33	1347.95	1351.30	1590.78	1596.32
9.	T_9 – AsA 100ppm	520.39	526.67	1387.88	1392.19	1593.37	1600.05
10.	T_{10} – Kinetin 5ppm	536.84	540.89	1395.87	1398.58	1610.56	1615.35
11.	T_{11} – Kinetin 10ppm	540.60	548.35	1426.55	1430.20	1651.15	1655.20
	SE(d)	12.23	12.96	27.24	26.72	37.71	37.48
	CD at 5%	25.51	27.05	56.82	55.73	78.67	78.02

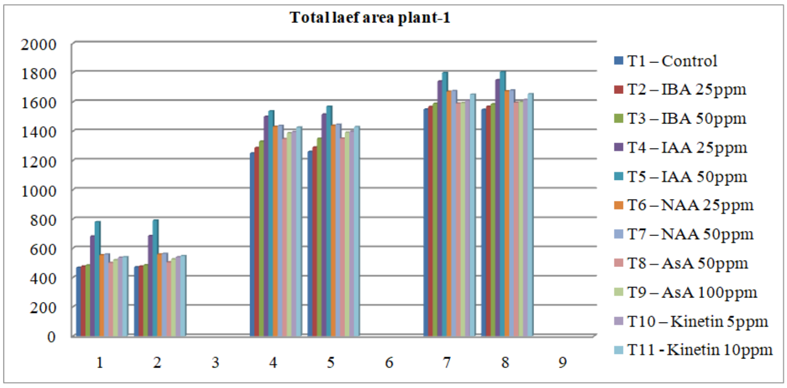

Fig. 3. Effect of plant growth regulators on Total leaf area plant^{-1} in hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Table 4: Effect of plant growth regulators on Chlorophyll intensity in leaves (%) of hybrid rice (*Oryza sativa* L.) at different crop growth stages.

Sr. No.	Treatments	Chlorophyll intensity in leaves (%)					
		Tillering		Anthesis		Dough	
		2021	2022	2021	2022	2021	2022
1.	T_1 – Control	27.20	27.60	35.18	35.80	31.00	31.10
2.	T_2 – IBA 25ppm	28.01	28.70	37.20	37.40	35.10	35.23
3.	T_3 – IBA 50ppm	28.42	28.95	37.49	37.61	35.44	35.57
4.	T_4 – IAA 25ppm	33.20	33.58	41.00	41.39	39.00	39.19
5	T_5 – IAA 50ppm	33.60	33.86	41.54	41.77	39.34	39.68
6	T_6 – NAA 25ppm	32.32	32.53	40.29	40.96	38.00	38.19
7	T_7 – NAA 50ppm	32.70	32.90	40.84	41.10	38.40	38.45
8	T_8 – AsA 50ppm	29.80	30.00	38.63	39.07	36.72	36.93
9	T_9 – AsA 100ppm	30.00	30.42	39.10	39.30	37.00	37.10
10	T_{10} – Kinetin 5ppm	30.18	30.54	39.76	39.87	37.64	37.85
11	T_{11} - Kinetin 10ppm	31.50	30.72	40.00	40.13	37.90	37.99
	SE(d)	**0.59**	**0.52**	**0.82**	**0.71**	**0.89**	**0.81**
	CD at 5%	**1.23**	**1.10**	**1.72**	**1.50**	**1.87**	**1.70**

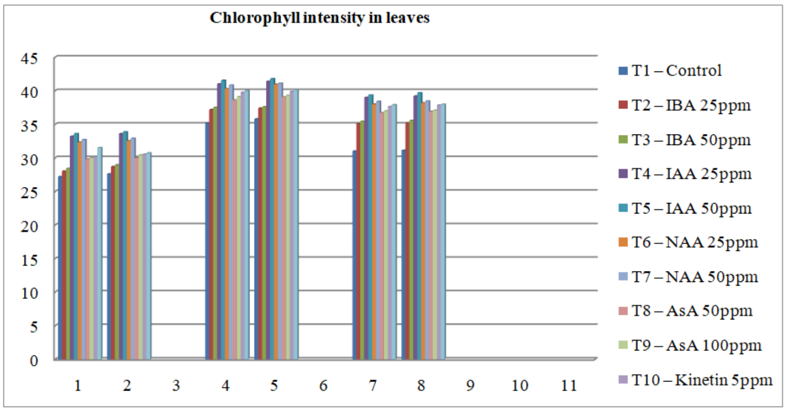

Fig. 4. Effect of plant growth regulators on Chlorophyll intensity in leaves (%) of hybrid rice (*Oryza sativa* L.) at different crop growth stages.

B. Number of tillers plant^{-1}

A perusal of Table 2 and Fig. 2 exhibit that different concentration of plant growth regulators had significant increase in number of tillers at different stages of growth with respect to control. Data presented in Table 2 were noted at tillering, anthesis dough and at maturity stage. Maximum number of tillers were recorded by the foliar application of IAA @ 50 ppm and followed by foliar application of IAA @ 25 ppm, NAA @ 25 ppm and 50ppm at different stages of crop growth. While, minimum number of tiller plant^{-1} was recorded by the untreated control during both the years of experiment. Tiller production continued to increase from the tillering to dough stage while, at maturity slight increase in all the treatment with the same trend of response as described above. Support for the findings came from research conducted by Prajapati *et al.* (2017); Goutam *et al.* (2019); Prajapati *et al.* (2020); Kumar *et al.* (2018).

C. Total Leaf Area plant^{-1} at different growth stages (cm^{-2})

Perusal of Table-3 exhibit that total leaf area affected by different concentration of plant growth regulators significant increase were observed over control. The significance of leaf area increase in production of grain discussed and emphasized where the higher leaf area was observed to be positively correlated with grain yield. Maximum increase in leaf area implies more because the sink source relationship increase which increase photosynthetic product and reflected to grains and showed maximum grain yield. Foliar spray of IAA @ 50ppm was observed that production of maximum leaf area at all growth stages of plant during both the years. However, lowest increase in leaf area by untreated control during both the years of experiment. The findings received validation from studies conducted by Aldesuquy (2001); Newaz *et al*. (2002); Eifediyi and Remison (2015); Khan and Mazid (2018); Kumar *et al.* (2018); Hana and Safa (2019); Mir *et al.* (2020).

D. Chlorophyll intensity in leaves (%)

Data presented in the Table 4 and Fig. 2 clearly showed that foliar application of different concentration of plant growth regulators effect were significant in different crop stages. Maximum increase in chlorophyll content was found at anthesis stage and after that slight decline in chlorophyll content at dough stage. Among the treatments maximum chlorophyll content observed with foliar spray of IAA @ 50ppm and followed by foliar spray of IAA @ 25ppm in both the years respectively. However, lowest value was recorded in control during both the years of experiment respectively. Findings were supported by Kaya *et al.* (2010); Kumar *et al*. (2018); Hana and Safa (2019); Zhang *et al*. (2020); Atif *et al*. (2022); Prajapati *et al*. (2020).

CONCLUSIONS

The application of IAA at a concentration of 50 ppm via foliar method exhibited remarkable effects on enhancing plant stature, increasing the number of tillers, expanding the overall leaf expanse, and intensifying chlorophyll content in hybrid plants. Notably, IAA at 25 ppm also demonstrated substantial benefits in these aspects. To summarize, our discoveries underscore the pivotal role of IAA in orchestrating root growth and bolstering detoxification mechanisms in rice plants. Plant hormones assume a crucial function in governing plant reactions to various growth-related and physiological metrics.

FUTURE SCOPE

The involvement of IAA in enhancing plant growth and physiology holds promise for future agricultural research and applications. A thorough understanding of its effects, interactions with various hormones, and environmental impact is vital for advancing sustainable crop production and strengthening food security.

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Conflict of Interest. None.

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