ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

Impact of Plant Growth Regulators on Yield and Yield Components in Rice (*Oryza sativa* L.) Under Field Conditions

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Article Information

Received: 01 July 2020
Revised version received: 15 September 2020
Accepted: 18 September 2020
Published: 29 September 2020

Cite this article as:
A.S. Soomoro et al. (2020) Int. J. Appl. Sci. Biotechnol. Vol 8(3): 318-322. DOI: 10.3126/ijasbt.v8i3.31611

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Peer reviewed under authority of IJASBT

Abstract

The exercise of using (PGRs), especially Gibberellic acid and in field of agriculture has become commercialized in some of the country including Pakistan. Number of different crops are being treated by farmers mostly vegetables; currently evaluated in rice crop through foliar application at different intervals to evaluate their efficiency at different doses. Results revealed that there was no significant difference in crop maturity compared with control. Plant height was variable among treated plots, highest plant height was recorded (121.2cm) in 2017-18 experiment in T-3 Gibberellic acid @ 12grams/acre while minimum (96.2cm) in 2016-17 in T-7 Control. Tillers/hill was increased, and maximum counted 18.5/hill in T-3 Gibberellic acid @ 10gms/acre whereas 11.9/hill was recorded in T-7 Control. Grain filling was obvious recorded with significance; counted 83 percent in T-5 Naphthalene acetic acid treated 100ml/acre whereas average minimum (71.3%) was recorded in T-7 Control. Not only plant development was modified by the treatments but yield was also increased average maximum (3228kgs/acre) with 19.61 percent was recorded in T-5 Naphthalene acetic acid @ 100ml/acre.

Keywords: Gibberellic acid; Naphthalene acetic acid (NAA); Plant Growth Regulators, Rice, Yield Impact

Introduction

Rice (*Oryza sativa* L.) is a staple food (Shaikh *et al*., 2011) consumed by approximately 62.8 percent of the world's population; performing as a good source of calories taken by the peoples of the world; mostly in Asia with 29.3 percent (Timmer, 2010). In Pakistan it occupies 10% over all cultivated area (Shaikh *et al*., 2011). Plants are known as sessile and are not able to travel to the place for their comfort. As a result, different processes like growth and development are significantly exaggerated; mostly by high temperature stress is considered as one of the most harmful aspect (Lobell and Field, 2007). Currently rise in temperature is one of the most important global issues causing stress in cultivated plants (IPCC 2007). No doubt that rice plant has high tolerance to sustain high temperature during vegetative stage, but defenselessness observed when the temperature rises during the phase of reproduction especially when its start bearing flowers (Yoshida *et al*., 1981; Prasad *et al*., 2006). Pollination reduction and increased spikelet sterility are generally caused by night raised temperature ultimately results low grain yield (Jagadish, 2010). Different plant growth regulators applied

for inducing heat tolerance of rice plant (Fahad *et al*., 2015). Gibberellic acid (GA_3) known as a growth regulator used to stimulate enzyme production for mobilization of seed reserves in germinating grains and stimulates growth of intact plants (Salisbury and Ross, 1992; Arteca, 1995). In rice, application of GA_3 as seed treatment significantly improves germination percentage, seedling emergence and seedling height (Asborno *et al*., 1999). Naphthalene acetic acid generally shortened NAA with the formula $C_{10}H_7CH_2CO_2H$ is an organic compound and known as a plant hormone, belongs to auxin family (Dimitrio *et al*., 2008). NAA a synthetic growth regulator has established it's prospective that in apposite concentration. NAA affects the growth and yield of a number of plants (Chhonkar and Singh 1959). Plant defense response against number of biotic and a biotic stress increased due to physiological response of plant growth regulators through foliar application (Walia *et al*., 2007).

In recent years environment; especially the temperature and humidity affected adversely to rice crop in Sindh, Pakistan. Pollen formation and grain filling was not obvious and ultimately yield losses were observed heavily. Plant Growth Regulators are one of the sources to stimulate the growth and development process with ease. Naphthalene acetic acid (NAA) and Gibberellic acid (GA_3) were tested on different doses through foliar application to find their effects on Growth, development and yield attributes of Rice crop under field conditions.

Materials and Methods

The experimentation was carried out at Department of Plant Physiology, Rice Research Institute, Dokri Larkana Pakistan during *Kharif* 2016-17 and 2017-18 for evaluation of different plant growth regulators and their effective dose. The research trial was designed in RCBD with three replications and seven treatments. Plot Size was measured 32.4m^2 with 27 plants entries/row and 30 plants were planted in each row.

Two different plant growth regulators were applied for determination of their impact. 1st foliar application was given after 30 days of transplanting; other two foliar applications were applied with 20 days interval after applying 1st one and tested the effectiveness of plant growth regulators on yield and yield attributes. Growth parameters; 90% maturity and Plant height (in centimeters) were recorded and analyzed through mean, different yield parameters tillers/hill, grain filling per spike were recorded by simple percentage formula

$$Spikelet(\%) = \frac{\text{Number of filled spikelet}}{Total\ spikelet\ per\ spike} \times 100$$

Yield/ Acre and yield increase percentage were also recorded for the determination of both PGRs effect in growth, development and yield of rice crop. Gibberellic acid- (GA_3) was applied 08, 10 and 12grams/Acre respectively and Naphthalene acetic acid-(NAA) plots were treated by 80, 100 and 120ml/Acre and compare with un-treated (Control).

Results

Growth Attributes

A. ***90 percent maturity***

The results shown that; there was no significant difference among the treated plots in terms of maturity. All the treated plots and control were mature almost at the same time. Average maximum late maturity was observed in T-3 Gibberellic acid @ 12gms/Acre (89 days) whereas control consumed 84.35 days (Table 1).

B. Plant Height

1st Foliar application (after 30 days of transplanting) of Gibberellic acid earlier shown increase in inter-node length among all the treatments of GA_3 @ 08,10 and12 grams/Acre respectively; but later there was no significant difference in inter-node length after 2nd and 3rd application. T3-Gibberellic acid @12gms/Acre shown highest Plant height (115.85cm) followed by T2-Gibberellic acid @ 10gms (109cm) compare to control (97.7cm) all the treatment including control (Table 1).

Table 1: Effect of foliar applications of PGR on Growth components.

S. N.	Treatment	90 Percent Maturity			Plant Height in Cm		
		1st Year	2nd Year	Average	1st Year	2nd Year	Average
1	Gibberellic acid @08gms	85.7	88.7	**87.2**	102.2	103.7	**102.95**
2	Gibberellic acid @ 10gms	85.0	86.5	**85.75**	106.5	111.5	**109**
3	Gibberellic acid @12gms	89.5	88.5	**89**	110.5	121.2	**115.85**
4	Naphthalene acetic acid @80gms	84.7	84.6	**84.65**	99.7	99.5	**99.6**
5	Naphthalene acetic acid @100gms	83.2	85.3	**84.25**	101.2	101.6	**101.4**
6	Naphthalene acetic acid @120gms	85.7	85.2	**85.45**	104.5	104.4	**104.45**
7	Control	84.2	84.5	**84.35**	96.2	99.2	**97.7**

Yield Attributes

A. ***Tillers/Hill***

It was observed that; tillers/hill increased with the foliar application of Plant Growth Regulators significantly as those were compared with control. Even plant canopy development in transplanted rice take 25 to 40 days depending upon the soil, nutrients availability, irrigation, fertilizer application and environmental factors but it was evaluated that new tillers/hill were sprouted after the application of PGRs. Average maximum tillers/hill were counted (18.5/hill) in T-3 Gibberellic acid GA_3 @ 10gms/Acre, followed by (17.6/hill) in T-5 Naphthalene acetic acid whereas (11.9/hill) tillers were counted per hill in T-7 Control/Check plot (Table 2).

B. Grain filling percentage

Results revealed that Grain filling percentage was better than control; there was significant difference between treated and untreated plots. Average maximum grain filling (83.4%) were recorded in T-5 Naphthalene acetic acid @ 100ml/Acre followed by (82.9%) in T-2 Gibberellic acid GA_3 @ 10gms/Acre were recorded whereas average minimum grain filling (71.3%) was recorded in T-7 Control under field conditions (Table 2).

Yield

Foliar exercise of growth regulators significantly increased yield of rice crop under filed conditions. Maximum yield was recorded in 2016-17 3344.7kg/Acre in T-5 Naphthalene acetic acid (NAA) @ 100ml/Acre. Minimum yield (2565.5kgs/Acre) was recorded in 2017-18 in T-7 Control. Over all maximum yield (3228kgs/Acre) traced in T-5 Naphthalene acetic acid @ 100ml/Acre followed by (3211.6kgs/Acre) the yield documented in T-2 Gibberellic acid @ 10gm/Acre while T-7 Control produced 2698kg/Acre in conducted experiment (Table 3).

Yield Increase Percentage

It was evaluated that all the treated plots increased yield as they were treated with PGRs. 11.45%, 19%, 16.99%, 15.45%, 19.61% and 16.26% recorded in GA3 @ 08gms, 10gms, and 12gms and NAA @ 80ml, 100ml and 120ml/Acre respectively (Fig.1).

Table 2. Yield attributes of Rice crop after foliar applications of PGR.

S. N.	Treatment	Tillers/Hill			Grain filling %		
		1st Year	2nd Year	Average	1st Year	2nd Year	Average
1	Gibberellic acid @ 08gms	14.5	13.7	14.1	80.3	78.2	79.25
2	Gibberellic acid @ 10 gms	21.5	17.5	18.5	81.7	84.1	82.9
3	Gibberellic acid @ 12 gms	18.7	15.1	16.9	80.5	83.7	82.1
4	Naphthalene acetic acid @ 80ml	15.3	14.2	14.75	84.3	82.5	83.4
5	Naphthalene acetic acid @ 100ml	18.5	16.7	17.6	92.2	87.7	81.95
6	Naphthalene acetic acid @120ml	15.4	14.2	14.8	80.2	78.2	79.2
7	Control	12.3	11.5	11.9	70.2	72.4	71.3

Table 3: Effect of PGRs (GA_3 and NAA different doses) on the yield of rice crop under field conditions.

S. N.	Treatment/Acre	1st Year	2nd year	Mean
1	Gibberellic acid @ 08gms	3011.5	3004.3	3007.9±5.091
2	Gibberellic acid @ 10gms	3321.7	3101.5	3211.6±155.704
3	Gibberellic acid @ 12gms	3244.4	3070.7	3157.5±122.824
4	Naphthalene acetic acid @ 80ml	3208.4	3025.5	3116.9±129.329
5	Naphthalene acetic acid @ 100ml	3344.7	3111.3	3228.0±165.038
6	Naphthalene acetic acid @ 120ml	3220.5	3092.5	3156.5±90.509
7	Control	2832	2565.5	2698.75±188.44

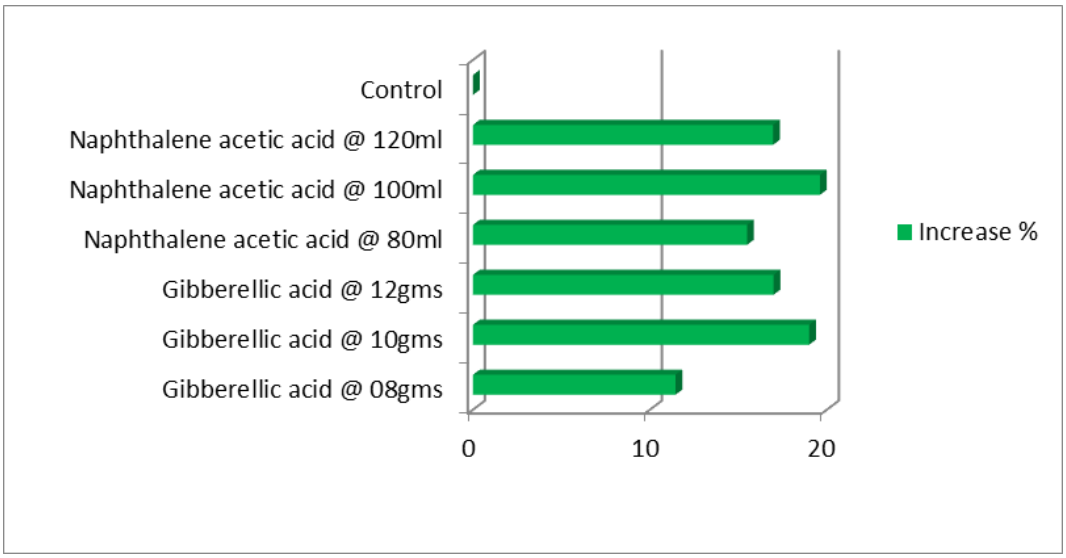

Fig. 1: Average yield increase percentage after foliar application of GA_3 and NAA

Discussion

The experiment was design with two plant growth regulators with three doses of each one, doses were applied to evaluate their impact on growth, yield attributes and the production obtained per acre from treated plots, Naphthalene acetic acid (NAA) foliar applications produced no significant difference on crop maturity days while NAA shown good impact on plant height. Plant canopy development numbers of tiller were increased in NAA treated plots. Maximum yield increase percentage 19.61% was recorded at NNA foliar application on 100ml/Acre.

Experiment shown that, leaves/plant, plant height and tillers/plant were found to boost in 100 and 200ppm naphthalene acetic acid (NAA). Rate of growth of plant was heights at early stage and then declined. 100ppm NAA produced better stimulation (Nargis and Golam, 2011). Similarly, good chlorophyll content with better crop canopy and increase grains/panicle with good grain weight ended significantly yield increase with the foliar spray of NAA (Grewal and Gill, 1986). It was evaluated that the maximum plant tallness was recorded due to 200ppm. Numbers of tillers were found to increase due to 100ppm NAA. Yield attributes increased in both 100 and 200 ppm (Golam and Nargis, 2011). Results found that 1- naphthalene acetic acid NAA a synthetic auxin, when applied in spray influences the life cycle if rice via metabolic processes to manifest beneficially through translocation assimilates the effect of NAA on the growth, yield attributes and yield (Basu, 2016). Investigations of various concentrations of Naphthalene acetic acid at 25mg/l, 50mg/l, 75mg/l and 100mg/l to test the effect on the growth and yield. Spike length, grain/spike and 1000 grain weight greater than control. NAA 50mg/l increases 12.24% higher over control (Nargis and Golam 2013).

Gibberellic acid (GA_3) was another PGR applied to weigh up its efficiency and contribution for surveillance, better development and yield increase of rice crop under field conditions. It was found that GA3 was impressive and contributed significantly in rice plant growth and yield increase as well. Plant height number of tillers/hill, number of filled grains and yield increased percentage was significantly better than control under field conditions.

Results revealed that the PGR's superior value in all stages of crop with respect of control. Yield and yield attributes were found superior with foliar application of GA3 (200ppm) (Mayanak *et al.*, 2018). The growth and yield parameters of rice like tallness of plant, and tiller per hill, flag leaf index, spikes/meter and filled grains per panicle were strikingly impressive due to Gibberellic acid @25g h-1 in both seasons. The lowest growth characteristic of yield attributes and grain yield were recorded in control (no foliar spray) (Ramesh *et al.*, 2019). The use of a variety of plant growth hormones considerably boosted seed yield with a range of 14.85g to 23.54g. Treatment; T2- GA_3 45g, T1 -GA3 30g, T5- NAA 200g and T3- NAA 100g. The application of growth regulators significantly increased yield components (Tiwari 2011). GA3 application was very effective in increasing seed set rate and seed yield. 225 and 150g/h of GA3 were found the most effective and economical (Gavino *et al*, 2008).

Conclusion

Gibberellic acid and Naphthalene acetic acid both PGRs performed on different doses when applied with foliar applications three times 1st after 30 days of transplanting and other two with twenty days interval. Difference was clearly observed as the treated plots were compared with control. Gibberellic acid (GA_3) at 10grams/acre and

Naphthalene acetic acid (NAA) at 100ml/acre was found to be the best among all treatments in rice crop.

Conflict of Interest

The authors do not have any conflict of interest with the present publication

Acknowledgement

The authors are grateful to the necessary support given by Ashraf Ali Soomro (Director) Rice Research Institute Dokri, Larkana, Pakistan.

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