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RESPONSE OF RICE TO FOLIAR APPLICATION OF PLANT GROWTH REGULATOR ON GROWTH AND YIELD OF RICE

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Abstract

Field experiments were conducted at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India during Navarai (January – May, 2018) and Kuruvai (June- October, 2018) to study the performance of rice to the foliar application of plant growth regulators on growth and yield of rice. The treatments comprised of, T_1 – Sodium Para-Nitrophenolate 0.3 % SL @ 5 ml/L, T_2 - Sodium Para-Nitrophenolate 0.3 % SL @ 10 ml/L, T_3 – Sodium Para-Nitrophenolate 0.3 % SL @ 20 ml/L, T_4 – Triacontanol 0.1 % EW @ 0.5 ml/L, T_5 – Gibberellic acid 0.001 % L @ 0.36 ml/L, T_6 – Control. The experiments were laid out in randomized block design with four replications. The result revealed that, foliar application of Sodium Para-Nitrophenolate 0.3 % SL @ 5 ml/L (T_1) at 20-25, 45-50, and 65-70 days after transplanting recorded the highest growth attributes (plant height, number of tillers plant^{-1}, leaf area index and dry matter production), and yield attributes (number of panicles m^{-2}, number of grains panicle^{-1} and test weight) and yield (grain and straw) of rice during Navarai and Kuruvai seasons.

Key words : Rice, PGR, growth attributes, yield attributes and yield.

Introduction

Rice (*Oryza sativa*) is the major staple food for more than half of the global population and considered as the "global grain". About 90% of rice grown in the world is produced and consumed only in Asian countries (Vasudevan *et al.*, 2014). Globally, India ranks first in terms of area under rice whereas second in production next to china. 'Rice of life" was the theme of International year of rice, 2004 that reflects the importance of rice, which holds the key to our country's ability to produce enough food for our people (Madhukeshwera *et al.*, 2018). In the world, rice is the second most widely consumed cereal next to wheat and it has occupied an area of 163.47 M ha with production and productivity of 501.56 MT and 4.58 t/ha respectively (USDA, 2019). In India, it is grown over an area of 44.5 M ha area with the production of 116 MT with an average productivity of 3.91 t/ha respectively. In Tamil Nadu, rice is grown in an area of 17.80 lakhs hectare with the production of 60 lakhs MT and having the productivity of 3.37 t/ha (Anonymous, 2018). The food security of India and other countries is now at risk due to increase in the population. By 2050, population of India is expected to be 1.6 billion from the current level of 1.1 billion (Madhukeshwera *et al.*, 2018). This implies that the rice requirement of 1.5 million tons is needed every year to meet the demand of increasing growth rate of population and many nations are facing second generation challenge of producing more rice at less cost in a deteriorating environment. Therefore, improving technologies are required to achieve the goal of ensuring food security, which is a challenging task. So, enhancing productivity of rice through novel approaches will be necessary (Pan *et al.*, 2013). The productive potential of rice is mainly governed by soil types, fertilizer, water, genotype and agronomic practices adopted in a particular climate. But, deficiency of PGR at any stage of plant may create a barrier to attain high grain yield (Pandey *et al.*, 2001). The plant growth hormones are synthesized indigenously and play a pivotal role in activating and inactivating the gene expression, growth and behavioural process in plant thus, the introduction of chemical plant growth regulator have added a new

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dimension to the possibility of modifying plant growth, development and metabolism (Nirmal Kumar *et al.*, 2018). Plant also have ability to store excessive amounts of exogenously supplied hormones in the form of reversible conjugates, which release active hormone when and where plants needs them during the growth period (Tiwari *et al.*, 2011). The plant growth regulators *viz.*, Triacontanol and Gibberellic acid have long been ascertained for variety of plant growth and development. Triacontanol is a potent PGR used in agriculture and horticulture crops. In recent years, biostimulants are a category of relatively new product that positively affects a plant's vital processes (Przybysz *et al.*, 2014). Atonik belongs to biostimulants substance (Abd Alla *et al.*, 2015) and it showed positive effect on vegetative growth of seedlings, shoot, root and branches reproductive growth in number of flowers and number of fruits and biomass accumulation (both fresh weight and dry matter) (Arysta life science, 2014). However information on the use of ATONIK (Sodium Para – Nitrophenolate 0.3% SL) in rice is dearth.

Materials and Methods

The field experiment were conducted during Navarai (January – May, 2018) and Kuruvai (June- October, 2018) at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalainagar, Tamil Nadu. The soil of experimental field was clayloamin texture. The soil was low in available Nitrogen, medium in available Phosphorous, high in available Potassium. The pH and EC were 7.42 and 0.26 dsm^{-1} The rice variety chosen for study is CO 51 (Short duration) for both the seasons. The experiments were laid out in randomized block design with four replications. The treatments comprised of, T_1 – Sodium Para-Nitrophenolate 0.3 % SL @ 5 ml/L, T_2 - Sodium Para-Nitrophenolate 0.3 % SL @ 10 ml/L, T_3 – Sodium Para-Nitrophenolate 0.3 % SL @ 20 ml/L, T_4 – Triacontanol 0.1 % EW @ 0.5 ml/L, T_5 – Gibberellic acid 0.001 % L @ 0.36 ml/L,T_6 -Control. The recommended dose of fertilizer (120:40:40 kg of N, P_2O_5 and K_2O ha^{-1}) was applied in the form of Urea (46 %), DAP (18% N and 46 % P_2O_5) and Muriate of Potash (60 % K_2O). The entire dose of P_2O_5, half dose of N and K_2O were applied as basal which was incorporated into the soil two days before transplanting. The remaining half of N and K_2O were top dressed in two equal splits at active tillering and panicle primordial initiation stages. Growth regulators *viz.*, Sodium Para – Nitrophenolate, Triacontanol and Gibberellic acid were foliar sprayed as per the treatments during morning hours at 20-25, 45-50, and 65-70 days after transplanting with the help of hand operated knapsack sprayer. Observation on growth attributes, yield attributes and yield parameters were recorded at respective stages.

Results and Discussion

Crop growth attributes

Plant height is an important agronomic trait of rice that is closely related to biomass production and yield of the crop (Zhang *et al.*, 2017). The plant height was significantly influenced by application of plant growth regulators over the control (T_1) The tallest plant height was observed from Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1). It increased the plant height per cent of, 28.15 and, 28.98 over the control at harvest stage during Navarai and Kuruvai seasons. This finding was in agreement with Haroun *et al*. (2011), Kazda *et al*. (2015), Banful and Attivor (2017) and Szparaga *et al*. (2018). Atonik increased the endogenous auxin content (Djanaguiraman *et al.*, 2005a). This finding was confirmed in the present study that application of Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1) recorded the tallest plant height, this might due to increase in content of endogenous auxin. Auxin involved in cell division, cell elongation and cell expansion, thereby it promoted the plant growth and development. Similar result was found by Djanaguiraman *et al*., (2005b).

Number of tillers is a dominant agronomic trait for panicle number per unit area as well as rice grain production and dry weight (Badshah *et al.*, 2014). The maximum number of tillers $hill^{-1}$ per cent of 21.04 and 19.30 over the control at active tillering stage during Navarai and Kuruvai seasons was recorded under Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1). The findings are close in agreement with Banful and Attivor (2017). Foliar spray of synthetic auxin (NAA) significantly increased the number of tillers (Jahan and

Adam, 2011). Similar result was found by Djanaguiraman *et al*., (2005), who reported that application of Atonik increased the endogenous auxin content.

LAI indicates the area of ground occupied by plant and is an important structural property of vegetation. Leaf surfaces are the primary sites of energy and mass exchange and other important processes such as canopy interception, evapotranspiration and gross photosynthesis which are directly proportional to LAI (Fang and Liang, 2014). The highest leaf area index was observed in Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1) and it increased the per cent leaf area index of 17.09 and 21.62 over the control at flowering stage during Navarai and Kuruvai seasons. Atonik increased in level of endogenous IAA content (Abd Alla *et al.*, 2015).

The highest DMP was the result of increased efficiency of photosynthetic apparatus, which was manifested by a higher leaf area, an increase in the intensity of photosynthesis, higher chlorophyll content (Kazda *et al.*, 2015 and Przybysz *et al.*, 2014) and the leaf area index particularly at reproductive stage play specific role in dry matter production of rice (Balamurugan *et al.*, 2018). These findings was close agreement with the present study that foliar application of Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1) increased the leaf area, which in turn improved the chlorophyll content and intensity of photosynthesis, that resulted in highest DMP. The maximum DMP was obtained from Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1) with increased per cent of 30.00 and 31.83 over the control at harvest stage during both seasons. Similar results were found by Djanaguiraman *et al*. (2005a), Haroun *et al*. (2011), Zhang *et al*., (2016) and Banful and Attivor (2017). The overall functions of the plant ultimately lead to progressive accumulation of the dry matter in the plant body. All the physiological process resulted in accumulation of dry matter (Kamble, 2015). This result has also been reported by Abd Alla *et al*., (2015), who reported that Atonik increased the endogenous auxin content, which enhanced the cell division and cell elongation, which finally increased the DMP.

Crop yield and yield attributes

The different plant growth regulators Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1) increased the yield attributes *viz.*, number of panicle m^{-2}, number of grains $panicle^{-1}$ and thousand grain weight that highly influenced the yield of crop. The biostimulants Atonik affects every level of a plant's biological organization in terms of structure and function, canopy and whole plant, *via* particular organs and cells, to physiological and biochemical processes. Atonik stimulates generative rather than vegetative growth (Przybysz *et al.*, 2014).

Number of productive tillers and fertile grains are known as primary yield components, which play an important role in yield formation (Gevrek *et al.*, 2012). Tillers that produce panicle are called productive tillers. Number of tillers per plant has an indirect effect on yield, but it has a positive effect *via* number of panicles per plant (Adam and Jahan, 2011). In this regard, more number of effective tillers per plant was observed under foliar application of Atonik @ 450 ml/ha (Banful and Attivor, 2017). This was confirmed in the present study that the number of panicles m^{-2} was recorded maximum under Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1)

Table 1: Effect of plant growth regulators on growth attributes of rice.

Treatments	Plant height at harvest stage (cm)		Number of tillershill^{-1} at active tillering stage		LAI at flowering stage		DMP at harvest stage(kg ha^{-1})	
	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai
T_1	118.01	121.50	9.78	10.63	6.44	6.75	16713	17143
T_2	114.12	116.85	9.52	10.26	6.21	6.52	16094	16532
T_3	111.37	114.34	9.50	10.19	6.09	6.34	15921	16296
T_4	97.89	100.4	9.26	9.78	5.82	6.01	14879	15071
T_5	96.20	98.77	9.23	9.67	5.74	5.87	14677	14882
T_6	92.09	94.20	8.08	8.91	5.50	5.55	12856	13004
SEd	1.56	1.78	0.11	0.14	0.083	0.092	216.66	222.00
CD (P=0.05)	3.32	3.78	0.23	0.29	0.18	0.20	461.80	473.19

Table 2: Effect of plant growth regulators on yield attributes and yield of rice.

Treatments	Number of panicles m^{-2}		Number of grains $panicle^{-1}$		Thousand grain weight (g)		Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai
T_1	317.79	319.35	139.95	142.88	16.29	16.32	6996	7153	9501	9784
T_2	310.15	311.29	136.22	138.79	16.29	16.32	6761	6913	9220	9500
T_3	308.38	310.18	136.09	138.14	16.29	16.32	6709	6842	9100	9307
T_4	299.00	301.15	128.54	130.67	16.28	16.29	5908	6017	8828	8896
T_5	297.88	298.38	127.88	128.85	16.28	16.29	5813	5938	8707	8764
T_6	258.69	263.08	117.50	120.41	16.25	16.25	4595	4608	8070	8268
SEd	3.56	3.60	1.60	1.73	0.45	0.48	108.87	112.33	123.84	127.28
CD (P=0.05)	7.60	7.68	3.42	3.69	NS	NS	234.19	239.44	263.98	271.29

and it increased by 22.85% and 21.39% number of panicles m^{-2} over the control at maturity stage during Navarai and Kuruvai seasons. This was in synchrony with the findings of Zhang *et al*., (2016). The highest number of grains $panicle^{-1}$ was recorded in Atonik (Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1) and it caused 19.11% and 18.66% increased over control during Navarai and Kuruvai seasons. This finding consistent with Svobodova and Misa (2004), who reported that foliar application of Atonik, lowered the reduction of fertile florets, which in turn increased the number of grains per spike.

The weight of thousand grain depends on size and filling of grains. Also, 1000 grain weight is associated with the mobilization and translocation of assimilates from plant parts to developing grains (Adam and Jahan, 2011). Similar result was found by Djanaguiraman *et al*., (2009), who reported that nitrophenolate spray increased photoassimilates to partitioning between plant sinks by delaying leaf senescence. This was confirmed in the present study that application of Sodium Para - Nitrophenolate 0.3% SL increased the 1000 grain weight by effective translocation of assimilates to sinks.

Yield

Atonik increased the yield is a consequence of increased stimulation of generative rather than vegetative development (Kazda *et al.,* 2015). Positive influence of yield attributes of the crop reflected significant results in the yield of rice crop (Pal *et al.,* 2009). These findings are consistent with Svobodova and Misa (2004), Adam and Jahan (2011), Gevrek *et al*., (2012) and Banful and Attivor (2017), who also reported that more number of effective tillers and number of grains $panicle^{-1}$ are closely associated with high seed yield per plant resulted in higher productivity. This was close agreement with present study that application of Atonik increased the number of panicles m^{-2}, number of grains $panicle^{-1}$ and 1000 grain weight, which in turn increased the final yield. The maximum yield was obtained from Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1). It increased 52.25% and 55.23% in grain yield as compared to control during Navarai and Kuruvai seasons and the same treatment (T_1) caused increased grain yield per cent of 18.42 and 20.35 in Navarai and 18.88 and 20.46 in Kuruvai over Triacontanol 0.1% EW and Gibberellic acid 0.001% L, respectively.

Highest leaf area index increased the source sink relationship with increased photosynthates, that it reflected to grains hence more grain yield was recorded (Nirmal Kumar *et al.,* 2018). Increased biomass resulted in higher yield (Przybysz *et al.,* 2014). These findings were confirmed in the present study that Atonik increased the LAI, effective translocation of assimilates to sinks and DMP, which in turn increased the final yield. Atonik manipulated the content and activities of natural auxin and growth inhibitor, which resulted in increased yield (Abd Alla *et al.,* 2015). Similar result was reported by Djanaguiraman *et al*., (2005b). These were the reason behind the increased yield.

The maximum straw yield was recorded in Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T_1). It increased the straw yield per cent of 17.73 and 18.34 over the control in both the season and the same treatment (T_1) caused increased straw yield per cent of 7.62 and 9.13 in Navarai and 9.98 and 11.64 in Kuruvai over Triacontanol 0.1% EW and Gibberellic acid 0.001% L, respectively. This finding was in harmony with Svobodova and Misa (2004). Kumar *et al*. (2017), who also reported that straw yield was influenced by accumulation of dry matter.

Conclusion

The experiment result concluded that application of Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L increased the growth attributes, yield attributes and yield of rice Therefore this treatment was found to be agronomical superior, economically sustainable and ecologically viable practices for cultivation of rice. So this practice can be recommended to farming community

References

Abd Alla, M.A., N.H.M. El-Greadly and Y.T. Emam (2015). Effect of foliar spray with biostimulants on growth, head yield, phytohormones and nutrients of cabbage (*Brassica oleracea* var. Capitata). *Egypt. J. Hort*., **42(2):** 707-719.

Adam, A.M.M.G. and N. Jahan (2011). Effects of naphthalene acetic acid on yield attributes and yield of two varieties of rice *(Oryza sativa* L.). *Bangladesh J. Bot*., **40(1):** 97-100.

Ajith, K., V. Geethalakshmi, K.P. Ragunath, S. Pazhanivelen and S. Panneerselvam (2017). Rice acreage estimation in Thanjavur, Tamil Nadu using lands at OLIMAGES and GIS techniques. *Int. J. Curr. Microbiol. App. Sci*., **6(7):** 2327-2335.

Arysta Life Science Limited (2014). Atonik product information. www.arysta.hu.

Badshah, M.A., N. Tu, Y. Zou, M. Ibrahim and K. Wang (2014). Yield and tillering response of super hybrid rice liangyoupeijiu to tillage and establishment methods. *The Crop Journal*, **2:** 79-86.

Balamurugan, R., R. Babu, C. Swaminathan, K. Baskar and N.O. Gopal (2018). Performance of organic nutrition on physiological characters and yield of aerobic rice. *Int. J. Curr. Microbiol. App. Sci.*, **6:** 2936-2947.

Banful, B.K. and D. Attivor (2017). Growth and yield response of two hybrid rice cultivars to Atonik plant growth regulator in a Tropical environment. *Environment, Earth and Ecology*, **1(1):** 33-45.

Djanaguiraman, M., J. Annie Sheeba, D. Durga Devi and U. Bangarasamy (2009). Cotton leaf senescence can be delayed by nitrophenolate spray through enhanced antioxidant defense system. *J. Agronomy and Crop Science*, **195:** 213-224.

Djanaguiraman, M., J. Annie Sheeba, D. Durga Devi and U. Bangarusamy (2005a). Effect of Atonik seed treatment on seedling physiology of cotton and tomato. *J. Biol. Sci*., **5(1):** 163-169.

Djanaguiraman, M., J. Annie Sheeba, D. Durga Devi and U. Bangarusamy (2005b). Response of cotton and Atonik and TIBA for growth, enzymes and yield. *J. Biol. Sci*., **5(2):** 158-162.

Gevrek, M.N., G.D. Atasoy and A. Yigit (2012). Growth and yield response of rice (*Oryza sativa*)to different seed coating agents. *Int. J. Agric. Biol*., **14(5):** 826 – 830.

Haroun, S.A., W.M. Shukry, M.A. Abbas and A.M. Mowsafy (2011). Growth and physiological responses of *Solanum lycopersium* to atonik and benzyl adenine under vernalized conditions. *Journal of Ecology and the Natural Environment*, **3(9):** 319-331.

Kamble, E.R. (2015). Influence of plant growth regulators on physiological behavior of rice (*Oryza sativa* L.) in kharif season of konkan. M.Sc. (Ag.) Thesis, College of Agriculture, Dapoli.

Kazda, J., G. Herda, T. Spitzer, V. Ricarova, A. Przybysz and H. Gawronska (2015). Effect of nitrophenolates on pod damage caused by the brassica pod midge on the photosynthetic apparatus and yield of winter oil seed rape. *J. Pest. Sci*., **88:** 235-247.

Kumar, R., A. Singh, R.B. Yadav, A. Kumar, S. Kumar, U.P. Shahi and A.P. Singh (2017). Growth, development and yield response of rice (*Oryza sativa* L.) as influenced by efficient nitrogen management under subtropical climatic condition. *Journal of Pharmacognosy and Phytochemistry*, **SPL:** 791-797.

Madhukeshwara Puttappanavara, B. and V.K. Deshpande (2018). Effect of GA_3 with organic and in-organic supplements in KRH-4 hybrid rice seed production. *Int. J. Pure App. Bio. Sci*., **6(4):** 728-732.

Kumar, N., D.P. Rawat, A. Kumar and S.P. Kushwaha (2018). The response of different bio-regulators on growth and physiological traits of hybrid rice. *Journal of Pharmacognosy and Phytochemistry*, **7(4):** 257-260.

Pal, D., S. Mallick, R.K. Ghosh, P. Pal, L. Tzudir and K. Barui (2009). Efficacy of triacontanol on growth and yield of rice crop in inceptisol of west Bengal. *J. Crop and weed*, **5(2):** 128-130.

Pandey, N., S.K. Upadhyay and R.S. Tripathi (2001). Effect of plant growth regulators and fertility levels on growth and yield of transplanted rice. *Indian J. Agric. Res*., **35(3):** 205-207.

Przybysz, A., H. Gawronska and J. Gajc-Wolska (2014). Biological mode of action of a nitrophenolates - based biostimulant: case study. *Front. Plant Sci.*, **5(713):** 1-14.

Svobodova, I. and P. Misa (2004). Effect of drought stress on the formation of yield elements in spring barley and the potential of stress expression reduction by foliar application of fertilizers and growth stimulator. *Plant Soil Environ*., **50(10):** 439-446.

Szparaga, A., S. Kocira, A. Kocira, E. Czerwinska, M. Swieca, E. Lorencowicz, R. Kornas, M. Koszel and T. Oniszczuk (2018). Modification of growth, yield and the nutraceutical and antioxidative potential of soybean through the use of syntehtic biostimulants. *Front. Plant Sci.*, **9(1401):** 1-20.

Tiwari, D.K., P. Pandey, S.P. Giri and J.L. Dwivedi (2011). Effect of GA_3 and other plant growth regulators on hybrid rice seed production. *Asian J. Plant Sci*., **10(2):** 133-139.

Vasudevan, S.N., Basangouda, R.C. Mathad, S.R. Doddagoudar and N.M. Shakuntala (2014). Standardization of seedling characteristics for paddy transplanter. *Journal of Advanced Agricultural Technol.*, **1(2):** 141-146.

Zhang, J., S. Zhang, L. Chen and C. Wei (2016). Alleviation of seedling chlorosis by plant growth regulators in drip – irrigated rice. ACTA Agriculture Scandinavica, Section B – Solid and Plant Science: 1-7.

Zhang, Y., C. Yu, J. Lin, J. Liu, B. Liu, J. Wang, A. Huang, H. Li and T. Zhao (2017). OsMPH1 regulates plant height and improves grain yield in rice. *Plos One*,**12(7):** 1-17.