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EFFECT OF FOLIAR APPLICATION OF PLANT GROWTH REGULATOR ON YIELD, NUTRIENT UPTAKE AND NUTRIENT USE EFFICIENCY OF RICE

K. Suseendran*, M. Hari Priya, C. Kalaiyarasan, S. Jawahar and S.R. Vinod Kumar

Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar (Tamilnadu), India.

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, T1 - Sodium Para-Nitrophenolate 0.3 % SL @ 5 ml/L, T2 - Sodium Para-Nitrophenolate 0.3 % SL @ 10 ml/L, T3 - Sodium Para-Nitrophenolate 0.3 % SL @ 20 ml/L, T4 - Triacontanol 0.1 % EW @ 0.5 ml/L, T5 - Gibberellic acid 0.001 % L @ 0.36 ml/L, T6 - Control. The experiments were laid out in randomized block design with four replications. The results of the study evidently proved that foliar application of Sodium Para-Nitrophenolate 0.3 % SL @ 5 ml/L (T1) at 20-25, 45-50 and 65-70 days after transplanting recorded the highest yield attributes (number of panicles m^{-2}, number of grains panicle-1 and test weight), yield (grain and straw) and The highest N, P and K uptake, agronomic efficiency and apparent recovery efficiency was recorded in Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T1) during Navarai and *Kuruvai*seasons. The lowest nutrient uptake, agronomic efficiency and apparent recovery efficiency was recorded under T6 (control). The highest soil available N, P and K was recorded in T6 (control) during Navarai and *Kuruvai* seasons. The least available nutrient was recorded under Sodium Para Nitrophenolate 0.3% SL @ 5 ml/L (T1).

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 behavioral process in plant thus, the introduction of chemical plant growth regulator have added a new

***Author for correspondence :** E-mail : lenasusee@gmail.com

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. Vaiyapuri and Sriramachandrasekaran (2003) concluded that application of traicontanol 0.1 % registered higher uptake of nutrient (106.7, 29.0, 51.8 kg NPK/ha) over the control. Ammonia, amide nitrogen, amino nitrogen, total soluble nitrogen, total nitrogen was increased in tomato plants under the influence of vernalization in combination with Atonik @ 1000 ppm (Haroun *et al.,* 2011). El-Ekhtyar *et al.,* (2014) reported that application of gibberellic acid (GA3) and potassium significantly increased the nitrogen and phosphorous percentage of rice cultivars.

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-1the 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, T1 - Sodium Para-Nitrophenolate 0.3% SL @ 5 ml/L, T2 - Sodium Para-Nitrophenolate 0.3% SL @ 10 ml/L, T3 - Sodium Para-Nitrophenolate 0.3% SL @ 20 ml/L, T4 - Triacontanol 0.1% EW @ 0.5 ml/L, T5 - Gibberellic acid 0.001% L @ 0.36 ml/L, T6 -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 yield attributes and yield parameters nutrientuptake were recorded at respective stages.

Results and Discussion

Crop yield and yield attributes

The different plant growth regulators Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T1) 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 (T1) 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 (T1) 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

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. 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. 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 (T1). 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.

Effect of plant growth regulators on nutrient uptake (N, P, K) (kg.ha^{-1})

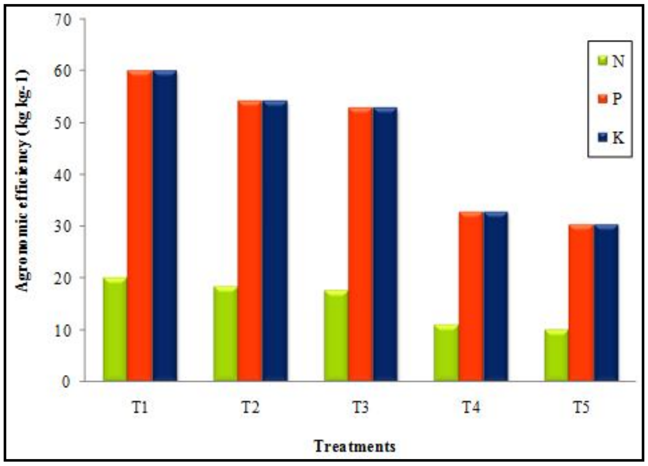
Among the various plant growth regulators, foliar application of Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T1) recorded the highest nutrient uptake of 156.57, 23.56 and 121.67 kg ha^{-1} N, P and K during Navarai and 160.37, 25.37 and 125.54 kg ha^{-1} N, P and K during *Kuruvai* seasons. It was significantly superior to rest of the treatments. Efficient uptake of mineral elements (NPK) by rice root was mediated by expression of transporters (genes) *viz.,* Nitrate transporter, Pi transporters and Potassium transporters (Sasaki *et al*., 2016). Basuchaudhuri (2016) reported that NAA influenced root activities effectively that created potential gradient for further nutrient uptake and the stimulatory effect of NAA (synthetic auxin) in absorbing nutrient increased the uptake of NPK (Islam and Jahan, 2016). The nutrient uptake decreased with increasing concentration of Sodium Para - Nitrophenolate 0.3% SL. However T2 (Sodium Para - Nitrophenolate 0.3% SL @ 10 ml/L) and T3 (Sodium Para - Nitrophenolate 0.3%

Table 1: Effect of Plant Growth Regulators on Yield Utes and Yield Of Rice.

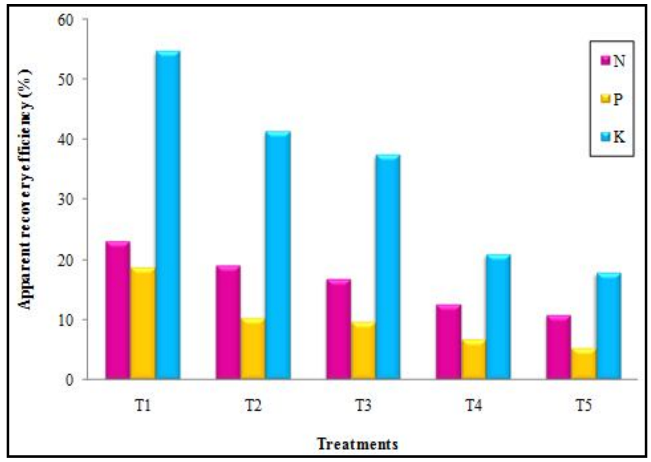
Treatments	Number of panicles m^{-2}		Number of grains panicle^{-1}		Thousand grain weight (g)		Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai	Navarai	Kuruvai
T_1	317.79	319.35	139.95	142.88	16.29	16.32	6996	7153	9501	9784
T_2	310.15	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

Table 2: Effect of plant growth regulators on N, P, K uptake (kg.ha-1) of rice during Navarai and Kuruvai seasons.

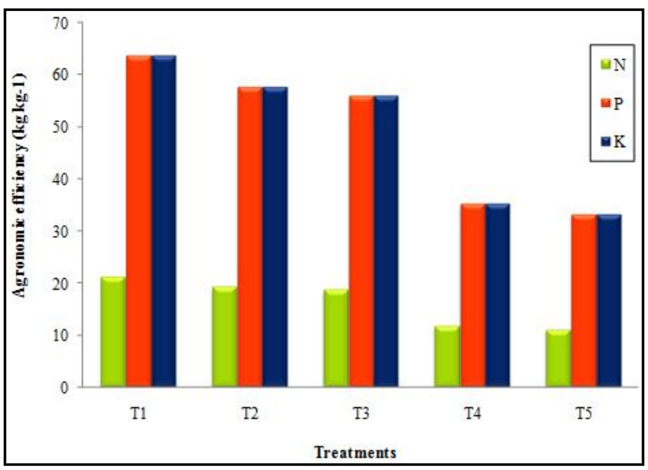
Treatments	Navarai			Kuruvai		
	N	P	K	N	P	K
T_1 - Sodium Para- Nitrophenolate 0.3% SL @ 5 ml/L	156.57	23.56	121.67	160.37	25.37	125.54
T_2 - Sodium Para- Nitrophenolate 0.3% SL @ 10 ml/L	151.76	20.16	116.32	154.02	23.61	120.50
T_3 - Sodium Para- Nitrophenolate 0.3% SL @ 20 ml/L	149.09	19.90	114.76	152.16	22.99	117.34
T_4 - Triacontanol 0.1% EW @ 0.5 ml/L	144.08	18.78	108.12	146.75	19.65	112.58
T_5 - Gibberellic acid 0.001% L @ 0.36 ml/L	141.93	18.21	106.90	143.14	19. 08	110.12
T_6 - Control	129.00	16.09	99.81	137.19	17.00	100.97
SEd	2.04	0.30	1.84	2.37	0.33	1.98
CD (P=0.05)	4.34	0.64	3.93	5.05	0.69	4.23



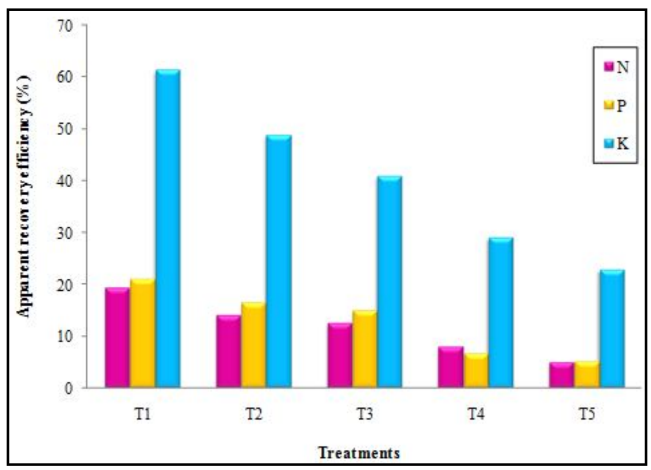
Effect of plant growth regulators on agronomic efficiency (kg kg-1) of rice during Navarai season.



Effect of plant growth regulators on apparent recovery efficiency (%) of rice during Navarai season.



19 Effect of plant growth regulators on agronomic efficiency (kg kg-1) of rice during Kuruvai season.



Effect of plant growth regulators on apparent recovery efficiency (%) of rice during Kuruvai season.

SL@20ml/L), T4 (Triacontanol 0.1% EW) and T5 (Gibberellic acid 0.001% L) were on par with each other in both seasons. The lowest nutrient uptake status was recorded in control treatment in (T6) in both seasons.

Effect of plant growth regulators on nutrient use efficiency

Among the various growth regulators, foliar application of Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L (T1) recorded the maximum agronomic efficiency of 20.01, 60.03 and 60.03, N, P and K kg kg-1 during Navarai and 21.21, 63.62 and 63.62 kg kg^{-1} N, P and K during Kuruvai seasons. It was superior to rest of the treatments. Islam and Jahan (2016) reported that increased in NUE by stimulatory effect of NAA. The minimum agronomic efficiency of 10.15, 30.45 and 30.45 N, P and K kg.kg^{-1} during Navarai and 11.08, 33.35 and 33.35 kg.kg^{-1} N, P and K during Kuruvai seasons were recorded in Gibberellic acid 0.001% L and the maximum apparent recovery efficiency of 22.98, 18.68 and 54.68% N, P and K during Navarai and 19.32, 20.93 and 61.42% N, P and K during Kuruvai seasons. Apparent Nutrient recovery can be described by difference in nutrient uptake (above ground biomass of crops) between the fertilized and unfertilized crop relative to the quantity of nutrient applied (Ramesh *et al*., 2017). The minimum Apparent recovery efficiency of 10.78, 5.30 and 17.75% N, P and K during Navarai and 4.96, 5.20 and 22.88% N, P and K during Kuruvai seasons were recorded in Gibberellic acid 0.001% L.

Conclusion

The experiment result concluded that application of Sodium Para - Nitrophenolate 0.3% SL @ 5 ml/L increased the yield attributes yield, nutrient uptake and nutrient use efficiency 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

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