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Influence of sodium para nitrophenolate 0.3% SL on growth and yield of rice in new Alluvial Zone (NAZ) of West Bengal

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ABSTRACT

Plants produce their own plant growth regulators (PGRs); however various studies have shown that plants may respond to exogenously applied growth hormones. Field experiments were conducted in rabi and kharif seasons of 2017-18 & 2018-19 at Kalyani D block Farm, Kalyani, Nadia under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal with total six (6) treatments; T_1: Sodium para-nitrophenolate 0.3% SL @5 ml L^{-1}, T_2: Sodium para-nitrophenolate 0.3% SL @10 ml L^{-1}, T_3: Sodium para-nitrophenolate 0.3% SL @20 ml L^{-1}, T_4: Triacontanol 0.1% EW @250 ml ha^{-1}, T_5: Gibberellic acid 0.001%L @180 ml ha^{-1} and T_6: Untreated control; to evaluate the bio-efficacy of Sodium para-nitrophenolate 0.3% SL (PGR) on boro and kharif rice at New Alluvial Zone (NAZ) of West Bengal. All the plant growth regulators (PGRs) were applied as foliar spray at three times in both the seasons i.e. 1st spray at 20-25 DAT, 2nd spray at 45-50 DAT and 3rd spray at 65-70 DAT. Results from the experiment revealed that the application of Sodium para-nitrophenolate 0.3% SL @2% a.i., i.e., 20 ml L^{-1} formulation significantly increased the growth attributes i.e. height of hill (cm) and number of effective tillers per sq.m., yield attributes i.e. length of panicle (cm), number of filled grains per panicle and 1000 seed wt. (g) and ultimately grain yield and straw yield (t ha^{-1}) of both boro and kharif rice in both the year while effect on days to maturity and days to 50% flowering of crop remain same instead of application of plant growth regulators.

***Keywords*:** Growth attributes, PGR, rice, yield, yield attributes.

Rice (*Oryza sativa* L.) is an important cereal grain crop worldwide, particularly in third world nations (Wang *et al.,* 2015). Rice is classified as a staple food since it provides a necessary calorie source for over half of the global total population (Bahuguna *et al.,* 2017). In year 2020-21, 509.7 million metric tonnes rice was produced globally, of which 124.4 million metric tonnes produced by India (USDA, 2022). Rice has an important role in India; it accounts for 46 per cent of the country's grain production and is a staple meal for two-thirds of the population (Goutam *et al.,* 2019).

The issue facing current agricultural production today is to meet the world's fast rising population's increasing need for food and plant-based resources. Rice demand is increasing substantially as the world's population grows, and many countries are confronting a second-generation problem of growing more rice at lower costs amid a harmful impact; as a result, providing nutritional and food security is a difficult undertaking (Tiwari *et al.,* 2011). Consequently, advanced technologies are necessary to close the gap in order to feed the growing population. As a result, yield-increasing agro-strategies such as the use of plant growth regulators (PGRs) must be properly considered. In agriculture, PGRs have been applied, but their influence has been minimal; however, a lack of PGR at any stage of the plant might make it difficult to achieve large grain yields (Pandey *et al.,* 2001).

Plant growth regulators (PGRs) are non-nutritive organic substances that alter physiological functions of the plant and are effective at extremely low concentrations in the plants (Gianfagna, 1987). They work within plant cells as well as contribute in crop development, production, and quality (Kariali and Mohapatra, 2007). They control the amount, direction and kind of plant growth, resulting in extraordinary improvements in plants growth and production in a variety of crops (Shah *et al.,* 2006; Emongor, 2007). According to Bari and Jones (2009), using PGRs can boost photosynthetic efficiency, increase rice seed-setting rate and postpone leaf senescence. Plants produce their own plant growth regulators (PGRs); however various studies have shown that plants may respond to exogenously applied growth hormones. Externally provided hormones can be stored by plants in the form of reversible conjugates, which release active hormones as per the plant needs it throughout the growing period (Tiwari *et al.,* 2011).

Nitrophenolates (NP) are phenolic substances that have a role in the metabolic processes of the plants e.g., they can promote development and growth, boost endogenous auxin levels, increase nutrient absorption by plant roots and promote antioxidant and photosynthetic activities of plants (Djanaguiraman *et al.,* 2010; Valero *et al.,* 2014). A good influence on seedling vegetative development, root, branch growth and shoot,

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reproductive growth (number of flowers and fruits), and biomass accumulation can be seen on application of Nitrophenolates based plant growth regulators (both dry matter and fresh weight) (Arysta life science, 2014). It is also been reported that nitrophenolate applications resulted increased yields of rice (Banful and Attivor, 2017; Suseendran *et al.,* 2020), cucumber (Mhaibes *et al.,* 2019; Ashvathama *et al.,* 2020), cotton (Bynum *et al.,* 2004; Oosterhuis and Brown, 2004; Townsend, 2004; Fernandez and Correa, 2005) and tomato (Djanaguiraman *et al.,* 2004).

The aim of the present study was to evaluate the bio-efficacy of Sodium para-nitrophenolate 0.3% SL (Plant Growth Regulator) on rice, grown in *rabi* and *kharif* seasons at New Alluvial Zone (NAZ) of West Bengal.

MATERIALS AND METHODS

The field experiments were conducted in *rabi* and *kharif* seasons of 2017-18 & 2018-19 in the sub-humid subtropical climatic condition of West Bengal at Kalyani D block Farm, Kalyani, Nadia under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The farm is situated at New Alluvial Zone (NAZ) of West Bengal situated at 22º58' N latitude and 88º3'E longitude with an altitude of 9.75m above mean sea (MSL). The land topographically is referred as medium land situation. The topography of land is known as medium land and the soil was sandy clay loam in texture having a pH of 7.6. Soil of this zone is mostly fertile, deep and almost neutral in reaction developed from recent alluvium of the river Ganges. The rice variety chosen for study was IET 4786 (Satabdi) for both the seasons with a duration of 111 days during *kharif* and 132 days during *rabi* (*boro* rice*)*. The experiments were laid out in randomized block design with four (4) replications. Plot size was 5 m × 5 m for each treatment with 20 cm row to row and 10 cm plant to plant spacing. There were total six (6) treatments; T_1: Sodium para-nitrophenolate 0.3% SL @5 ml L^{-1}, T_2: Sodium para-nitrophenolate 0.3% SL @10 ml L^{-1}, T_3: Sodium para-nitrophenolate 0.3% SL @20 ml L^{-1}, T_4: Triacontanol 0.1% EW @250 ml ha^{-1}, T_5: Gibberellic acid 0.001% L @180 ml ha^{-1} and T_6: Untreated control. The recommended dose of fertilizers for rice was 60:30:30 kg ha^{-1} N-P_2O_5-K_2O and 120:60:60 kg ha^{-1} N-P_2O_5-K_2O for *kharif* and *rabi* season, respectively. 25% N and full P_2O_5 and K_2O was applied as basal and incorporated with soil two days prior to transplanting and rest 50% and 25% was applied as top dressing at active tillering and panicle initiation stages, respectively. All the plant growth regulators (PGRs) were applied as foliar spray at three times in both the seasons *i.e.,* 1st spray at 20-25 DAT, 2nd spray at 45-50 DAT and 3rd spray at 65-70 DAT. During experiment ten hills were randomly selected from each treatment replication wise and tagged. Observations were recorded from the selected hills only. Observations recorded on the following parameters: height of hill (cm), panicle length (cm), number of effective tillers per m^2, number of filled grains per panicle, test wt. (g) (1000 seed wt.), days to maturity, days to 50% flowering, grain yield (t ha^{-1}) and straw yield (t ha^{-1}).

RESULTS AND DISCUSSION

From this experiment, it was found that number of effective tillers per m^2 and height of hills was significantly influenced by application of plant growth regulators over the un-treated control (T_6) whereas, days to maturity and days to 50% flowering was insignificant (Table 1). Rice plant height is a crucial agronomic factor that influences biomass accumulation and yield (Zhang *et al.,* 2017). The tallest plant height was observed from Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} (T_3) in both seasons (Fig. 1). At the time of harvesting, in T_3 treatment height of the hill was 73.6 cm and 123.8 cm in *boro* and *kharif* rice respectively which was 3.52 % and 8.79 % higher over the control. This finding is agreed with the results of Haroun *et al.* (2011), Kazda *et al.* (2015), Banful and Attivor (2017), Szparaga *et al.* (2018) and Suseendran *et al.* (2020). Nitrophenolates (NP) based PGRs are the phenolic compounds that have a role in several plant metabolic activities *e.g.,* they increase the endogenous auxins levels and boost growth and development of the plants (Djanaguiraman *et al.,* 2010). This was corroborated in the current investigation, which found that using Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} (T_3) resulted in the highest plant height, perhaps owing to an increase in endogenous auxin concentration. Auxin stimulated plant's growth and development by promoting cell division, cell expansion and cell elongation. Similar result was found by Djanaguiraman *et al.* (2005b).

Tillers number of rice is a major agronomic factor for panicle number per unit area as well as dry weight and rice grain yield (Badshah *et al.,* 2014). Effective tillers are those that generate panicle. Although number of effective tillers per plants has indirect impacts on yield, it has favorable impacts though number of panicles per plant (Adam and Jahan, 2011). The T_3 treatment also had the highest number of effective tillers per sq.m. which shows an increase of 22.6% and 35.7% higher effective tillers per sq. m over control (T_6) in case of *boro* and *kharif* rice, respectively (Table 2 & Fig. 2). The findings are close in agreement with Banful and Attivor (2017) and Suseendran *et al.* (2020). The number of tillers was significantly improved after foliar spraying with synthetic auxin (NAA) (Adam and Jahan, 2011). Djanaguiraman *et al.* (2005a) also observed a similar outcome, reporting

Table 1: Effect of different plant growth regulators on growth attributes of *boro* and *kharif* rice

Treatments	Pooled data							
	Height of hill (cm)		No. of effective tillers m^{-2}.		Days to 50% flowering		Days to maturity	
	Boro	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*
T_1	71.4	116.7	706.5	502.6	94	72	132	110
T_2	72.8	122.1	767.5	628.1	93	71	134	112
T_3	73.6	123.8	848.2	651.6	92	70	135	114
T_4	72.3	120.3	751.2	594.4	94	72	132	110
T_5	71.9	119.7	730.3	536.8	94	72	133	111
T_6	71.1	113.8	691.8	480.2	95	72	132	110
SEm (±)	0.5	1.3	14.1	7.3	0.02	0.06	0.03	0.04
LSD (0.05)	1.6	3.8	42.2	21.6	NS	NS	NS	NS

Note: *T_1: Sodium para-nitrophenolate 0.3% SL @5 ml L^{-1}, T_2: Sodium para-nitrophenolate 0.3% SL @10 ml L^{-1}, T_3: Sodium para-nitrophenolate 0.3% SL @20 ml L^{-1}, T_4: Triacontanol 0.1% EW @250 ml ha^{-1}, T_5: Gibberellic acid 0.001% L @180 ml ha^{-1} and T_6: Untreated control*

Table 2: Effect of different plant growth regulators on yield attributes and yield of *boro* and *kharif* rice

Treatments	Pooled data									
	Panicle length (cm)		No. of filled grains panicle^{-1}		Test wt. (g) (1000 seed wt.)		Grain Yield (t ha^{-1})		Straw Yield (t ha^{-1})	
	Boro	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*
T_1	22.4	22.3	102.2	69.8	22.6	20.1	4.90	3.75	5.64	4.62
T_2	23.9	23.7	116.8	78.4	22.7	20.3	5.39	4.36	6.18	5.10
T_3	24.5	24.6	129.4	81.2	22.9	20.4	6.21	4.52	7.06	5.21
T_4	23.5	23.4	110.6	74.6	22.7	20.2	5.26	4.12	6.03	5.01
T_5	22.8	22.6	105.4	72.5	22.6	20.1	5.08	3.99	5.88	4.85
T_6	22.1	22.2	100.4	66.2	22.5	19.8	4.78	3.60	5.55	4.53
SEm (±)	0.4	0.4	3.8	2.2	0.08	0.15	0.12	0.05	0.14	0.03
LSD (0.05)	1.2	1.1	11.4	6.5	NS	NS	0.34	0.15	0.40	0.10

Note: *T_1: Sodium para-nitrophenolate 0.3% SL @5 ml L^{-1}, T_2: Sodium para-nitrophenolate 0.3% SL @10 ml L^{-1}, T_3: Sodium para-nitrophenolate 0.3% SL @20 ml L^{-1}, T_4: Triacontanol 0.1% EW @250 ml ha^{-1}, T_5: Gibberellic acid 0.001% L @180 ml ha^{-1} and T_6: Untreated control*

that Atonik treatment boosted endogenous auxin content.

Different yield attributes and yield of both *boro* and *kharif* rice are significantly increased with the application of all the PGRs (Table 2). Yield attributes *i.e.,* the number of productive tillers and viable grains, are vital in the development of yields (Gevrek *et al.,* 2012). The biostimulants Atonik which is a Nitrophenolate based PGR, influences all the plant's biological acivities, from the canopy to the entire plant via specific cells and plant parts to biochemical and physiological mechanisms (Suseendran *et al.,* 2020). Rather than vegetative growth, Atonik promotes generative development (Przybysz *et al.,* 2014).

Maximum panicle length was achieved under the application of Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} (T_3) in both the seasons (Table 2). An increase of 10.9% and 10.8% higher panicle length was observed in T_3 treatment over control in *boro* and *kharif* rice, respectively (Fig. 3). This observation matched the findings of Zhang *et al.* (2016) and Suseendran *et al.* (2020). Highest number of filled grains panicle^{-1} also observed in T_3 treatment by application of Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} in case of both *boro* and *kharif* rice and it causes 28.9% and 22.7% increase over control (Fig. 4). This is similar with the results of Suseendran *et al.* (2020). These findings are agreeing with the statement of Svobodova and Misa (2004), that foliar application of Atonik (Nitrophenolate based PGR) reduced the loss of viable florets, enhancing the quantity of grains per spike.

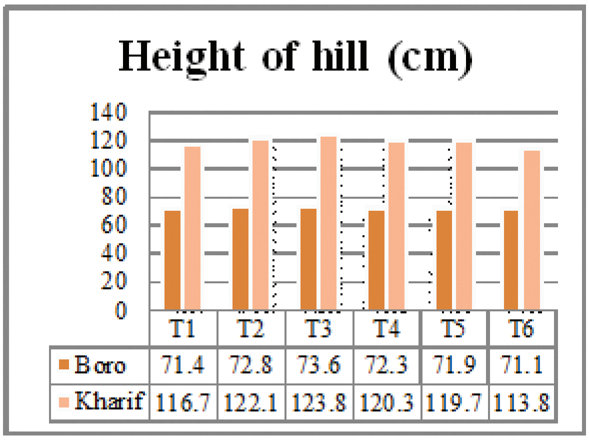

Fig. 1: Effect of treatments on height of hill

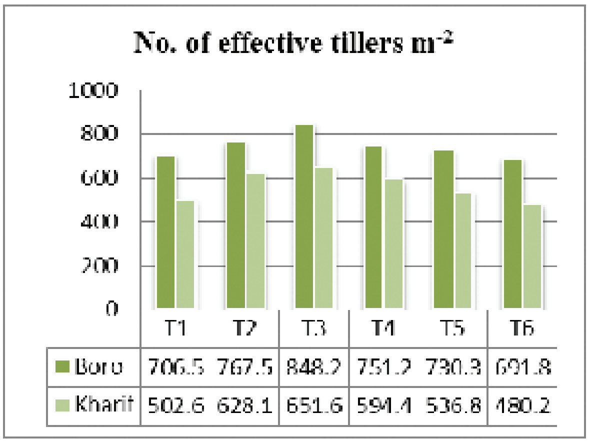

Fig. 2: Effect of treatments on no. of effective tillers m^{-2}

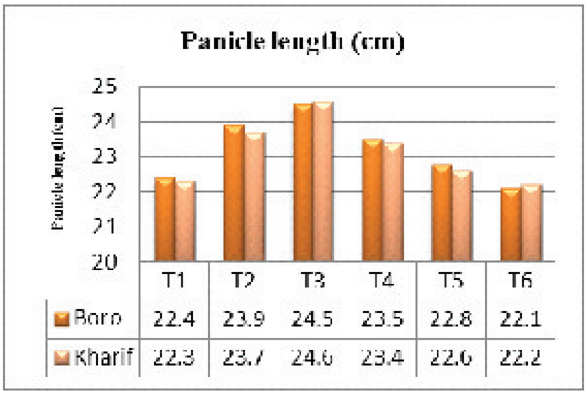

Fig. 3: Effect of treatments on panicle length

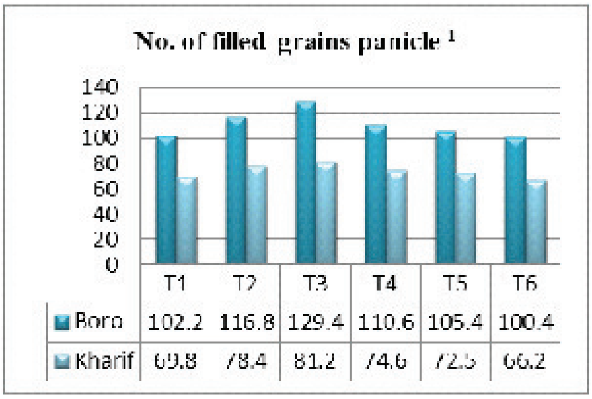

Fig. 4: Effect of treatments on no. of filled grains panicle^{-1}

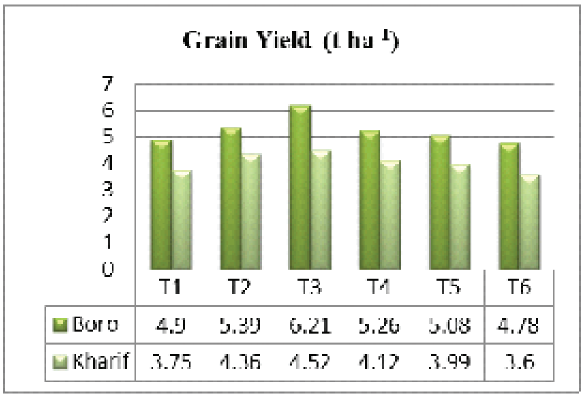

Fig. 5: Effect of treatments on grain yield

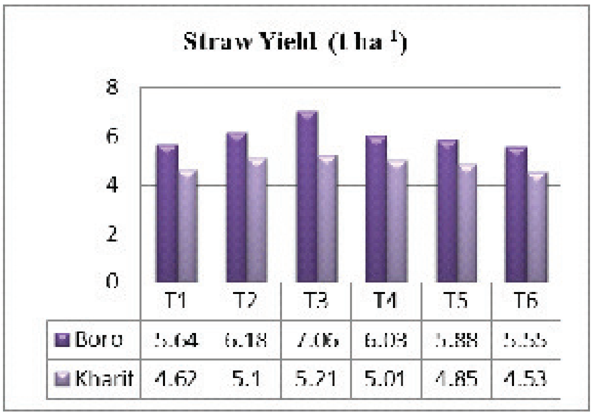

Fig. 6: Effect of treatments on straw yield

Compared to the control treatment, application of plant growth regulators, in general, resulted in an increase in test weight (g) of rice grains (Table 2). Although test weight does not increase significantly in the treated plots over control, application of 20 ml L^{-1} of Sodium para-nitrophenolate 0.3% SL recorded highest test weight *i.e.,* 22.9 g and 20.4 g in *rabi* and *kharif* seasons, respectively. The mobilization and transfer of photosynthate from plant components to growing grains is correlated to 1000 grain weight (Adam and Jahan, 2011). According to Djanaguiraman *et al.* (2009), nitrophenolate spray delayed leaf senescence, which boosted photo-assimilates to partitioning across plant sinks. As a result, the increased test weight observed in this investigation under the influence of Sodium para-nitrophenolate 0.3% SL might be related to efficient assimilates translocation to sinks.

Rice grain yield was significantly varied among the different treatments (Table 2). The positive impact of agricultural yield characteristics has a considerable impact on crop production of rice. 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 higher seed production per plant is usually related with more grains per panicle and effective tillers, resulting in increased rice production. These findings are in close agreement with this present experiment that the increase in no. of effective tillers m^{-2}, panicle length, no. of filled grains $panicle^{-1}$ and 1000 seed weight of rice influenced the final rice grain yield. The maximum yield was obtained from Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} (Fig. 5). Grain yield ranges from 4.78 t ha^{-1} in untreated control (T_6) to 6.21 t ha^{-1} in T_3 treatment in case of *boro* rice and 3.60 t ha^{-1} in control to 4.52 t ha^{-1} (T_3) with the application of Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} in *kharif* rice. The percentage increased in the *boro* rice grain yield was the lowest (2.51%) in T_1 while highest (29.92%) in T_3 over control treatment. The similar tendency was also observed in case of *kharif* rice, where lowest (4.17%) and highest (25.56%) grain yield was recorded in T_1 and T_3, respectively. The application of Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} (T_3) also caused increased grain yield per cent of 18.06 and 22.24 in *rabi* and 9.71 and 13.28 in *kharif* over Triacontanol 0.1% EW (T_4) and Gibberellic acid 0.001% L (T_5), respectively. These findings are in agreement with the results of Djanaguiraman *et al.* (2005b) and Suseendran *et al.* (2020).

Rice straw yield varied significantly among different treatments ranging between 5.55 t ha^{-1} (T_6) to 7.06 t ha^{-1} (T_3) and 4.53 t ha^{-1} (T_6) to 5.21 t ha^{-1} (T_3) in *boro* and *kharif* rice, respectively (Table 2). The maximum straw yield was recorded in Sodium para-nitrophenolate 0.3% SL @ 20 ml L^{-1} (T_3) in both seasons (Fig. 6). It increased the straw yield per cent of 27.21 and 15.01 over the control in *boro* and *kharif* season, respectively and the same treatment (T_3) caused increased straw yield per cent of 17.08 and 20.07 in *boro* rice and 3.99 and 7.42 in *kharif* rice over Triacontanol 0.1% EW (T_4) and Gibberellic acid 0.001% L (T_5), respectively. According to Kumar *et al.* (2017) dry matter accumulation affects the straw yield. Svobodova and Misa (2004) and Suseendran *et al.* (2020) found similar results.

Considering the results, recorded on growth and yield attributing parameters, panicle characters and yield data of the improved rice variety Satabdi (IET 4786) grown during *rabi* and *kharif* season, it can be concluded that significant increase in plant height and panicle length of *boro* and *kharif* rice were recorded due to application of Sodium para-nitrophenolate 0.3% SL @2% a.i., *i.e.,* 20 ml L^{-1} formulation. Significant increase in rice yield attributing parameters including grain yield and straw yield grown during *rabi* and *kharif* season were recorded due to application of the same formulation than other doses tested & other PGRs used. Thus, it may be concluded that Sodium para-nitrophenolate 0.3% SL @2% a.i., *i.e.,* 20 ml L^{-1} formulation applied three times during crop growing period *i.e.,* 1st spray at 20-25 DAT, 2nd spray at 45-50 DAT and 3rd spray at 65-70 DAT may be recommended for increasing growth and yield attributing parameters, panicle characters and yield of *boro* and *kharif* rice.

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