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Avick Kumar Kundu
Ph.D. Scholar,
Department of Agronomy,
Institute of Agricultural Science,
University of Calcutta, Ballygunge,
West Bengal, India

Pratistha Mitra
Ph.D. Scholar,
Department of Agronomy,
Institute of Agricultural Science,
University of Calcutta, Ballygunge,
West Bengal, India

Corresponding Author:
Avick Kumar Kundu
Ph.D. Scholar,
Department of Agronomy,
Institute of Agricultural Science,
University of Calcutta, Ballygunge,
West Bengal, India

Enhancing the productivity of indigenous aromatic Rice (*Kanakchur*) through the Application of Paclobutrazole and Chlormequat chloride in coastal saline zone of West Bengal

Avick Kumar Kundu and Pratistha Mitra

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Abstract

A field experiment was conducted to study the effects of different concentrations of paclobutrazol and chlormequat chloride on yield and yield attributes of *Kanakchur* rice during the *Kharif* (warm wet) season of 2023 at a farmers' field Sonarpur of South 24 Parganas district of West Bengal. The experiment comprised of 7 different foliar treatments, viz., water spray; chlormequat chloride 50% SL @ 0.15%, 0.20% and 0.25%; paclobutrazole 23% SC @ 0.01%, 0.02% and 0.03%. The foliar spray was done at 35 and 45 days after transplanting. The experiment was laid out in a randomized block design (RBD) with 3 replications. The results revealed that application of paclobutrazol 23% SC @ 0.01% at 35 DAT and 45 DAT proved to be the most effective in reducing plant height (129.6 cm), increasing effective tiller (362.16 m⁻¹), and ultimately boosting the grain yield (3.39 t ha⁻¹) of *Kanakchur* rice. The grain yield was statistically at par with the treatment comprising of chlormequat chloride 50% SL @ 0.15% was sprayed at 35 and 45 DAT. It is important to note that all the foliar nutrients enhanced grain yield of rice significantly over control. Since paclobutrazol is costly therefore the application of chlormequat chloride 50% SL @ 0.15% at 35 DAT and 45 DAT proved to be the most economically viable option due to its higher B: C ratio (1.34).

Keywords: Rice lodging, growth retardants, paclobutrazol, chlormequat chloride

Introduction

As global grain demand is set to double by 2050, the world faces a critical challenge substantially boosting rice production, the cornerstone of global food security. As a semi-aquatic annual grass from tropical Asia, rice sustains over 3.5 billion people globally, making it a cornerstone of global food security (CGIAR, 2022) [4]. Rice serves as a staple food grain for over 50% of the global population. India boasts the world's largest rice-growing area, with a staggering 46.38 million hectares under rice cultivation and as the second-largest producer globally, it yields a substantial 130.29 million tonnes (Yadav *et al.*, 2025) [19], though its average productivity remains at 2.81 tonnes per hectare (GOI, 2022) [7]. The greatest diversity of scented and non-scented rice is found in India, surpassed by China when it comes to rice outputs. While traditional rice varieties offer a wealth of bioactive chemicals, micronutrients, and pharmaceutical benefits, they are gaining renewed recognition for their captivating aromas, diverse colours, and natural pest resistance (Nandhini *et al.*, 2023) [9]. West Bengal is home to a rich diversity of indigenous aromatic rice varieties renowned for their exceptional grain quality, particularly their distinctive fragrance. This unique fragrance and flavour elevate its value above premium non-aromatic varieties, making it highly sought-after in the market (Yadav *et al.*, 2014) [20].

The primary cause of the decline in the heritage types of aromatic rice varieties was the Green Revolution (Deb, 2005) [5], but the demand still exists and is steadily rising in both domestic and foreign markets as well. One of the Indigenous rice varieties *Kanakchur* – known for its unique flavour and cultural significance, is popular in West Bengal, as it is used to make the famous “Jaynagarer Moa”, and is mostly grown in the parts of Sundarban Heritage Site of Coastal West Bengal, the native area of cultivation being Joynagr-Mojilpur and Gosaba (Adhikari *et al.*, 2011; Rohilla *et al.*, 2000) [1, 11]. But the cultivation comes at a price as it has been facing challenges

related to lodging, which leads to reduced yields.

Lodging, defined as the bending or breaking of rice plants due to environmental factors, such as wind or heavy rain, has a deleterious impact on crop productivity. Rice lodging will lengthen the time needed to reach maturity, thus lowering quality and production. The taller plants with long internodes have a significant impact on lodging. Stem lodging and root lodging are the two types of rice lodging (Shah *et al.*, 2017) ^[12], where the former is more common in transplanted rice. The development of mechanical tissue in basal internodes, plant type, and stem internode layout are all important elements in rice that affect the plant's ability to withstand stem lodging. Lodging has become a major problem in West Bengal due to heavy rain, cyclones, thunderstorms and other related events. Several growth regulators especially growth retardants play a significant role in mitigating crop lodging by influencing plant growth and development (Jones *et al.*, 2009) ^[8].

Plant growth retardants are used in rice to lower the plant's height by lodging. A growth retardant is a substance that physiologically regulates plant height by inhibiting cell proliferation and elongation in the shoot apex without adversely affecting overall plant development (Cathey, 1964) ^[3]. Growth retardants directly oppose the growth-promoting actions of gibberellins (Gas) and auxins, leading to reduced shoot elongation (Rademacher W, 2000) ^[10]. Tolbert (1960) ^[16] reported that the main goal for applying chlormequat chloride in plants was to avoid lodging. Paclobutrazol – a member of the triazole class of plant growth inhibitors, reduces oxidative damage by increasing antioxidant levels (Dong *et al.*, 2012) ^[6], also reducing plant height, improving chlorophyll stuffing, stimulating root growth, which provides the stem with strength against lodging (Sinniah *et al.*, 2012) ^[13]. The application of paclobutrazole at panicle initiation in rice reduces the plant height due to retardation of the culm and increased lodging resistance (Wahyuni *et al.*, 2002) ^[18]. Bashir *et al.*, 2010 ^[2] proposed that a foliar application of paclobutrazol during the tillering stage offers a chemical solution to mitigate lodging in cereal crops. In addition to preventing lodging, plant growth retardants optimize nutrient and photosynthate distribution, leading to higher rice productivity (Toungos, 2018) ^[17]. It is vitally important to enhance the productivity of *Kanakchur* rice through a novel approach, therefore the current study was undertaken to check the effect of paclobutrazole and chlormequat chloride on its growth, yield and yield contributing characters.

Materials and Methods

The field experiment was conducted during the *kharif* (warm wet) season of the year 2023 at farmers' field Sonarpur of South 24 Parganas district in West Bengal (22.4473° N, 88.3920° E). The site received an average of 163.38 mm of rainfall during the entire cropping period. The temperature reached a maximum of 33 degrees in July and the minimum temperature went down to 21 degrees in November during the crop-growing season. The soil texture of the field was mostly sandy loam to clay loam, with an acidic pH of 5.27, along with nitrogen, phosphorus and potassium content of 312.05 Kg ha⁻¹, 48.36 Kg ha⁻¹, 212.35 Kg ha⁻¹ respectively. The rice variety *Kanakchur* Heritage Rice was used which has an average productivity of 3-4 t ha⁻¹.

The experiment was laid out in an RBD (Randomized Block Design) with 7 treatments and 3 replications. The treatments used were T₁ – Control (water spray); T₂ – Spray of growth retardant chlormequat chloride 50% SL @ 0.15% at 38 DAT and 47 DAT; T₃ – Spray of chlormequat chloride 50% SL @ 0.20% at 38 DAT and 47 DAT; T₄ – Spray of chlormequat chloride 50% SL @ 0.25% at 38 DAT and 47 DAT; T₅ – Spray of growth retardant

paclobutrazol 23% SC @ 0.01% at 38 DAT and 47 DAT; T₆ – Spray paclobutrazol 23% SC @ 0.02% at 38 DAT and 47 DAT; T₇ – Spray paclobutrazol 23% SC @ 0.03% at 38 DAT and 47 DAT. The germinated rice seedlings were transplanted in the main field on 10th August 2023 with crop geometry of 23 cm (row-to-row spacing) and 23 cm (plant-to-plant spacing). Except for SSP 25 kg ha⁻¹, there was no application of additional chemical fertilizers. Suitable plant protection measures were adopted. Due to sufficient rains during the growth stages, artificial irrigation was avoided. The crops were harvested on 22nd November 2023. The growth parameters like plant height, number of tillers per plant and yield attributes like panicle length and weight were taken from the 5 tagged plants of rice. The grain, straw and biological yield were determined from the central 10m² of each plot, finally converting it to t ha⁻¹. The necessary procedures were followed and the required types of equipment were used for the lab analysis of various elements.

Results and Discussion

Plant Height

The results showed that foliar application of paclobutrazole and chlormequat chloride showed significant influence in reducing the plant height, where the lowest plant height was observed in the treatment T₅ (paclobutrazole 23% SC @ 0.01%) with a value of 129.60 cm at the time of harvest which is a reduction of 9.09% over control (T₁ – 142.56 cm). The treatment T₂ (chlormequat chloride 50% SL @ 0.15%) also significantly decreased the plant height to 130.66 cm compared to the control. The reduction in plant height was due to decreased internodal length (Sinniah *et al.*, 2012) ^[13]. The results of Spitzer *et al.*, 2016 ^[14] also confirm that compounds like paclobutrazole inhibit physiological functions and are responsible for controlling cell elongation, shoot and stem growth.

Yield and yield attributes

The maximum number of effective tillers and highest panicle length were observed in treatment T₅ (362.16 m⁻² and 26.17 cm respectively) for paclobutrazole and in T₂ (308.76 m⁻² and 26.17 cm respectively) for chlormequat chloride. The highest number of filled grains was observed in T₅ (103.67 panicle⁻¹) which was closely followed by T₂ (101.67 panicle⁻¹). This increase may be due to improved physiological processes due to restriction of excessive growth by the PGRs (Sinniah *et al.*, 2012) ^[13]. The highest 1000-grain weight was recorded in T₅ (19.63g) which was statistically at par with all the chlormequat chloride treatments T₂, T₃, and T₄. The highest average panicle weight of 3.21g was observed in T₂, maybe due to the efficient translocation of photosynthates from source to sink because the application of PGRs had reduced the length between source to sink.

The highest grain yield of 3.39 t ha⁻¹ and 3.34 t ha⁻¹ and the lowest straw yield of 5.43 t ha⁻¹ and 5.45 t ha⁻¹ was observed in T₅ (paclobutrazol 23% SC @ 0.01%) and T₂ (chlormequat chloride 50% SL @ 0.15%) respectively. The higher grain yield might be due to greater production of photosynthates, which is a result of growth regulation treatments at the early stages of the crop, and as Tang *et al.*, 2018 ^[15] stated that these photosynthates were later on partitioned to the reproductive parts since the growth retardants triggers the acid invertase and sucrose lyase activity in the grains, therefore accelerating the transport of photosynthates towards the grains. The lowest straw yield on the other hand might be primarily due to the effect of the growth retardant treatments inhibiting gibberellin production which reduces plant height thus producing less vegetative biomass.

The highest harvest index was observed in T₅ (38.44%) followed by T₂ (38.02%). The data are provided in Table below

Table 1: Effect of treatments on yield, yield attributes and economic returns of *Kanakchur* rice

Treatments	Effective tillers m ⁻²	Panicle length (cm)	Filled grains panicle ⁻¹	Test Weight (g)	Average Panicle weight (g)	Grain Yield (t ha ⁻¹)	Straw Yield (t ha ⁻¹)	Harvest Index (%)	Gross Returns (Rs ha ⁻¹)	Net Returns (Rs ha ⁻¹)	Benefit: Cost ratio
T ₁	245.80	23.57	86.33	16.17	1.86	2.88	6.31	31.33	161200	88397	1.21
T ₂	308.76	26.17	101.67	18.90	3.21	3.34	5.45	38.02	177550	101777	1.34
T ₃	283.62	25.00	93.67	18.80	2.31	3.10	5.68	35.30	167900	91137	1.19
T ₄	252.04	24.90	95.00	18.36	2.21	3.17	5.61	36.11	170700	92947	1.20
T ₅	362.16	26.20	103.67	19.63	2.46	3.39	5.43	38.44	179700	77263	0.75
T ₆	321.43	24.83	93.00	18.67	2.13	3.01	5.79	34.21	164400	73637	0.81
T ₇	340.34	24.50	91.00	18.30	1.93	2.95	5.85	33.54	162000	80217	0.98
SE(m)±	4.29	0.41	1.53	1.05	0.18	0.04	0.05				
CD at 5%	13.25	1.28	4.70	3.25	0.56	0.13	0.14				

Conclusion

The application of foliar growth retardants successfully controls lodging and increases the grain yield of *Kanakchur* rice. Treating the crop with 0.01% paclobutrazol 23% SC produces the most significant physical improvements, including a minimum plant height of 129.60 cm and a maximum grain yield of 3.39 t ha⁻¹. However, the high material cost of paclobutrazol leads to a poor benefit to cost ratio of 0.75, making it financially impractical. Alternatively, applying 0.15% chlormequat chloride 50% SL provides a statistically similar grain yield of 3.34 t ha⁻¹. This chlormequat chloride treatment delivers the highest benefit to cost ratio of 1.34, making it the most economically sound choice. It can be concluded that applying 0.15% chlormequat chloride at 35 and 45 days after transplanting gives farmers the optimal balance of crop physical stability and maximum financial return.

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