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Effect of Nitrobenzene 20% EW on the growth and yield of rice

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Abstract
A field experiment was conducted at Agriculture Research Station, Sakoli, Dist: Bhandara under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during the *Kharif* season in 2023 to study the performance of nitrobenzene 20% EW on growth and yield of rice. Five different concentrations of nitrobenzene 20% EW (1.5 mL T-1, 3.0 mL T-2, 4.5 mL T-3, 6.0 mL T-4 and T-5 water spray) as foliar spray were tested on rice variety PDKV Sadhana under irrigated condition. Application of nitrobenzene 20% EW at different concentrations with recommended fertilizers (RF) showed significant effect on rice growth and yield. Among all treatments, treatment T3 i.e. foliar application of nitrobenzene 20% EW@ 4.5 mL L-1 of water recorded significantly highest grain and straw yield along with growth and yield attributing characters of rice crop, which produced the superior results compared with other concentrations of nitrobenzene. Among the treatments, 4.5 milliliter of nitrobenzene per liter of water showed optimum levels to ensure the growth and yield performance of rice. However, since nitrobenzene is a new type of plant stimulant, detailed studies on its mode of action, interaction with other plant growth hormones and environmental effects are required to get an insight on rice response to nitrobenzene and its widespread application in rice cultivation.

Keywords: Rice growth, rice yield, foliar spray, economic benefit

Introduction
Rice (*Oryza sativa* L.) is the major food crop in the world. Nearly 40% of the world population consumes rice as the major staple food. Most of the people, who depend on rice as primary food, live in the less developed countries. Archeological evidence on rice in India dates back to 1500-1000 B.C. Since the dawn of civilization, rice has served humans as a life-giving cereal in the humid regions of Asia and to a lesser extent in West Africa (Dunna and Roy, 2013) [5]. The increasing demand for rice grain production has to be achieved by using an integration of organic and inorganic fertilizers to maintain the sustainability in crop production (Dutta and Chauhan, 2010) [6]. In India, farmers generally use more chemical fertilizers with little or no use of organic manures to meet the rice nutrient requirement and get more yield to satisfy the hunger of tremendously increasing population, which results in degraded soil health and decreased rice yield (Sarkar *et al.*, 2016) [15] after its continuous application. Farmers could not use sufficient organic manures as they are required in bulk amount and are less available. Also, total use of organic fertilizers to the soil degraded due to chemical fertilizers is also risky, as it may affect the rice yield. Therefore, to minimize the use chemical fertilizer as well as to increase rice yield and maintain soil health, an efficient and sustainable alternative is to use plant growth regulators. Plant growth regulators are widely used for their ability to increase crop growth and yield. Among the plant growth regulators, nitrobenzene found as effective in improving crop production in some studies (Aziz and Miah, 2009; Kohombange *et al*., 2017; Kohombange *et al*., 2019) [2, 10. 11].

Nitrobenzene is a combination of nitrogen and plant growth regulators, extracted from sea weeds that act as plant energizer, flowering stimulant and yield booster. Nitrobenzene 20% Liquid Formulation is designed to stimulate vigorous and robust stem development in plants. By fortifying the plant's structural integrity, it facilitates accelerated vegetative growth, resulting in luxuriant foliage and overall healthier plant development. Nitrobenzene is quickly absorbed into the plants and it influences the biochemical pathway of plants to uptake more nutrients from the soil. It also promotes vegetative growth and yield by increasing nutrient use efficiency, flowering and retention of flower and fruits (Deb *et al.*, 2012) [4]. The use of plant growth regulators like nitrobenzene 20% EW in ricein India is very limited. It is imperative to properly understand the effects of nitrobenzene 20% EW on rice growth and yield before its wide spread use in rice cultivation.

Therefore, study was conducted to evaluate the effect of nitrobenzene 20% EW on the growth and yield ofrice crop.

Materials and Methods

A field experiment was conducted at Agriculture Research Station, Sakoli, Dist: Bhandara, under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Eastern Vidarbha region of Maharashtra), India in *Kharif*, 2023 (Fig. 1). The experiment was laid out in randomized block design with five replications and five treatments viz., T1= RF + Nitrobenzene @ 1.5 mL, T2 = RF + Nitrobenzene @ 3.0 mL, T3 = RF + Nitrobenzene 4.5 mL, T4 = RF + Nitrobenzene 6.0 mL, and T5 = RF + water spray. In this study, the efficacy of Nitrobenzene (Nitrobenzene 20% EW obtained by thetrade name BOOM Flower was tested in five treatment combinations on rice cultivar PDKV Sadhana. Twenty-one days old 2-3 seedlings/hill of PDKV Sadhana were transplanted in plot size of 5 x 5 m with 20 cm × 15 cm spacing. All agronomic practices like ploughing, harrowing, puddling, fertilizer application was done as per recommendation given for the EVZ region of Maharashtra. The recommended rates of nitrogen (N), phosphorus (P), potassium (K), sulfur (S) and zinc (Zn) were applied. Nitrobenzene of different doses were sprayed five times on the rice plant during the growing period according to the spray schedule (Table 1).

Table 1: The spray schedule of Nitrobenzene

Sr. No.	Spray Schedule	Spray Time
1	First spray	Foliar application at 21.07.2023 (5 to 7 days before transplanting)
2	Second spray	Foliar application at 17.08.2023 (20 days after transplanting).
3	Third spray	Foliar application at 06.09.2023 (40 days after transplanting).
4	Fourth spray	Foliar application at 26.09.2023 (60 days after transplanting).

Number of Foliar Application-Four

Table 2: Treatment details

Sr. No.	Treatment	Concentration	Foliar Application
1	T1	Nitrobenzene 20% EW foliar Application @ 1.5 mL L-1 of water	1st :-Application at 5 to 7 days before transplanting.
			2nd :-Application at 20 days after transplanting.
			3rd :-Application at 40 days after transplanting.
			4th:-Application at 60 days after transplanting.
2	T2	Nitrobenzene 20% EW foliar Application @ 3.0 mL L-1 of water	1st:-Application at 5 to 7 days before transplanting.
			2nd:-Application at 20 days after transplanting.
			3rd:-Application at 40 days after transplanting.
			4th:-Application at 60 days after transplanting.
3	T3	Nitrobenzene 20% EW foliar Application @ 4.5 mL L-1 of water	1st:-Application at 5 to 7 days before transplanting.
			2nd:-Application at 20 days after transplanting.
			3rd:-Application at 40 days after transplanting.
			4th:-Application at 60 days after transplanting.
4.	T4	Nitrobenzene 20% EW foliar Application @ 6.0 mL L-1 of water	1st:-Application at 5 to 7 days before transplanting.
			2nd:-Application at 20 days after transplanting.
			3rd:-Application at 40 days after transplanting.
			4th:-Application at 60 days after transplanting.
5	T5	Untreated Control with water spray.	1st:-Application at 5 to 7 days before transplanting.
			2nd:-Application at 20 days after transplanting.
			3rd:-Application at 40 days after transplanting.
			4th:-Application at 60 days after transplanting.

*plus 100% recommended rate of NPK Fertilizer & other inputs

The quantity of nitrobenzene 20% EW Foliar application required for per plot was calculated on the basis of water per plot volume required quantity of water. Weeding, pesticide application and other necessary intercultural operations were done when required. At maturity, the crop was harvested from net plot and the grain yield was adjusted to 11 percent moisture content. For recording plant height (cm), number of tiller hill-1, panicle length (cm), filled grains and unfilled grains panicle-1, five plants were randomly selected and tagged from each net plot and observations were recorded. For recording number of days to 50% of flowering, the number of days taken after sowing (DOS) until 50% of plants in a plot had at least one open flower were recorded from each net plot. Total number of panicles per square meter, grain yield and straw yield (kg/ha) were counted from each net plot of all the treatments. For grain yield and straw yield (kg/ha) yield obtained after threshing and drying the produce from each net plot and weight was converted into kg ha-1. 1000 grains were counted and weight was recorded as per the treatments from representative samples. Harvest index (HI) was estimated based on grain and straw yields using the following formula: where, Biological yield = grain yield + straw yield.

The data related to rice crop growth and yield were subjected to analysis of variance (ANOVA) to determine the treatment effects. Least Significance Difference (LSD) at the 5% level of probability was used to separate the means for treatments effect. The data obtained from experiment on various parameters were statistically analyzed in MSTAT–C computer program (Russel, 1986) [14].

Fig 1: Field view of Experimental area

Sr. No.	Month	Rainfall (mm)	Days
1	May	-	-
2	June	266.50	6
3	July	407.50	17
4	August	152.00	10
5	September	259.50	17
6	October	17.50	1
7	November	12.50	1
8	December	9.50	2
Total		1125.50	54

Average Rainfall (mm): 1278.08 mm (53 Rainy Days)
Actual Rainfall During *Kharif* 2023: 1125.00 mm (54 Rainy Days)
Percent Rainfall Compare to Average Rainfall: 88.03%
Excess / Deficit Over Average Rainfall: 11.97% Deficit

Fig 2: Rainfall Data of study location during crop growing period

Results and Discussion

Effect of Nitrobenzene 20% EW on plant height(cm), No. of tillers/hill, Panicle Length (cm) and Number of days taken to panicle emergence

Plant Height (cm)

Perusal of the data presented in table 3 revealed that the plant height (cm) at harvest of rice influenced statistically during investigation period due to various treatments. Data indicated that the treatments T3 i.e. nitrobenzene 20% EW – foliar application @ 4.5 mL L-1 of water* recorded highest Plant height over rest of the treatments. Similar results were also obtained by Patil *et al.* (2011) [13] and reported that plant height is increased maximum by treatment nitrobenzene (20%). In contrast, the shortest plant was produced from treatments T4 i.e. nitrobenzene 20% EW – foliar application @ 6.0 mL L-1 of water*.

Number of tillers/hill

The yield contributing character viz., number of tillers hill-1 influenced significantly due to various treatments. Treatment T3 i.e. nitrobenzene 20% EW foliar application @ 4.5 mL L-1 of water* recorded significantly highest number of tillers (13) over remaining treatments. Whereas, the lowest number of tillers (10) were recorded from treatments T4 i.e. nitrobenzene 20% EW – foliar application @ 6.0 mL L-1 of water*. Aziz and Miah (2009) [2] reported that the application of flora (nitrobenzene) or chemical fertilizer either alone or in combination increased the tiller production.

Number of days taken to 50% flowering

Number of days taken to 50% flowering was affected due to various treatments. Treatments T5 i.e. untreated control with water spray recorded significantly earliest days for 50% flowering (84 Days) over rest of the treatments

Number of panicles/Square Meter

The yield contributing character viz., number of panicles sq. m-1 influenced significantly due to various treatments. Treatment T3 i.e. nitrobenzene 20% EW foliar application @ 4.5 mL L-1 of water* recorded significantly highest number of panicles (323) over control. Whereas, treatment T5-untreated control with water spray recorded significantly lowest number of panicles (301) over treatments. It may be due to increase in availability of nutrient by nitrobenzene, resulted better growth and yield attribute the similar results was also reported by Ganguly *et al.* (2019) [7] and Uraon P. et. al., (2023) [16].

Data indicated (table 3) that the treatments T3 i.e. nitrobenzene 20% EW – foliar application @ 4.5 mL L-1 of water* recorded highest plant height (cm) (118.40 cm), number of tillers hill-1 (13) and number of panicles sq.m-1 (323) at over rest of the treatments. Chowdhury B. *et al*., 2018

[3] also found that plant height, number of tillers per hill and number of spikelet increases with nitrobenzene spraying and spraying rates of nitrobenzene was significantly affected on morpho-physiological and yield attributes characters, which produced the superior result compare with other rates of nitrobenzene.

Effect of Nitrobenzene 20% EWON yield attribute Characters of rice

Length of panicle (cm)

The yield attributing character of rice crop influenced significantly due to foliar application of nitrobenzene 20% EW (Table-4). Treatment T3 i.e. foliar application of nitrobenzene 20% EW@ 4.5 mL L-1 of water* recorded significantly highest length of panicle (24.50 cm) followed by treatment T2 (23.9 cm) which are significantly superior over rest of treatments. While, lowest length of panicle (23.00 cm) was recorded by treatment T4 i.e. Foliar application of nitrobenzene 20% EW@ 6.0 mL L-1 of water* over other treatments

Number of filled grain/panicle

The Number of grains panicle of paddy crop was also affected due to various treatments. Treatments T3-Foliar application of nitrobenzene 20% EW@ 4.5 mL L-1 of water recorded significantly highest number of filled grains panicle-1 (152.16) over rest of the treatments. While, lowest number of filled grains panicle-1 (123.08) was recorded by treatment T4 i.e. foliar application of nitrobenzene 20% EW@ 6.0 mL L-1 of water* over other treatments.

Number of unfilled grain/panicle

The number of unfilled grains panicle of paddy crop was also affected due to various treatments. Treatments T3-Foliar application of nitrobenzene 20% EW@ 4.5 mL L-1 of water recorded significantly lowest number of unfilled grains panicle-1 (14.20) over rest of the treatments. Whereas, highest number of unfilled grains panicle-1 (23.80) was recorded by treatment T4 i.e. Foliar application of nitrobenzene 20% EW @ 6.0 mL L-1 of water* over other treatments.

Treatment T3 i.e. Foliar application of nitrobenzene 20% EW@ 4.5 mL L-1 of water* recorded significantly highest length of panicle (24.50 cm), number of filled grains panicle-1 (152.16) and significantly lowest number of unfilled grains panicle-1 (14.20) over rest of the treatments followed by treatment T2 which are significantly superior over rest of treatments. Panicle length and filled grain were significantly higher with nitrobenzene sprayed at 4.5 mL T-3, which indicates that nitrobenzene might have positive effect on rice flowering and grain filling. The application of nitrobenzene and its immediate transport to the auxiliary buds would have resulted in a better sink for the quick mobilization of photo-assimilates. The increased number of filled grain might be influenced by triggering of such metabolic processes and the increased accumulation of carbohydrates into the rice grain which resulted in reduced grain sterility, similar results were verified by Jahan A. *et al*., 2022 [9].

Our study shows that, Treatment T3 i.e. Foliar application of nitrobenzene 20% EW @ 4.5 mL L-1 of water* recorded significantly highest plant height, number of tillers hill-1, length of panicle, number of filled grains panicle-1 and significantly lowest number of unfilled grains panicle-1 (14.20) over rest of the treatments, whereas treatment T4 i.e. foliar application of nitrobenzene 20% EW @ 6.0 mL L-1 of water* recorded significantly lowest plant height, number of tillers hill-1, length of panicle, No. of filled grains panicle-1 and significantly highest number of unfilled grains panicle-1 (14.20) over rest of the treatments, which indicates that application of nitrobenzene 20% EW at concentration above 4.5 mL L-1 of water showed no significant effect on the growth and yield of rice plants, similar to the results of Jahan A. *et al*., 2022 [9]. Guo *et al*., 2010 [8] found that in solution culture the growth of soyabean seedlings increased at low concentration of 5 mg L-1 and after 10 mg L-1 showed genotoxic effects. Moreover, higher concentrations of nitrobenzene in water bodies are hazardous to aquatic organism and plants by irrigation (Guo *et al*., 2010) [8].

Foliar application of nitrobenzene elongated the plant cell and enlarges the panicle which ultimately confirms the greater yield. Similar result was also obtained by Kumar and Son's (2011) [12] who found that the application of nitrobenzene ("Flora") increase the number of fruits plant–1 is about 20–30%.

1000gram weight (g)

Foliar application of nitrobenzene 20% EW@ 3.0 mL L-1 of water recorded highest 1000 grain weight (26.54 g) followed by treatment T3 (26.34 g). However, these treatments found at par with each other and significantly Superior over Control. However, Aziz and Miah (2009) [2] reported that the application of flora (nitrobenzene) or chemical fertilizer either alone or in combination increased the 1000–grain weight

Effect of Nitrobenzene 20% EW on grain and straw yield of rice

Data Presented in Table 5 about grain and straw yield kg/ha revealed that treatments T3 i.e. foliar application of nitrobenzene 20% EW @ 4.5 mL L-1 of water recorded significantly highest grain and straw yield (5435 and 6294 kg ha-1) over rest of the treatments. Increased grain and straw yield of paddy var PDKV Sadhana with nitrobenezene sprayed at a concentration of 4.5 ML (T3) was attributed to higher number of tillers, panicles and filled grains with this treatment, similar to the results of Jahan A. *et al*., 2022 [9], Deb *et al*., 2012 and Kohombange *et al*., 2019 [4, 11]. In spite that, treatments T5 i.e. i.e. untreated control with water spray recorded significantly lowest grain and straw yield (4891 and 5563 kg/ha) over rest of the treatments similar to the results of Chowdhury B. *et al*., 2018 and Uraon P. *et al*., 2023 [3, 16].

Treatment T1, T2, T3 and T4 recorded Percent increase in grain yield over control were 5.46% 7.68%, 11.12% and 4.05% respectively for 1.5 ml, 3.0 ml, 4.5 ml and 6.0 ml doses during experimentation.

Table 3: Effect of Nitrobenzene 20% EW on plant height (cm), No. of tillers hill-1, Panicle length (cm) and Number of days taken to panicle emergence

Treatment	Plant height (cm)	Number. of tillers hill-1	Number of days taken to 50% flowering	Number of Panicles Sq.M-1
T_1-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 1.5 mL L-1 of water*	113.68	11	85	313
T_2-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 3.0 mL L-1 of water*	115.68	12	86	317
T_3-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 4.5 mL L-1 of water*	118.40	13	86	323
T_4-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 6.0 mL L-1 of water*	113.38	10	86	307
T_5-Untreated control with water spray.	114.28	12	84	301
SEM	0.19	0.18	0.18	2.12
C.D.at 5%	0.57	0.55	0.54	6.35
G.M.	115.08	11.54	85.44	312.32

Table 4: Effect of Nitrobenzene 20% EW on yield attribute characters of rice

Treatment	Panicle Length (cm)	Number. of filled grains panicle-1	Number. of unfilled grains panicle-1	1000 grain weight (g)
T_1-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 1.5 mL L-1 of water*	23.8	137.40	18.00	25.67
T_2-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 3.0 mL L-1 of water*	23.9	148.80	16.20	26.54
T_3-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 4.5 mL L-1 of water*	24.5	152.16	14.20	26.34
T_4-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 6.0 mL L-1 of water*	23.0	123.08	23.80	24.80
T_5-Untreated control with water spray.	23.6	135.92	17.72	25.32
SEM	0.12	1.84	0.46	0.16
C.D.at 5%	0.35	5.51	1.39	0.48
G.M.	23.77	139.47	17.98	25.74

Table 5: Effect of Nitrobenzene 20% EW on grain and straw yield of rice

Treatment	Grain yield (kg/ha)	Percent increase in grain yield over Control	Straw Yield (kg ha-1)
T_1-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 1.5 mL L-1 of water*	5158	5.46	6057
T_2-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 3.0 mL L-1 of water*	5267	7.68	6097
T_3-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 4.5 mL L-1 of water*	5435	11.12	6294
T_4-Boom Flower 20 EW (Nitrobenzene 20% EW) foliar application @ 6.0 mL L-1 of water*	5089	4.05	5810
T_5-Untreated control with water spray.	4891		5563
SEM	52.17		57.29
C.D.at 5%	156.41		171.75
G.M.	5168		5964.43

Conclusion

Field experiment conducted during *kharif* 2023 at Agriculture Research Station, Sakoli Dist. Bhandara under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra), India for bio-efficacy testing of nitrobenzene 20% EW foliar application on rice crop. Treatment T3 i.e. foliar application of nitrobenzene 20% EW @ 4.5 mL L-1 of water recorded significantly highest grainand straw yield similarly growth and yield attributing character of rice crop, which produced the superior result compared with other concentrations of nitrobenzene. Among the treatments, 4.5 milliliter of nitrobenzene per liter of water showed optimum levels to ensure the growth and yield performance of rice.

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