Journal of Advances in Biology & Biotechnology

Volume 27, Issue 11, Page 286-294, 2024; Article no.JABB.126278
ISSN: 2394-1081

Studies on the Efficacy of AGMA-Foliar (Kazuki Gold/Yoshi Gold) for Growth Development and Yield of Paddy (*Oryza sativa*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i111612

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126278

Original Research Article

Received: 28/08/2024
Accepted: 30/10/2024
Published: 04/11/2024

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***Cite as:** Karak, S., K. Maity, D. Sarkar, K. Sharma, and U. Thapa. 2024. "Studies on the Efficacy of AGMA-Foliar (Kazuki Gold/Yoshi Gold) for Growth Development and Yield of Paddy (Oryza Sativa)". Journal of Advances in Biology & Biotechnology 27 (11):286-94. https://doi.org/10.9734/jabb/2024/v27i111612.*

ABSTRACT

Rice (*Oryza sativa L.*) is a principal staple food, with significant production worldwide. In 2021, rice covered 161.77 million hectares globally, with India as the second-largest producer. For sustained output, rice (*Oryza sativa L.),* a major crop around the world, needs balanced fertilization. Overuse of fertilizers degrades the soil, requiring the use of bio stimulants as an alternative. This study evaluates AGMA Foliar (Kazuki Gold/Yoshi Gold) and AGMA Energy on rice cultivar IET 4786 (Satabdi) during the kharif season of 2021-22 at C-block farm, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, Nadia, and West Bengal. A randomized block design with seven treatments and three replications was used. Treatments included AGMA Kazuki Gold and Kazuki Energy applied at various stages. AGMA treatments significantly enhanced plant height, dry matter, grain count, and yield. Results indicated that T3 treatment (Kazuki Gold applied twice at 25-30 and 40-45 DAT) achieved the highest plant height (93.00 cm), dry matter (983.66 g m^{-2}), grain count (180.05 grains $panicle^{-1}$), and grain yield (5.26 t ha^{-1}), with statistical significance confirmed by F-tests at 5% level. T6 treatment (AGMA Foliar (Kazuki Energy) showed comparable results. Chlorophyll content was also highest in T3. Control plots consistently showed the lowest values. The study emphasizes the effectiveness of AGMA Foliar bio stimulant applications, which significantly improve rice growth, yield, and nutrient efficiency. It highlights their potential as sustainable agricultural inputs and suggests optimal application stages for maximizing benefits.

Keywords: Rice; physio-activator; bio stimulant; chlorophyll content.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the principal staple food grain, accounting for over half of the world's production and extensively cultivated worldwide (Muthayya *et.al.,*2014). In 2021, it was grown on 161.77 million hectares globally, producing 749.19 million metric tons. India ranks second in rice production (122.3 MMT), following China (209.61 MMT). West Bengal ranks first in area and production in the country. About 78% of total area under rice in the State is concentrated under high and medium productivity groups, which accounts for nearly 84% of total production of rice in the State and average productivity of the State is 2,259 kg/ha. (www.drdpat.bih.nic.in).

In India, rice cultivation covers 45.07 million hectares, yielding 122.27 million tons with an average productivity of 2713 kg ha^{-1} (by www.fao.org/markets-and-trade/commodities/ rice/en in). However, the indiscriminate use of fertilizers has led to imbalanced soil nutrient use, gradually decreasing soil productivity. Balanced fertilizer use is essential for sustaining rice production (Chettri *et.al*. 2005. Singh, V.K., 2017 and Ramteke *et.al.,* 2023).

AGMA Biostimulant Foliar products modulate the physiological and molecular processes of plants, promoting growth, increasing production, and reducing abiotic stress impacts such as salinity, heavy metals, heat, nutritional stress, and water stress (Chatterjee *et.al.,* 2023 and Rahaman *et.al*;.2024). They stimulate carbon and nitrogen metabolism, regulate N uptake through enzymes involved in the N assimilation process, and modulate the activity of enzymes in the tricarboxylic acid cycle (Van Oosten *et al.,* 2017). The bioactive peptides in these products may also affect hormonal functions, with studies showing that PHs derived commercial products induce hormone-like activities (auxin and gibberellins), enhancing shoot growth and crop productivity (Colla *et.al.,* 2017 and Martín *et. al.,*2022). Additionally, PHs have indirect effects on plant nutrition and growth by increasing the efficiency of macro and micronutrient absorption and utilization through foliar treatments (Colla *et.al*., 2017; Martín *et. al.,*2022 and Kundu *et.al.* 2023).

To address these challenges, an experiment was conducted to standardize the efficacy of Kazuki Gold and Kazuki Energy. The objectives were to standardize AGMA-Foliar's effectiveness for rice growth and yield and to determine the optimal application stage of AGMA-Foliar in rice cultivation.

2. MATERIALS AND METHODS

The field experiment was conducted at C-block farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, and West Bengal. The experiment was done during the kharif season of 2022. The laboratory work was carried out at the "Department of Vegetable Science" and the

"Quality Control Laboratory", Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia. The experimental site is located at 22.89º N latitudes and 88.45º E longitudes at 9.75m AMSL. The "C" block farm is situated in a warm sub-tropical humid. The experimental field is located in the New Alluvial Plains of West Bengal. The soil was sandy loam with a slightly acidic nature. The experimental site had assured irrigation facilities. The trial was laid out in a randomized block design with seven treatments, each replicated three times with 3.0 × 3.0 m^2 plot size and spacing 15×20cm.

The rice cultivar IET 4786 (*Satabdi*) was under investigation. A full Recommended Dose of Fertilizers (RDF) was applied (120 kg N, 60 kg P_2O_5, 60 kg K_2O ha^{-1}). Phosphate, potash, and half the nitrogen were applied basally; the remaining nitrogen was top-dressed at 25 days after transplanting (DAT). All recommended agronomic practices and plant protection measures were adopted for rice crop production. Growth-attributing characters and yield parameters were observed in five randomly selected and tagged plants from each plot, which were monitored up to harvesting. 31-day-old seedlings were transplanted with care at a 20 cm x 15 cm spacing, placing 3-4 seedlings per hill at a depth of 2-3 cm. The F-test was computed to determine the significance of treatment impacts on the rice crop. Standard deviation and critical differences of various treatments were computed at the 5% level of significance to assess the authenticity of each respective treatment.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The plant height of rice was recorded at 30, 60, and 100 days after transplanting (DAT) under different treatments, showing significant variation that are presented in Table 1 and Fig. 1. At 30 DAT, plant height ranged from 33.35 to 41.42 cm, with a variation of 24.19%. The highest plant height of 41.42 cm was observed in the T3 treatment (AGMA Kazuki Gold applied at 30-35 DAT and pre-panicle initiation stage), followed by the T6 treatment (AGMA Foliar Kazuki Energy applied similarly), both statistically similar. The control plot had the lowest height of 33.35 cm.

At 60 DAT, plant height ranged from 72.20 to 80.99 cm, with a variation of 12.17%. Again, the T3 treatment recorded the maximum height of 80.99 cm, followed by T6, both statistically comparable.

At 100 DAT, no significant difference in plant height was observed among treatments. The T3 treatment still showed the maximum height of 93.00 cm, followed by T6, while the control plants had the lowest height of 82.27 cm. Treatments were statistically non-significant at this stage. Similar type result founded by Jha et al., 2024 and Kantwa *et al*., 2019.

Dry matter production: The dry matter production of transplanted kharif rice at 30, 60, and 100 days after transplanting (DAT) was significantly influenced by different treatments, as shown in Table 1 and Fig. 2. Regardless of the observation date, dry matter accumulation per plant increased with crop age, peaking at harvest.

At 30 DAT, treatment T3 had the highest dry matter production at 58.41 g m^{-2}, followed by T6, with a range of 45.90 to 58.41 g m^{-2} across treatments (Arun *et al*., 2019).

List 1. The treatment factors included the following treatments

Treatments	Products (Biostimulant)	Dose/acre	No. of application	Time of Application
T1	AGMA Foliar (Kazuki Gold/Yoshi Gold)	500 ml	1	25-30 DAT
T2	AGMA Foliar (Kazuki Gold/Yoshi Gold)	500 ml	1	40-45 DAT
T3	AGMA Foliar (Kazuki Gold/Yoshi Gold)	500 ml	2	1^{st} application: 25-30 DAT 2^{nd} application: 40-45 DAT
T4	AGMA Foliar (Kazuki Energy)	500 ml	1	25-30 DAT
T5	AGMA Foliar (Kazuki Energy)	500 ml	1	40-45 DAT
T6	AGMA Foliar (Kazuki Energy)	500 ml	2	1^{st} application: 25-30DAT 2^{nd} application: 40-45 DAT
T7	Control (water only)		2	1^{st} application: 25-30DAT 2^{nd} application: 40-45 DAT

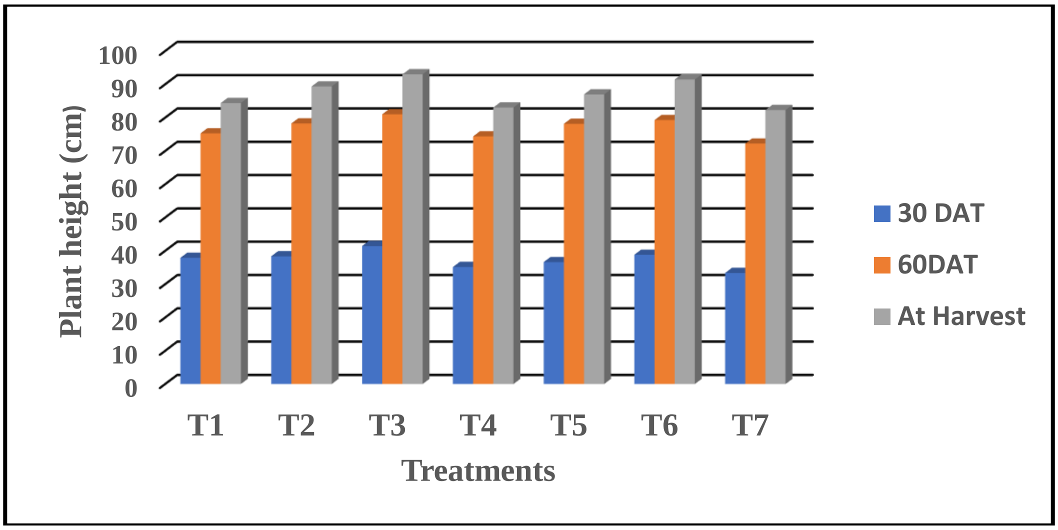

Fig. 1. Effect of AGMA foliar (Kazuki Gold / Yoshi Gold & Kazuki Energy) on Plant height (cm)

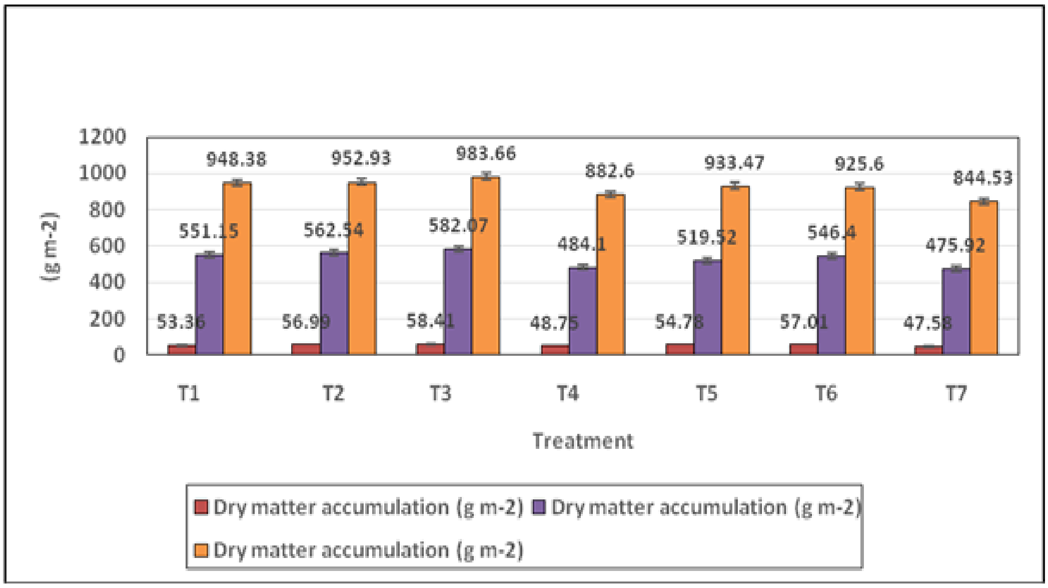

Fig. 2. Effect of AGMA foliar (Kazuki Gold / Yoshi Gold & Kazuki Energy) on Dry matter accumulation (g m^{-2}).

Table 1. Effect of AGMA FOLIAR (Kazuki Gold/Yoshi Gold &Kazuki Energy) on Plant height and on Dry matter accumulation (gm^{-2}) of rice

Treatment	Plant height (cm)			Dry matter accumulation (g m^{-2})		
	30 DAT	60DAT	At Harvest	30 DAT	60DAT	100DAT
T1	37.90	75.27	84.36	53.36	551.15	948.38
T2	38.36	78.24	89.36	56.99	562.54	952.93
T3	41.42	80.99	93.00	58.41	582.07	983.66
T4	35.14	74.36	83.02	48.75	484.10	882.60
T5	36.61	78.13	86.96	54.78	519.52	933.47
T6	38.81	79.26	91.44	57.01	546.40	925.60
T7	33.35	72.20	82.27	47.58	475.92	844.53
SEm (±)	0.638	0.792	NS	0.827	3.750	1.141
CD at 5%	1.935	2.403	NS	2.508	11.372	3.459

At 60 DAT, foliar application of AGMA significantly influenced total dry matter accumulation. T3 recorded the highest production at 582.07 g m^{-2}, followed by T at 562.54 g m^{-2}, while the control had the lowest at 475.92 g m^{-2}, significantly differing from other treatments.

At harvest (100 DAT), T3 again showed the maximum dry matter accumulation at 983.66 g m^{-2}, followed by T6 at 952.93 g m^{-2}. The control had the lowest dry matter production at 844.53 g m^{-2}.

Total number of grains panicle^{-1}: The most important yield component of rice in terms of total number of grains panicle^{-1} was found statistically significant as influenced by different AGMA foliar application at different stage of application. (Table 2 and Fig. 4). It has been observed that the total number of grains panicle^{-1} was to tune of 126.86 to 180.05 among the treatments. The maximum number of total number of grains panicle^{-1} was recorded at T3 (180.05) followed by treatment T6 (170.86) which were statistically at par. The lowest number of total number of grains panicle^{-1}was observed in the control treatment (126.86).

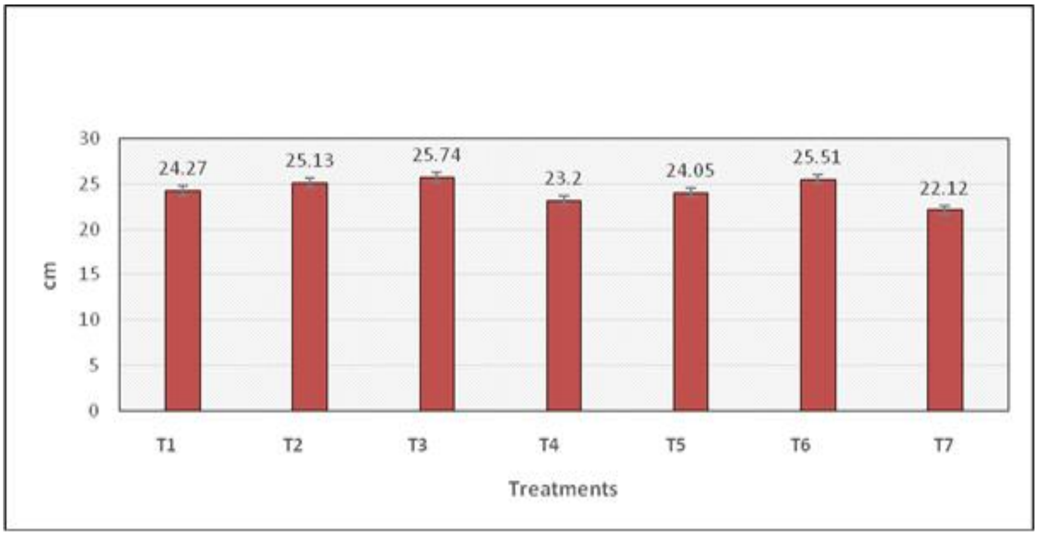

Fig. 3. Effect of AGMA foliar (kazuki Gold / Yoshi Gold & Kazuki Energy) on Panicle length (cm)

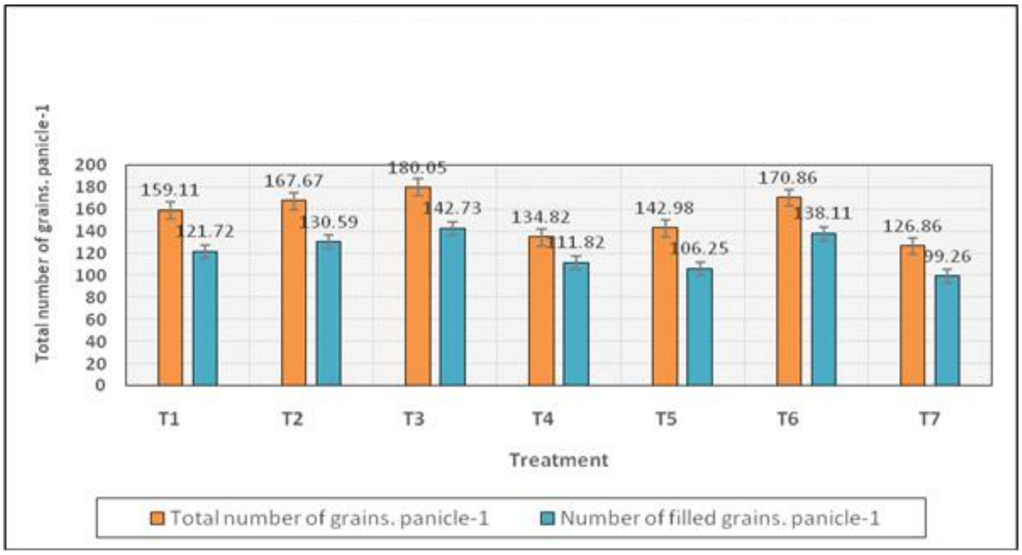

Fig. 4. Effect of AGMA foliar (Kazuki Gold / Yoshi Gold & Kazuki Energy) on total number of grain panical^{-1} (cm)

Number of filled grains panicle^{-1}: Number of filled grains panicle^{-1} was significantly influenced by different application of AGMA foliar at different treatments. (Table 2, and Fig. 2) Number of filled grains panicle^{-1} varied from 99.26 to 142.73. T3 exhibits the maximum number of 142.73 of filled grains panicle^{-1}. In the similar manner T6 treatment second highest number of filled grains panicle^{-1} recorded from Table 2. The lowest number of filled grains panicle^{-1} was obtained in T1 treatment. The other treatments are significantly differed from each other.

Panicle length (cm): The Panicle length was found significantly different with the treatments (Table 2 and Fig. 3). It has been observed that the panicle length of rice varied in their length from 22.12 to 25.74 cm. The maximum panicle length (25.74 cm) was achieved in T3. The second highest panicle length of 25.51 was observed in T6 treatment. The very short panicle length (22.2 cm) was observed by the control treatment. Similar type of result found by Ghodake *et al.,* 2022 Kundu *et*. Al. 2023.

Thousand grain weight (Test weight): The test weight (1000 grain weight) was found significant. (Table 2 and Fig. 5). The test weight in the different treatments varied from 18.65 to 20.58g. However, the highest and lowest values were obtained with T3 (20.58g) and T7 (18.65g) treatments, respectively. From the observation of the present investigation, it was seen that T3 found to be a best for getting the highest Thousand seed weight (Test weight). Arun *et al.,* 2019 observed similar results.

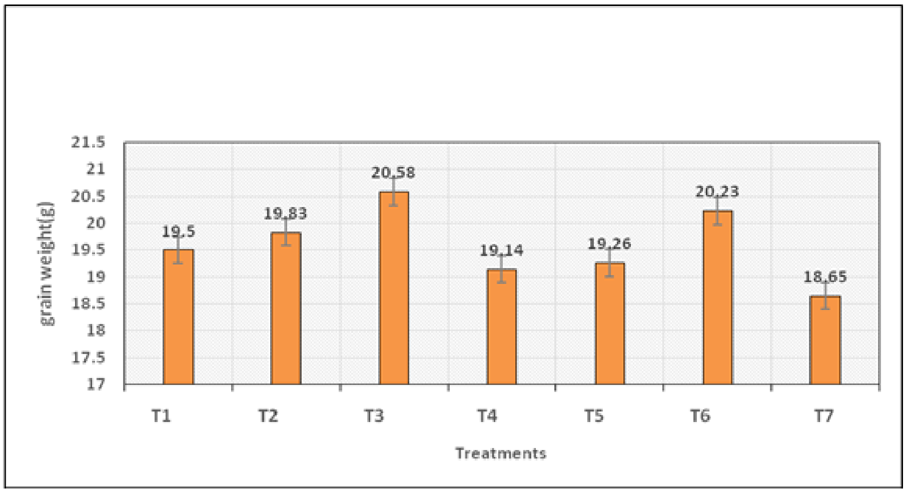

Fig. 5. Effect of AGMA foliar (Kazuki Gold / Yoshi Gold & Kazuki Energy) on 1000 grain weight (g)

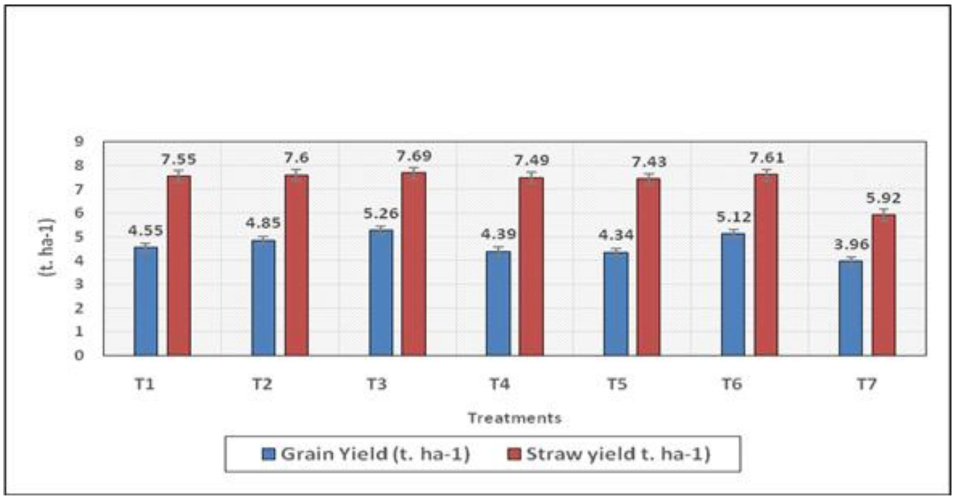

Fig. 6. Effect of AGMA foliar (Kazuki Gold / Yoshi Gold & Kazuki Energy) on grain weight (t ha^{-1}) and straw yield (t ha^{-1})

3.3 Yield Attributes and Yield

Grain yield (t. ha^{-1}): AGMA foliar application at different growth stages improved significantly the grain yield of rice due to the improvement in yield attributing characters (Table 2 and Fig. 6). The grain yield of rice cv. IET 4786 (Satabdi) varied to the range of 3.96 to 5.26 t ha^{-1}. The highest grain yield (5.26 t/ha^{-1}) was recorded in T3. Lowest yield was recorded in control plot (3.96 t. ha-1). Ghodake *et al.,* 2022 and Prama nick *et al.,* 2014 both reported similar outcomes.

Straw yield: The data on straw yield of rice as influenced by AGMA foliar application (Kazuki Gold/Yoshi Gold &Kazuki Energy) are presented in Table 2 Fig. 6. The differences in the straw yield due to different treatments were found significant. The straw yield of rice significantly increased from 7.32 to 7.69 t ha^{-1} applied T3 treatment. So, T3 recorded the highest straw yield of 7.69 t/ha, followed by T6 (7.61 t/ha) The lowest straw yield was recorded in control plot (5.92 t ha^{-1}) (Ghodake *et al*., 2022).

Harvest index: The harvest index was found statistically significant with different AGMA foliar application. The harvest index of rice increased from 34.24% to 41.44%. The data on harvest index (%) as influenced by different treatments are presented in Table 2 and Fig. 7. The harvest index differed significantly among different treatment. However, treatment T3 gave highest value of harvest index (41.44%) compared to rest of the treatment combinations. The lowest value of 34.24% was recorded in T7. The higher values of harvest index indicated the greater translocation of photosynthates from source to sink and also better portioning towards reproductive growth. Pramanick *et al*., 2014 discovered Similar type of results.

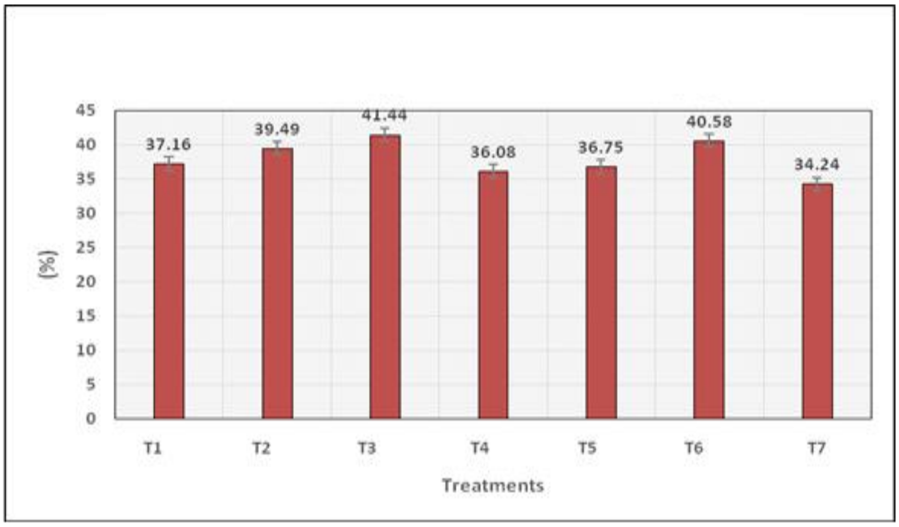

Fig. 7. Effect of AGMA foliar (Kazuki Gold / Yoshi Gold & Kazuki Energy) on Hervest Index (%)

Table 2. Effect of AGMA FOLIAR (Kazuki Gold/Yoshi Gold &Kazuki Energy) on Yield and yield attributing characters

Treatment	Total number of grains. panicle^{-1}	Number of filled grains. panicle^{-1}	Panicle length (cm)	1000 grain weight (g)	Grain Yield (t. ha^{-1})	Straw yield t. ha^{-1})	Harvest Index (%)
T_1	159.11	121.72	24.27	19.50	4.55	7.55	37.16
T_2	167.67	130.59	25.13	19.83	4.85	7.60	39.49
T_3	180.05	142.73	25.74	20.58	5.26	7.69	41.44
T_4	134.82	111.82	23.20	19.14	4.39	7.49	36.08
T_5	142.98	106.25	24.05	19.26	4.34	7.43	36.75
T_6	170.86	138.11	25.51	20.23	5.12	7.61	40.58
T_7	126.86	99.26	22.12	18.65	3.96	5.92	34.24
CD (5%)	3.27	1.50	0.29	0.17	0.21	0.08	1.07

Table 3. Effect of AGMA FOLIAR (Kazuki Gold/Yoshi Gold &Kazuki Energy) on Chlorophyll a ($mg\ g^{-1}$), Chlorophyll b ($mg\ g^{-1}$) and Total Chlorophyll ($mg\ g^{-1}$)

Treatment	Chlorophyll A ($mg\ g^{-1}$)	Chlorophyll B ($mg\ g^{-1}$)	Total Chlorophyll ($g\ g^{-1}$)
T_1	1.36	0.868	2.228
T_2	1.39	0.884	2.274
T_3	1.50	0.931	2.431
T_4	1.26	0.779	2.039
T_5	1.30	0.807	2.107
T_6	1.45	0.894	2.339
T_7	1.07	0.707	1.777
CD (5%)	3.27	1.50	0.29

Chlorophyll Content ($mg\ g^{-1}$): Total Chlorophyll, Chlorophyll a and b contents of leaf were measured at 45 Days After Transplanting. Highest Total chlorophyll (2.431) Chlorophyll a (1.50) and Chlorophyll b (0.931) content were recorded in T3 that presented in Table 3 and Fig. 7. These results were at par with treatments T6. Remaining other treatments recorded lower chlorophyll content. While the lowest were obtained from T7. presented in Table 3 and Fig. 7.

It can be inferred from the present finding that, application of AGMA FOLIAR is to improve Rice yield. Although the application of stages is also one of the important factors for vegetative parameters of crop growth.

4. CONCLUSIONS

Based on the finding of the experiments, the following conclusions were drawn.

- ✓ The highest grain yield (5.09 t/ha) was recorded in T3 treatment i.e. First application 30-35 DAT and Second application during Pre Panicle initiation stages.
- ✓ Kazuki Energy also has some pronounced effect but Kazuki Gold in overall has found to be superior for obtaining higher yield and yield attributing characters.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Our research was conducted entirely through manual methods, without the use of any artificial intelligence tools or technologies. All data collection, analysis, and observations were carried out by hand to ensure accuracy and a thorough understanding of each process. This approach allows for a hands-on, detailed examination of the effects and outcomes, emphasizing the rigor and reliability of our findings.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/126278