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# Effect of Different Doses of Gibberellic Acid GA3 on Growth, Yield and Seed Production in Rice (*Oryza sativa* L.)

S. Rakesh[1], Abhigna[1], Abhinav Dayal[1], Neha Thomas[1], G.M. Lal[1]

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## ABSTRACT

**Background:** The present study was conducted in field Experimentation Centre and Seed Testing Laboratory of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Uttar Pradesh) during *Kharif* 2023-2024.

**Methods:** The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in randomized block design with eight treatments including control which were replicated thrice.

**Result:** The results revealed that plant height (213.53 cm), days to 50% flowering (93.67 DAS), days to maturity (123.67 DAS), flag leaf length (37.83 cm), flag leaf width (top) (0.56 cm), flag leaf width (middle) (1.04 cm), flag leaf width (bottom) (1.02 cm), number of tillers (22.63), total productive tillers (18.29), panicle length (32.76 cm), seed yield per plot (35.84 g), test weight (25.87 g), spikelets per panicle (81.43), biological yield (142.84 g) were recorded significantly higher in treatment (T5) followed by T4. The study conducted in seed testing laboratory revealed that germination percent (93.67%), root length (13.84 cm), shoot length (13.67 cm), seedling length (27.51 cm), seedling fresh weight (1.15 g), seedling dry weight (0.28 g), seedling vigor index I (2576.88), seedling vigor index II (25.75) were observed significantly higher in treatment (T5) followed by T4. It was concluded from the study that treatment T5- gibberellic acid (125 PPM) recorded significantly higher physiological, yield parameters and biochemical parameters.


**Key words:** Gibberellic acid, Physiological parameters, Rice.

## INTRODUCTION

Rice (*Oryza sativa*) is one of the most important staple crops worldwide, serving as a primary food source for more than half of the global population. This cereal grain, cultivated for thousands of years, plays a crucial role in food security, economic stability and cultural heritage across diverse regions, particularly in Asia, Africa and Latin America. With its rich history and profound impact on human civilization, rice continues to be a focal point of agricultural research, aiming to enhance yield, nutritional value and sustainability in the face of increasing global challenges (Gevrek *et al*., 2012). The domestication of rice dates back approximately 9,000 years, originating in the fertile regions of the Yangtze River Valley in China. Over centuries, rice cultivation spread to different parts of the world, adapting to a wide range of environmental conditions. The Green Revolution of the mid-20$^{th}$ century marked a significant milestone in rice production, introducing high-yield varieties and advanced farming techniques that dramatically increased global output and alleviated hunger in many developing nations. Rice is more than just a food crop; it is deeply intertwined with the socio-economic fabric of many countries. In Asia, rice farming supports the livelihoods of millions of smallholder farmers and is a critical component of rural economies. The crop's economic significance extends to international trade, with major producers such as China, India, Thailand and Vietnam playing pivotal roles in the global rice market. Beyond its economic contributions, rice holds cultural and religious significance, featuring prominently in rituals, festivals and culinary traditions (Shshaibhushan *et al*., 2021). Rice is a vital source of energy, providing essential carbohydrates and, in some varieties, significant amounts of protein, vitamins and minerals. While white rice is commonly consumed, there is growing interest in brown, red and black rice varieties due to their higher nutritional content and health benefits. Efforts to biofortify rice, such as developing Golden Rice enriched with Vitamin A, aim to address micronutrient deficiencies prevalent in many rice-dependent populations (Singh *et al*., 2018). The rice sector faces numerous challenges, including climate change, water scarcity, pests and diseases. Climate variability poses a significant threat to rice yields, necessitating the development of resilient

[1]Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211 007, Uttar Pradesh, India.

**Corresponding Author:** Abhinav Dayal, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211 007, Uttar Pradesh, India.
Email: abhinav.dayal@shiats.edu.in

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varieties that can withstand extreme weather conditions. Furthermore, sustainable agricultural practices, including precision farming and integrated pest management, are being promoted to ensure environmental sustainability and long-term productivity (Chunthaburee *et al*., 2014). Seed priming, is a pre-sowing technique that enhances the physiological and metabolic readiness of seeds. This method involves soaking seeds in water or nutrient solutions for a specific period, followed by drying before planting. Priming treatments, such as hydropriming, osmopriming and biopriming, have been shown to improve germination rates, uniformity and stress tolerance. These treatments initiate early metabolic processes within the seed, enabling more rapid and synchronized germination once sown (Abo *et al*., 2017).

## MATERIALS AND METHODS

The present study was conducted during *kharif* 2023-24 for 6 months in Field Experimentation Centre and Seed testing laboratory, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj U. P. located 25.35°N and longitude 82.25°E at an altitude of 78m above mean sea level, rice variety "PB-1885" sown at 30*25 cm which were treated with treatments of different concentrations of GA3 for foliyar spray. The gibberllic acid granules were converted from milligrams to ppm using PPM = mg/l formula and accordingly T0-0 ppm, T1-25 ppm, T2-50 ppm, T3-75 ppm, T4-100 ppm, T5-125 ppm, T6-150 ppm, T7-175 ppm were collected separately in different glass beakers and were sprayed during 10%, 20%, 30%, 50% heading stages respectively. Observations were recorded for every treatment on five randomly selected plants in each replications the field observations selected for investigation are plant height, days to 50% flowering, days to maturity, flag leaf length, flag leaf width (top, middle, bottom), number of total tillers, number of productive tillers, panicle length, seed yield per plot, test weight, number of spike lets per panicle, biological yield, harvest index Table 1. The laboratory parameters considered were germination percent, root length, shoot length, seedling length, fresh weight, dry weight, vigor index I, vigor index II. These observations gave a better understanding on effect of Gibberellic acid (GA3) in dosages for varietal seed production and their effect on seed setting in rice.

## RESULTS AND DISCUSSION

### Growth and yield parameters

#### Days to 50% flowering

From the data shown in Table 2 we can observe that significantly least number of days to 50% flowering was observed in treatment T5 in seeds treated with gibberellic acid (125 PPM) with 93.67 DAT and T4 with 94.00 DAT is statistically at par with T5. Highest days to 50% flowering was observed in T0 with 97.33 DAT. Gibberellic acid influences the hormonal balance within the plant, promoting the transition from vegetative to reproductive stages. This can lead to earlier panicle initiation and flowering, critical steps toward early crop maturity (Haifaa and Moses, 2022).

#### Days to maturity

As per the data pertained in Table 2 it can be observed that seeds primed with gibberellic acid (125 PPM) (T5) varied significantly and matured earlier over other treatments within 123.67 DAT and statistically at par values were observed in T4 with 124.33 DAT and higher days to maturity was recorded in T0 with 129.33 DAT. Gibberellic acid treated seeds generally exhibit quicker and more uniform germination. This early start allows seedlings to establish and develop faster than untreated counterparts. Gibberellic acid stimulates cell division and elongation, leading to rapid vegetative growth. This means that the plants reach the critical phases of their life cycle, such as tillering and heading, earlier (Wang *et al*., 2019).

#### Plant height

A perusal of data on plant height was recorded during the experimental crop growth period at the time of harvest, revealing a significant difference in plant height from treatment to treatment, which was recorded and tabulated in Table 2. The higher plant height was observed in treatment (T5) in which seeds treated with gibberellic acid (125 PPM) with 213.53 cm and statistically at par values were observed in T4 (210.38 cm) and the lowest was recorded in T0-control (140.33 cm). Gibberellic acid promotes plant height primarily through the stimulation of cell elongation and division in the internodes of the stem. The hormone activates the synthesis of enzymes that loosen the cell wall, allowing cells to expand. Additionally, GA influences the expression of genes involved in cell division and elongation, further contributing to increased plant height (Zhang *et al*., 2023).

#### Flag leaf length

Significantly higher flag leaf length was obtained in treatment (T5- gibberellic acid (125 PPM) with 37.83 cm and statistically at par values in flag leaf length were observed in T4 with 35.26 cm and lowest flag leaf length was observed in T0-control with 25.43 cm. The data pertaining to flag leaf length can be observed in Table 2. Gibberellic acid (GA) plays a crucial role in the redistribution of nutrients throughout the plant, effectively directing essential elements such as nitrogen, phosphorus and potassium to areas where they are most needed. In the case of the developing flag leaf in rice, Gibberellic acid facilitates the transport of these nutrients from storage tissues or older leaves to the growing flag leaf. This process ensures that the flag leaf, which is vital for photosynthesis during the grain filling stage, receives an ample supply of nutrients. As a result, the flag leaf can achieve optimal growth, contributing to higher

photosynthetic efficiency and, ultimately, improved crop yield and quality (Singh *et al*., 2018).

**Flag leaf width (top)**

From the data shown in Table 2 we can observe that significantly highest flag leaf width at the top was observed in treatment T5 in seeds treated with gibberellic acid (125 PPM) with 0.56 cm and T4 with 0.54 cm is statistically at par with T5. Lowest flag leaf width at the top was observed in T0 with 0.41 cm.

**Flag leaf width (middle)**

As per the data pertained in Table 2 it can be observed that seeds primed with gibberellic acid (125PPM) (T5) and treatment - T6 [gibberellic acid (150PPM)] varied significantly and realized highest flag leaf width in the middle over other treatments with 1.04 cm and statistically at par values were observed in T4 with 1.03 cm and least flag leaf width in the middle was recorded in T0 with 0.78 cm.

**Flag leaf width (bottom)**

Significantly higher flag leaf width at the bottom of the leaf was obtained in treatment [T5- gibberellic acid (125PPM)] with 1.02 cm and statistically at par values in flag leaf width were observed in T4 with 0.97 cm and lowest flag leaf width was observed in T0-control with 0.77 cm. The data pertaining to flag leaf width can be observed in Table 2.

**Number of tillers**

From the data shown in Table 2 we can observe that significantly highest number of tillers were observed in treatment T5 in seeds treated with gibberellic acid (125 PPM) with 22.63 and T4 with 21.87 is statistically at par with T5. Lowest number of tillers were observed in T0 with 18.39.

**Number of productive tillers**

As per the data pertained in Table 2 it can be observed that seeds primed with gibberellic acid (125 PPM) (T5) varied significantly and recorded higher number of productive tillers over other treatments with 18.29 and statistically at par values were observed in T4 with 17.71 and least number of productive tillers were recorded in T0-control with 11.71. Gibberellic acid primarily influences tillering by enhancing cell elongation and division within the meristematic tissues at the base of the stem. GA improves nutrient mobilization and assimilation within the plant. Enhanced nutrient uptake supports vigorous growth and development of new

**Table 1:** Analysis of variance for application of gibberellic acid (GA3) in dosages for varietal seed production and their effect on seed setting in rice (*Oryza sativa* L.) variety.

| Characters | Mean sum of squares | | |
|---|---|---|---|
| | Treatments (d.f = 7) | Replications (d.f = 2) | Error (d.f = 14) |
| Plant height | 2283.87* | 15.92 | 21.34 |
| Days to 50% flowering | 5.14* | 0.45 | 1.35 |
| Days to maturity | 13.80* | 2.21 | 2.80 |
| Flag leaf length | 53.24* | 0.24 | 0.49 |
| Flag leaf width (top) | 0.01* | 0.003 | 0.001 |
| Flag leaf width (middle) | 0.04* | 0.002 | 0.001 |
| Flag leaf width (bottom) | 0.02* | 0.003 | 0.002 |
| Number of tillers | 6.16* | 0.09 | 0.23 |
| Number of productive tillers | 16.14* | 0.10 | 0.12 |
| Panicle length | 7.27* | 0.25 | 1.37 |
| Spikelets per panicle | 29.80* | 2.13 | 4.76 |
| Seed yield per plot | 86.56* | 1.14 | 0.49 |
| Test weight | 4.27* | 2.23 | 0.31 |
| Biological yield | 1124.05* | 1.05 | 10.51 |
| Harvest index | 1.45* | 0.52 | 0.72 |
| **Characters** | **Treatments (d.f = 7)** | | **Error (d.f = 24)** |
| Germination per cent | 48.606** | | 2.634 |
| Root length | 6.019** | | 0.054 |
| Shoot length | 4.347** | | 0.043 |
| Seedling length | 20.271** | | 0.075 |
| Fresh weight of seedling | 0.059** | | 0.015 |
| Dry weight of seedling | 0.010** | | 0.003 |
| Seedling vigour index 1 | 322194.256** | | 2726.961 |
| Seedling vigour index 2 | 107.625** | | 25.919 |

*Indicates significant at 5% and 1% level of significance.

tillers. The hormone also interacts with other phytohormones like auxins and cytokinin's, which are vital for bud initiation and outgrowth (Pandey *et al*., 2017).

**Panicle length**

Significantly highest panicle length was obtained in treatment [T5- gibberellic acid (125 PPM)] with 32.76 cm alongside treatment [T4- gibberellic acid (150 PPM)] with 32.14 cm and statistically at par values were observed in T3 with 31.64 cm and lowest panicle length was observed in T0-control with 27.88 cm. The data pertaining to panicle length can be observed in Table 2. When rice seeds are treated with gibberellic acid, it penetrates the seed coat and initiates a cascade of biochemical events that culminate in germination. One of the primary mechanisms through which gibberellic acid functions is by stimulating the synthesis of hydrolytic enzymes such as α-amylase. This results in the increase of internodal length in panicles and increase in its length (Dong *et al*., 2016).

**Number of spikelets per panicle**

Significantly highest spikelets per panicle were obtained in treatment [T5- gibberellic acid (125 PPM)] with 81.43 and statistically at par values were observed in T4 with 80.69 and lowest spikelets per panicle were observed in T0-control with 72.37. The data pertaining to spikelets per panicle can be observed in Table 2.

**Seed yield per plot**

From the data shown in Table 2 we can observe that significantly highest seed yield per plot was observed in treatment T5 in seeds treated with gibberellic acid (125 PPM) with 35.84 gm and T4 with 34.61 gm is statistically at par with T5. Lowest seed yield per plot was observed in T0 with 21.79 gm. There is a positive correlation between flag leaf length and grain yield. Longer flag leaves can improve light capture and photosynthetic efficiency, contributing to better grain filling and higher yield. A longer flag leaf provides a larger surface area for light absorption, increasing the photosynthetic capacity of the plant. This is particularly beneficial during the grain filling stage when the flag leaf is the primary source of photosynthates (Chunthaburee *et al*., 2014).

**Test weight**

As per the data pertained in Table 2 it can be observed that seeds primed with gibberellic acid (125 PPM) (T5) varied significantly and recorded higher test weight with 25.87 gm and statistically at par values were observed in T4 with 25.43 gm and lowest test weight was recorded in T0-control with 22.71 gm.

**Biological yield**

Significantly highest biological yield was obtained in treatment [T5- gibberellic acid (125 PPM)] with 142.84 gm and statistically at par values were observed in T4 with 137.65gm and lowest biological yield was observed in T0-

**Table 2:** Effect of different doses of gibberilic acid (GA3) on the expression of various plant growth and yield parameters in rice (*Oryza sativa*).

| Treatments | Plant height | D.F.F | D.M | Flag leaf length | Flag leaf width (top) | Flag leaf width (middle) | Flag leaf width (bottom) | Number of tillers | Productive tillers | Panicle length | Seed yield per plot | Test weight | Spikelets per panicle | Biological yield | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T0 | 140.33 | 97.33 | 129.33 | 25.43 | 0.41 | 0.78 | 0.77 | 18.39 | 11.71 | 27.88 | 21.79 | 22.71 | 72.37 | 91.46 | 23.84 |
| T1 | 157.37 | 96.67 | 128.67 | 27.81 | 0.44 | 0.81 | 0.79 | 19.28 | 12.85 | 29.46 | 22.41 | 22.81 | 74.35 | 96.58 | 23.21 |
| T2 | 162.43 | 96.00 | 128.00 | 28.66 | 0.45 | 0.86 | 0.85 | 19.64 | 13.52 | 30.57 | 24.38 | 23.76 | 75.19 | 103.24 | 23.61 |
| T3 | 205.71 | 94.33 | 124.67 | 34.71 | 0.52 | 1.01 | 0.95 | 21.56 | 16.17 | 31.64 | 31.73 | 25.19 | 78.36 | 131.59 | 24.16 |
| T4 | 210.38 | 94.00 | 124.33 | 35.26 | 0.54 | 1.03 | 0.97 | 21.87 | 17.71 | 32.14 | 34.61 | 25.43 | 80.69 | 137.65 | 25.15 |
| T5 | 213.53 | 93.67 | 123.67 | 37.83 | 0.56 | 1.04 | 1.02 | 22.63 | 18.29 | 32.76 | 35.84 | 25.87 | 81.43 | 142.84 | 25.09 |
| T6 | 186.31 | 95.00 | 125.33 | 30.48 | 0.49 | 1.04 | 0.94 | 20.47 | 14.83 | 31.28 | 29.66 | 24.96 | 77.51 | 125.38 | 23.67 |
| T7 | 198.27 | 95.67 | 126.67 | 31.89 | 0.47 | 0.91 | 0.92 | 20.12 | 14.29 | 30.73 | 28.47 | 24.52 | 75.42 | 117.63 | 24.20 |
| Mean | 184.29 | 95.33 | 126.33 | 31.51 | 0.49 | 0.94 | 0.90 | 20.50 | 14.92 | 30.81 | 28.61 | 24.41 | 76.92 | 118.30 | 24.12 |
| Max | 213.53 | 93.67 | 123.67 | 37.83 | 0.56 | 1.04 | 1.02 | 22.63 | 18.29 | 32.76 | 35.84 | 25.87 | 81.43 | 142.84 | 25.15 |
| Min | 140.33 | 97.33 | 129.33 | 25.43 | 0.41 | 0.78 | 0.77 | 18.39 | 11.71 | 27.88 | 21.79 | 22.71 | 72.37 | 91.46 | 23.21 |
| C.V | 2.51 | 1.22 | 1.33 | 2.21 | 3.46 | 2.39 | 3.10 | 2.33 | 2.28 | 3.80 | 2.46 | 2.29 | 2.84 | 2.74 | 3.51 |
| C.D | 8.09 | 2.04 | 2.93 | 1.22 | 0.03 | 0.04 | 0.05 | 0.84 | 0.60 | 2.05 | 1.23 | 0.98 | 3.82 | 5.68 | 1.48 |
| S.Em | 2.67 | 0.67 | 0.97 | 0.40 | 0.01 | 0.01 | 0.02 | 0.28 | 0.20 | 0.68 | 0.41 | 0.32 | 1.26 | 1.87 | 0.49 |

**Table 3:** Effect of different doses of gibberellic acid (GA3) on mean performance of seedling characteristics in rice (*Oryza sativa* L.) variety.

| Treatments | Germination % | Root length | Shoot length | Seedling length | Fresh weight | Dry weight | Vigor index-I | Vigo index-II |
|---|---|---|---|---|---|---|---|---|
| T0 | 83.33 | 10.59 | 10.75 | 21.34 | 0.80 | 0.13 | 1778 | 10.48 |
| T1 | 85.33 | 10.81 | 11.23 | 22.04 | 0.85 | 0.15 | 1880 | 12.82 |
| T2 | 86.67 | 11.36 | 11.64 | 23.00 | 0.93 | 0.18 | 1993 | 15.18 |
| T3 | 90.33 | 13.11 | 12.86 | 25.97 | 1.00 | 0.23 | 2345 | 20.32 |
| T4 | 92.33 | 13.37 | 13.41 | 26.78 | 1.13 | 0.25 | 2472 | 23.11 |
| T5 | 93.67 | 13.84 | 13.67 | 27.51 | 1.15 | 0.28 | 2576 | 25.75 |
| T6 | 89.00 | 12.64 | 12.71 | 25.35 | 0.98 | 0.20 | 2256 | 17.83 |
| T7 | 88.33 | 11.73 | 12.54 | 24.27 | 0.95 | 0.18 | 2143 | 15.42 |
| Mean | 88.62 | 12.18 | 12.35 | 24.53 | 0.97 | 0.20 | 2181 | 17.61 |
| Max | 93.67 | 13.84 | 13.67 | 27.51 | 1.15 | 0.28 | 2576 | 25.75 |
| Min | 83.33 | 10.59 | 10.75 | 21.34 | 0.80 | 0.13 | 1778 | 10.48 |
| C.V | 1.831 | 1.903 | 1.676 | 1.117 | 12.470 | 28.864 | 2.394 | 28.901 |
| C.D | 2.383 | 0.340 | 0.304 | 0.402 | 0.178 | 0.083 | 76.664 | 7.474 |
| S. Em | 0.811 | 0.116 | 0.104 | 0.137 | 0.061 | 0.028 | 26.110 | 2.546 |

control with 91.46 gm. The data pertaining to biological yield can be observed in Table 2.

### Harvest index

From the data shown in Table 2 it is clear that T5 @ gibberellic acid (125 PPM) with 25.09% and T4 @ gibberellic acid (150PPM) with 25.15% had performed better over all other treatments and at par values were obtained in T7 and T3 with 24.20%, 24.16% and the lowest harvest index was observed in T1 with 23.21%. During the leaf growth stage, the rice root system is also developing and beginning to shape. The primary and secondary root systems of water-seeded crops share the same ancestor. In rice sown directly into the soil, the primary root system begins its growth at or close to the seed and the secondary system appears above the seed, emerging from the coleoptile's base. These variations in rice root systems may impact nutrient delivery and other crop management decisions throughout rice growth stages (El-Ekhtyar *et al*., 2008).

### Seedling analysis

As per the data pertained in Table 3 the treatment (T5) in which seeds treated with gibberellic acid (125PPM) was significantly higher in germination percentage, root length, shoot length, seedling length, fresh weight, dry weight, vigor index -I and vigor index-II.

## CONCLUSION

It is concluded that seeds treated with gibberellic acid (125 PPM) was found to be more desirable for producing significantly higher plant height (213.53 cm), number of tillers (22.63), total productive tillers (18.29), panicle length (32.76 cm), seed yield per plot (35.84 gm), test weight (25.87 gm), spikelets per panicle (81.43), germination percent (93.67%), seedling length (27.51 cm). Findings were based on research done in one season in Prayagraj (Allahabad) U.P. further trails may be required for considering it for the recommendation.

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### Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

### Conflict of interest

The authors have no competing interests.

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