

## Impact of Zinc and Iron Content of Seeds on Germination and Seedling Vigor in Rice

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**Abstract** A study was carried out to evaluate how zinc and iron content of rice (*Oryza sativa* L.) improved the germination and seedling vigor. A total of 180 rice genotypes were used for mineral content (Zn and Fe) analysis and categorized into low, medium and high iron and zinc content. Five and three genotypes from each category for iron and zinc were used for seed quality analysis. Results revealed that there was a progressive increase in seed germination (from 74.12 to 93.49% and 76.00 to 93.38%), seedling length (17.66 to 31.28 cm and 23.81 to 33.61 cm) and seedling vigor index (1310 to 2904 and 1856 to 3140) with increase in seed-Fe and Zn content, respectively.

**Keywords** Iron, Seed, Rice, Zinc.

### Introduction

Rice (*Oryza sativa* L.) is a global grain cultivated widely across the world and feeds millions of mankind, is the staple food for more than of the human population. Grown in Asia for at least 10,000 years, rice (the main product of the paddy plant) has become deeply embedded in the cultural heritage of Asian societies and is the life, heart and soul of the people throughout Asia. In India, rice continues to hold the key for sustained food production by contributing 20-25% to agriculture and assures food security for more than half of the total population. Out of 2234 calories per day per capita food intake, rice accounts for 30% in Indian diet.

Iron and zinc are important elements out of the 16 essential elements needed for plant growth. Iron is used for the synthesis of chlorophyll and is essential for the function of chloroplasts. Zinc (Zn) is essential in protein synthesis and gene expression in plants [1, 2]. It has been estimated that about 10% of the proteins in biological systems need Zn for their structural and functional integrity [3]. This element has also been indicated to be required as a cofactor in over 300 enzymes [4]. During germination, production of reactive oxygen species (ROS) is well known [5—7] and Zn plays a central role in detoxification of ROS in plant cells [1, 2].

Previous studies indicated that growing wheat crops with high seed Zn resulted in better seedling

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vigor and seed viability, higher yield and lessening of seed rate required for sowing, especially on potentially Zn deficient soils [8—10]. Applying Zn fertilizers in the soil also increases dry matter, grain yield and grain Zn concentration in rice [11,12]. Sowing rice seeds with high Zn content was found to result in a rapid and better germination, greater root length and better shoot growth [13]. In case of rice there is no much information on how the elevated level of seed zinc and iron may consequently affect germination and seedling growth. Therefore present has been conducted to know how seed zinc and iron will influence of germination and seedling vigor of rice.

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## Materials and Methods

A total of 180 rice genotypes available with Agricultural Research Station, Gangavathi, were used for mineral content (Zn and Fe) analysis and categorized into low, medium and high iron and zinc content. Five and three genotypes from each category for iron (Low; IET 22147, GNV-SW-L 73, RYC 238, TEHALKA, GNV-MSGP-01; medium : NAVARA, GNV-SW-L 48, GNV-SW-L 37, RYC 232, GNV-SW-L 120 and high IR10N211, GNV-MSGP-4, GNV-SW-L139, RYC 684, IET 23308) and zinc content (Low; GNV-SW-L 160, GNV-SW-L 149, GNV-SW-L 48; medium : GNV-MSGP-17, IET 21406, GNV-MSGP-15 and high : PAU 3130, RYC238, GNV-SW-L 197) respectively were used to study the effect of seed micronutrient (Zn and Fe) content on seed germination and seedling vigor index.

Germination per cent was determined as per ISTA rules for seed testing. The seeds were placed in rolled paper towels. Hundred seeds of four replications were tested at a constant temperature of 25°C . The number of normal seedlings were evaluated on 14<sup>th</sup> day and per cent germination was expressed on normal seedling basis [14].

From the standard germination test, ten normal

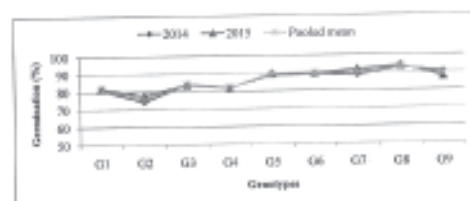


Fig. 1. Germination (%) as influenced by seed zinc content

Legend  
 G<sub>1</sub>: GNV-SW-L 160 G<sub>2</sub>: GNV-SW-L 149 G<sub>3</sub>: GNV-SW-L 48 G<sub>4</sub>: GNV-MSGP-17 G<sub>5</sub>: IET 21406  
 G<sub>6</sub>: GNV-MSGP-15 G<sub>7</sub>: PAU 3130 G<sub>8</sub>: RYC 238 G<sub>9</sub>: GNV-SW-L 197

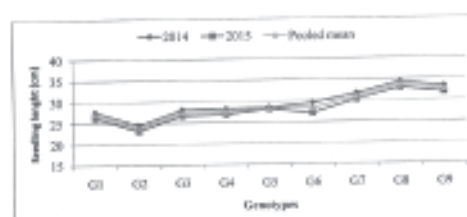


Fig. 2. Seedling length (cm) as influenced by seed zinc content

Legend  
 G<sub>1</sub>: GNV-SW-L 160 G<sub>2</sub>: GNV-SW-L 149 G<sub>3</sub>: GNV-SW-L 48 G<sub>4</sub>: GNV-MSGP-17 G<sub>5</sub>: IET 21406  
 G<sub>6</sub>: GNV-MSGP-15 G<sub>7</sub>: PAU 3130 G<sub>8</sub>: RYC 238 G<sub>9</sub>: GNV-SW-L 197

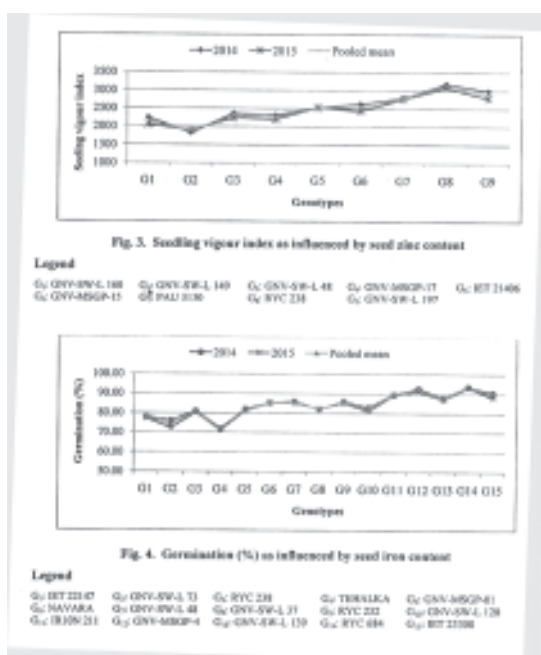
**Fig. 1.** Germination (%) as influenced by seed zinc content. **Fig. 2.** Seedling length (cm) as influenced by seed zinc content. Legend : G<sub>1</sub>: GNV-SW-L 160, G<sub>2</sub>: GNV-SW-L 149, G<sub>3</sub>: GNV-SW-L 48, G<sub>4</sub>: GNV-MSGP-17, G<sub>5</sub>: IET 21406, G<sub>6</sub>: GNV-MSGP-15, G<sub>7</sub>: PAU 3130, G<sub>8</sub>: RYC 238, G<sub>9</sub>: GNV-SW-L 197.

seedlings were selected at random in each replication on final count. The shoot and shoot length was measured, sum of shoot and root length constitute the seedling length and mean was calculated and expressed in centimeters. Seedling vigor index was computed by adopting the formula as suggested by Abdul-Baki and Anderson [15] and expressed in whole number.

$$\text{Seedling vigor index} = \frac{\text{Germination (\%)} \times \text{Mean seedling length (cm)}}{100}$$

## Results and Discussion

Beneficial effect of high seed-Zn during seed germination and early seedling growth have been reported by several authors [16, 17]. In the present investigation an attempt has been made to know the influence of seed-Fe and Zn content on seed germination and seedling vigor index in paddy genotypes.

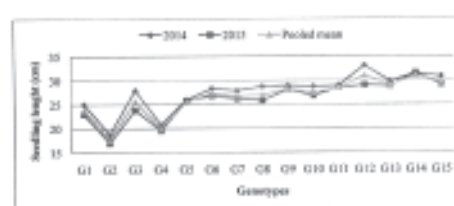


**Fig. 3.** Seedling vigor index as influenced by seed zinc content. Legend: G<sub>1</sub>: GNV-SW-L 160, G<sub>2</sub>: GNV-SW-L 149, G<sub>3</sub>: GNV-SW-L 48, G<sub>4</sub>: GNV-MSGP-17, G<sub>5</sub>: IET 21406, G<sub>6</sub>: GNV-MSGP-15, G<sub>7</sub>: PAU 3130, G<sub>8</sub>: RYC 238, G<sub>9</sub>: GNV-SW-L 197.

**Fig. 4.** Germination (%) as influenced by seed iron content. Legend: G<sub>1</sub>: IET 22147, G<sub>2</sub>: GNV-SW-L 73, G<sub>3</sub>: RYC 238, G<sub>4</sub>: TEHALKA, G<sub>5</sub>: GNV-MSGP-01, G<sub>6</sub>: NAVARA, G<sub>7</sub>: GNV-SW-L 48, G<sub>8</sub>: GNV-SW-L 37, G<sub>9</sub>: RYC-232, G<sub>10</sub>: GNV-SW-L 120, G<sub>11</sub>: IR10N 211, G<sub>12</sub>: GNV-MSGP-4, G<sub>13</sub>: GNV-SW-L 139, G<sub>14</sub>: RYC 684, G<sub>15</sub>: IET 23308.

Out of 180 genotypes evaluated for Fe and Zn content, genotypes were categorized in to three levels namely, low, medium and high. These genotypes were found to have different impact on germination and seedling growth.

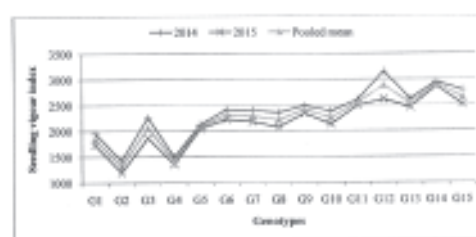
Seed germination significantly increased with increase in seed zinc content. Among the genotypes, RYC 238 which belonged to high zinc content group recorded significantly highest seed germination (93.00% in 2014, 93.75% in 2015 and 93.38 % in pooled mean) (Fig. 1), seedling length (34.30, 32.93 and 33.61 cm in 2014, 2015 and pooled mean, respectively) (Fig. 2) and seedling vigor index (3191, 3089 and 3140 in 2014, 2015 and pooled mean, respectively) (Fig. 3) compared to other genotypes



**Fig. 5.** Seedling length (cm) as influenced by seed iron content

Legend

G <sub>1</sub> : IET 22147	G <sub>2</sub> : GNV-SW-L 73	G <sub>3</sub> : RYC 238	G <sub>4</sub> : TEHALKA	G <sub>5</sub> : GNV-MSGP-01
G <sub>6</sub> : NAVARA	G <sub>7</sub> : GNV-SW-L 48	G <sub>8</sub> : GNV-SW-L 37	G <sub>9</sub> : RYC 232	G <sub>10</sub> : GNV-SW-L 120
G <sub>11</sub> : IR10N 211	G <sub>12</sub> : GNV-MSGP-4	G <sub>13</sub> : GNV-SW-L 139	G <sub>14</sub> : RYC 684	G <sub>15</sub> : IET 23308



**Fig. 6.** Seedling vigor index as influenced by seed iron content

Legend

G <sub>1</sub> : IET 22147	G <sub>2</sub> : GNV-SW-L 73	G <sub>3</sub> : RYC 238	G <sub>4</sub> : TEHALKA	G <sub>5</sub> : GNV-MSGP-01
G <sub>6</sub> : NAVARA	G <sub>7</sub> : GNV-SW-L 48	G <sub>8</sub> : GNV-SW-L 37	G <sub>9</sub> : RYC 232	G <sub>10</sub> : GNV-SW-L 120
G <sub>11</sub> : IR10N 211	G <sub>12</sub> : GNV-MSGP-4	G <sub>13</sub> : GNV-SW-L 139	G <sub>14</sub> : RYC 684	G <sub>15</sub> : IET 23308

**Fig. 5.** Seedling length (cm) as influenced by seed iron content. Legend: G<sub>1</sub>: IET 22147, G<sub>2</sub>: GNV-SW-L 73, G<sub>3</sub>: RYC 238, G<sub>4</sub>: TEHALKA, G<sub>5</sub>: GNV-MSGP-01, G<sub>6</sub>: NAVARA, G<sub>7</sub>: GNV-SW-L 48, G<sub>8</sub>: GNV-SW-L 37, G<sub>9</sub>: RYC 232, G<sub>10</sub>: GNV-SW-L 120, G<sub>11</sub>: IR10N 211, G<sub>12</sub>: GNV-MSGP-4, G<sub>13</sub>: GNV-SW-L 139, G<sub>14</sub>: RYC 684, G<sub>15</sub>: IET 23308.

while, lowest was noticed in genotypes which falls under low iron content category.

Seed iron content significantly influenced the germination percentage. Seed germination significantly increased with increase in seed iron content. Among the genotypes, RYC 684 belonged to high iron content group recorded significantly highest germination (93.67% in 2014, 93.31% in 2015 and 93.49% in pooled mean) (Fig.4), seedling length (31.44 in 2014, 31.46 in 2015 and 31.08 in pooled mean) (Fig.5) and seedling vigor index (2945 in 2014, 2864 in 2015 and 2904 in pooled mean) (Fig.6) compared to other genotypes. Whereas, genotypes which belonged to low zinc content group showed lower seed quality parameters.

There was a progressive increase in seed ger-

mination (from 74.12 to 93.49% and 76.00 to 93.38%) seedling length (17.66 to 31.28 cm and 23.81 to 33.61 cm) and seedling vigor index (1310 to 2904 and 1856 to 3140) with increase in seed-Fe and Zn content, respectively was observed. Seeds dense with iron and zinc content significantly recorded highest germination and seedling vigor compared to low and medium groups. Our results confirms the findings earlier [16—17] who also observed increase in seedling vigor with progressive increase in seed-Zn content. Genotypes with high seed-Zn recorded highest seedling length and seedling vigor index compared to genotypes with high seed-Fe. Increase in seed germination and seedling vigor with increase in seed-Zn could be ascribed as the microelement Zn is a component of protein synthesis and their related functions[2]. There are nearly 2800 proteins which need Zn for their structural and functional integrity [3]. These findings indicate that there may be high need for Zn during root and coleoptile development for active protein synthesis and/ or other related functions. During the seed germination, production of reactive oxygen species (ROS) is unavoidable and seeds/seedlings have defense mechanisms against ROS production (Qin and Liu 2010). One of the defense enzymes against ROS is superoxide dismutase which is Zn dependent [1,2].

In conclusion, the present study has shown that zinc and iron in rice see can be effectively improved the germination and seedling vigor and genotypes with higher zinc and iron content can be used for sowing to get uniform and better seedling growth under micronutrient deficient soil.

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