**THE IMPACT OF ZINC NUTRITION ON WEED COMPETITIVENESS IN RICE**

**ABSTRACT**

The experiment was conducted at Integrated Farming System Research Station, Karamana, Thiruvananthapuram, Kerala Agricultural University, Kerala, India during *Kharif* Season 2022-2023 to study the influence of different zinc nutrition treatments on weed competitiveness in rice. The treatments were T1- Soil application of ZnSO4 at 20 kg ha-1 T2- Nutri priming with Nano Zn at 0.05% T3- Nutri priming with Nano Zn at 0.05% + Foliar spray with Nano Zn at 0.05% at maximum tillering stage T4- Nutri priming with ZnSO4 at 0.5% T5- Nutri priming with ZnSO4 at 0.5% + Foliar spray with Nano Zn at 0.05% at maximum tillering stage T6- Foliar spray with Nano Zn at 0.05% at maximum tillering stage and panicle initiation stage T7- Foliar spray with ZnSO4 at 0.5% at maximum tillering stage and panicle initiation stage T8- Control (Recommended dose of nutrients without application of P and Zn). The experiment was laid out in randomized block design with three replications. The predominant weed flora was grasses. The highest weed smothering efficiency was recorded in T3 and T2 at 20 days after transplanting (DAT) and 40 DAT. The lowest weed persistence index was recorded in T3. It can be concluded that Nutri priming with Nano Zn at 0.05% followed by foliar spray with Nano Zn at 0.05% at maximum tillering stage enhanced the weed competitiveness in rice.

**Keywords:** Nutri priming, Foliar spray, Maximum tillering, Panicle initiation, Nano Zn.

**INTRODUCTION**

Rice is predominantly grown and consumed in Asian continent accounting for more than 90 per cent of the world’s production (Chauhan et al., 2015). India is the second major producer of rice after China, with the contribution of 21.5 per cent to the world rice production (Jehangir et al., 2021). In India, rice is grown on 43.8 mha, with a productivity of 2.68 t ha⁻¹ (Directorate of Economics and Statistics [DES], 2019)

Proper plant nutrition is essential not only for improving the quality and quantity of produce but also for supporting the overall growth and development of the plant. Micronutrients are essential nutrient component which plays vital role in plant physiology even if they are taken up in comparatively lesser amounts by the plants (Sharma et al., 2013). Zinc is one such micronutrient which is associated with biotic and abiotic stress management apart from playing major role in biochemical processes, integral factor of different enzymes, cofactor for enzymes required for specific protein biosynthesis and prominent in chlorophyll formation (Alloway, 2001; Das et al., 2018).

Despite of the crucial roles associated with the zinc micronutirent, its deficiency is particularly widespread and more problematic than other micronutrient deficiencies, significantly affecting photosynthesis in cereal crops (Barman et al., 2018). The main issue lies in the low solubility of Zn in soil, despite the adequate total Zn content. The application and availability of phosphorus in the soil play a vital role in regulating zinc uptake, as these two nutrients interact antagonistically in plant nutrition (Sánchez-Rodríguez et al., 2017; Watts-Williams et al., 2014; Zhang et al., 2012). Nanotechnology is revolutionizing agriculture by enhancing the efficiency of nutrient absorption in plants through the use of nanofertilizers. These fertilizers utilize nanoparticles, which are typically sized between 1 and 100 nanometers, to improve nutrient delivery and uptake (Nongbet et al., 2022; Yadav et al., 2023).

Weeds pose a significant biotic constraint in rice cultivation and are expected to become more challenging over time. Weed interference causes considerable yield losses, ranging from 11 to 90 per cent and, in severe cases, can lead to complete crop failure (Rao et al., 2015). Puddled-transplanted rice provides an anaerobic environment by maintaining a water layer on the surface, which reduces oxygen and light availability. This environment limits weed establishment, improving crop establishment and increasing the crop's competitiveness against weeds (Chauhan and Johnson, 2011). However, weed control in rice cultivation remains a persistent challenge for achieving optimal yield and quality, as weeds can significantly reduce both (Ashraf et al., 2018).

The present study was conducted to evaluate the effectiveness of Zn in managing biotic stress, with a focus on zinc application and their impact on weed competitiveness in rice cultivation.

**MATERIAL AND METHODS**

The field experiment was conducted in *Kharif* season 2022-2023 (april to august) at integrated farming system research station, karamana, Thiruvananthapuram. The site is located at 8 ̊ 28’ 26 N latitude and 76 ̊ 57’ 38 E longitude at an altitude of 10 m above mean sea level. The soil of the experimental site is sandy clay loam with pH being acidic, EC being normal, high organic carbon, low in available nitrogen, high in available phosphorus and low in available potassium.

The field was continuously under rice cultivation through transplanting previously. The weather condition during the growing season of the crop experienced many rainy days. The duration the crop was 140 days. The total rainfall received during the season was 540.01mm. The variety used was Uma (MO-16) which is a medium duration variety released from Rice Research Station, Moncompu, Alapuzha, Kerala Agricultural University.

The experiment was laid out in a randomized block design with three replications and eight treatments. The treatments of the experiment include T1- Soil application of ZnSO4 at 20 kg ha-1 T2- Nutri priming with Nano Zn at 0.05% T3- Nutri priming with Nano Zn at 0.05% + Foliar spray with Nano Zn at 0.05% at Maximum tillering stage T4- Nutri priming with ZnSO4 at 0.5% T5- Nutri priming with ZnSO4 at 0.5% + Foliar spray with Nano Zn at 0.05% at Maximum tillering stage T6- Foliar spray with Nano Zn at 0.05% at Maximum tillering stage and Panicle initiation stage T7- Foliar spray with ZnSO4 at 0.5% at Maximum tillering stage and Panicle initiation stage T8- Control (Recommended dose of nutrients without application of P and Zn).

 Seedlings were raised using wet nursery method and the seedlings are transplanted at the age of 21 days to the main field.

Lime application @ 600 kg ha-1 was applied in two splits, one as basal and the rest as top dressing at 30 days after transplanting. Seed rated adopted was 75 kg ha-1, in case of the nutri priming treatments; the seeds were soaked in the mentioned concentration of the nutrients for 16 hours. 63.9 kg ha-1 N, 21.6 kg ha-1 P and 87.75 kg ha-1 K was applied to the crop according the soil test based nutrient application based on package of practices, Kerala Agricultural University.

Weed density was observed usinga quadrant of 50 cm × 50 cm which was placed in the plot at random and the component plants were expressed as number of plants per square meter at 20 DAT and 40 DAT, respectively. The weeds were again classified into grasses, sedges and broad leaved weeds.

To assess weed dry matter, a quadrant of 50 cm × 50 cm was placed in the plot at random in two different sites. The weeds present in the quadrant were pulled along with roots, washed and dried under shade and oven died at 60 ± 5 ̊C to a constant weight. The dry weights of the weeds were expressed as g m-2.

Weed smothering efficiency (WSE) was computed using the formula and was expressed in percentage at 20 DAT and 40 DAT.

 WC- WT

WSE = × 100

WC

Where, WC- Dry weight of weeds in control plot

 WT- Dry weight of weeds in treated plot

Weed persistence index (WPI) was computed using the formula at 20 DAT and 40 DAT.

 Weed dry matter in treated plot Weed density in control plot

 WPI = **×**

Weed dry matter in control plot Weed density in treated plot

**3. Results and discussion**

**3.1 Weed Composition**

 The experimental site was previously under rice cultivation and the predominant weed species in the experimental site was grasses. The weed floras of the different treatments were grouped into grasses, sedges, broad-leaf weeds and are listed in the Table 1.

**Table 1. Major weed species observed during the crop season.**

|  |  |  |
| --- | --- | --- |
| **Common name** | **Scientific name** | **Family** |
| **Grasses** |
| Jungle rice | *Echinochloa colona* | Poaceae |
| Barnyard grass | *Echinochloa crusgalli* | Poaceae |
| Blood grass | *Isachne miliacea* | Poaceae |
| Chinese sprangletop | *Leptochloa chinensis* | Poaceae |
| Weedy rice | *Oryza sativa* | Poaceae |
| **Sedges** |
| Rice sedge | *Cyperus difformis* | Cyperaceae |
| Yellow nut sedge | *Cyperus iria* | Cyperaceae |
| Globe finger rush | *Fimbristylis miliacea* | Cyperaceae |
| **Broad-leaf weeds** |
| False daisy | *Eclipta prostrata* | Asteraceae |
| Goose weed | *Sphenoclea zeylanica* | Sphenocleaceae |
| Hermits water lily | *Limnocharis flava* | Limnocharitaceae |
| Blue moneywort | *Lindernia grandiflora* | Linderniaceae |
| Oval leaf pond weed | *Monochoria vaginalis* | Pontederiaceae |

**3.2. Weed Density**

The analyzed data revealed that at 20 DAT, the population of grasses and sedges were influenced by the treatments. The lowest weed density of grasses was recorded in T2 which was followed by T3, T4 and T5. The sedges population was the lowest in T3 and was on par with T2, T4, T5 and T6. The results clearly indicated that nutri priming with Zn enhanced the vigour of rice seedlings for early establishment and competitiveness. The highest weed density of grasses and sedges has been recorded in the control treatment (T8) which was on par with T1 and T7. Weed density at 40 DAT did not show any significant difference between treatments.

 Weed density was reported higher in control treatment which was the application of recommended dose of fertilizers excluding P and Zn, which makes the rice plants less established and less competitive compared to the treatments which are sufficiently supplied with nutrients. Absence of the phosphorous nutrition, which plays the important role in early root growth and root proliferation was lacking in the control treatment might have affected the proper establishment of the plants to compete with weeds in the control treatment (Malhotra et al., 2018).

**3.3 Weed Dry Matter**

Weed dry matter at 20 and 40 DAT differed significantly among the zinc application treatments. The treatment T8 has recorded the highest weed dry matter and was found on par with T1. The treatment T3 has recorded the lowest weed dry matter at 20 and 40 DAT.

 Plant growth and development required Zn to undergo biological processes like synthesis of proteins, nucleic acids (Han et al., 2004; Broadley et al., 2012). Weeds growth was also associated with nutrient supply when considered as plant species, weed biomass was higher in Zn soil application treatments (El- Metwalley et al., 2020; Saudy et al., 2021) which is in justification with treatment T1. Absence of both the P and Zn nutrients would make the plants species weak resulting in more weed dry matter in the control treatment.

**Table 2. Effect of zinc nutrition on weed density (no. m-2)in rice at 20 and 40 DAT**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **20 DAT** | **40 DAT** |
|  | **Grasses** | **Sedges** | **Broad- leaf** **weeds** | **Total weeds** | **Grasses** | **Sedges** | **Broad- leaf** **weeds** | **Total weeds** |
| T1- Soil application of ZnSO4 at 20 kg ha-1 | 33.00 | 9.07 | 4.73 | 46.80 | 17.40 | 4.47 | 3.13 | 25.00 |
| T2- Nutri priming with Nano Zn at 0.05%  | 18.53 | 6.13 | 3.47 | 28.13 | 17.60 | 4.27 | 2.67 | 24.53 |
| T3- Nutri priming with Nano Zn at 0.05% + Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 23.60 | 6.00 | 4.00 | 33.60 | 17.53 | 4.00 | 2.27 | 23.60 |
| T4- Nutri priming with ZnSO4 at 0.5%  | 25.33 | 7.33 | 4.47 | 37.13 | 17.33 | 4.40 | 2.93 | 24.87 |
| T5- Nutri priming with ZnSO4 at 0.5%+ Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 25.53 | 6.87 | 4.67 | 37.07 | 17.33 | 4.33 | 2.67 | 24.33 |
| T6- Foliar spray with Nano Zn at 0.05% at Maximum tillering stage and Panicle initiation stage  | 29.67 | 7.60 | 4.60 | 41.87 | 17.27 | 4.07 | 2.33 | 23.67 |
| T7- Foliar spray with ZnSO4 at 0.5% at Maximum tillering stage and Panicle initiation stage | 31.00 | 8.47 | 4.60 | 44.07 | 17.67 | 4.40 | 2.93 | 25.00 |
| T8- Control (Recommended dose of nutrients without application of P and Zn). | 34.67 | 9.80 | 4.93 | 49.40 | 17.80 | 4.67 | 3.13 | 25.60 |
| **SEm (±)** | 1.26 | 0.55 | 0.43 | 1.53 | 0.92 | 0.22 | 0.42 | 1.40 |
| **CD (0.05)** | 3.807 | 1.659 | **NS** | 4.631 | **NS** | **NS** | **NS** | **NS** |

**Table 3. Effect of zinc nutrition on weed dry matter g m-2 in rice at 20 and 40 DAT**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **20 DAT** | **40 DAT** |
| T1- Soil application of ZnSO4 at 20 kg ha-1 | 17.10 | 11.40 |
| T2- Nutri priming with Nano Zn at 0.05%  | 9.27 | 9.73 |
| T3- Nutri priming with Nano Zn at 0.05% + Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 9.10 | 8.63 |
| T4- Nutri priming with ZnSO4 at 0.5%  | 12.57 | 10.87 |
| T5- Nutri priming with ZnSO4 at 0.5%+ Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 13.30 | 10.57 |
| T6- Foliar spray with Nano Zn at 0.05% at Maximum tillering stage and Panicle initiation stage  | 15.57 | 8.73 |
| T7- Foliar spray with ZnSO4 at 0.5% at Maximum tillering stage and Panicle initiation stage | 15.23 | 10.50 |
| T8- Control (Recommended dose of nutrients without application of P and Zn). | 17.90 | 12.67 |
| **SEm (±)** | 0.42 | 0.52 |
| **CD (0.05)** | 1.266 | 1.59 |

**3.4. Weed Smothering Efficiency (WSE)**

Weed smothering efficiency at 20 DAT was found to be significant and the highest values in the treatment T3 and T2 which were on par and was superior to other treatments. The lowest WSE were recorded in treatment T1, T6 and T7. At 40 DAT, the highest WSE was recorded in T3, T6 and T2. The lowest WSE was recorded in T1.

Weeds undergo nutritional stress and herbicidal stress in due course of its growth period. Activation of ribulose 1,5- bisphosphate carboxylase / oxygenase in the process of photosynthesis was correlated with the Zn, decreased photosynthetic activity was seen in weeds which were insufficiently supplied with Zn micronutrient (Storey 2007; Sasaki et al., 1998). Moreover the treatments which were supplied with the Zn as Nano application and foliar application, the plants have absorbed the nutrients and became more competitive with the weeds. Similar results were also reported by (Hasanain et al 2019).

**Table 4. Effect of zinc nutrition on weed smothering efficiency in rice at 20 and 40 DAT**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **20 DAT** | **40 DAT** |
| T1- Soil application of ZnSO4 at 20 kg ha-1 | 7.73 | 9.76 |
| T2- Nutri priming with Nano Zn at 0.05%  | 48.13 | 23.10 |
| T3- Nutri priming with Nano Zn at 0.05% + Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 49.10 | 31.90 |
| T4- Nutri priming with ZnSO4 at 0.5%  | 29.86 | 14.15 |
| T5- Nutri priming with ZnSO4 at 0.5%+ Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 25.76 | 16.35 |
| T6- Foliar spray with Nano Zn at 0.05% at Maximum tillering stage and Panicle initiation stage  | 13.06 | 31.03 |
| T7- Foliar spray with ZnSO4 at 0.5% at Maximum tillering stage and Panicle initiation stage | 14.91 | 16.93 |
| T8- Control (Recommended dose of nutrients without application of P and Zn). | 0.00 | 0.00 |
| **SEm (±)** | 2.44 | 4.18 |
| **CD (0.05)** | 7.388 | 12.682 |

**3.5. Weed Persistence Index**

Weed persistence index as affected by zinc nutrition has shown in Table 5. The results revealed that significant difference were observed at 20 DAT, where the highest value has been recorded in T6 and all other treatments except T3 were on par and the lowest weed persistence index was recorded in the treatment T3. This may be attributed to the effect of nutri primed and foliar nutrition of Nano Zn. This proved the effectiveness of nano zinc through seed and foliar nutrition, which enhanced the competitiveness of rice in early stages. However, soil application of nutrients makes the weeds more available with nutrients and the population of it increases (Mahajan et al., 2014).

**Table 5. Effect of zinc nutrition on weed persistence index in rice at 20 and 40 DAT.**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **20 DAT** | **40 DAT** |
| T1- Soil application of ZnSO4 at 20 kg ha-1 | 1.01 | 0.97 |
| T2- Nutri priming with Nano Zn at 0.05%  | 0.91 | 0.81 |
| T3- Nutri priming with Nano Zn at 0.05% + Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 0.76 | 0.75 |
| T4- Nutri priming with ZnSO4 at 0.5%  | 0.93 | 0.89 |
| T5- Nutri priming with ZnSO4 at 0.5%+ Foliar spray with Nano Zn at 0.05% at Maximum tillering stage | 1.00 | 0.88 |
| T6- Foliar spray with Nano Zn at 0.05% at Maximum tillering stage and Panicle initiation stage  | 1.02 | 0.75 |
| T7- Foliar spray with ZnSO4 at 0.5% at Maximum tillering stage and Panicle initiation stage | 0.95 | 0.85 |
| T8- Control (Recommended dose of nutrients without application of P and Zn). | 1.00 | 1.00 |
| **SEm (±)** | 0.04 | 0.07 |
| **CD (0.05)** | 0.131 | NS |

**Table 6. Species composition of major weeds at 20 DAT**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments****20 DAT** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **SEm (±)** | **CD (0.05)** |
| **Grasses** |
| *Echinohloa colona* | 5.10(2.47) | 3.33(2.08) | 5.07(2.45) | 6.00(2.64) | 5.30(2.51) | 5.87(2.62) | 5.00(2.44) | 5.00(2.44) | 0.085 | 0.258 |
| *Echinochloa crusgalli* | 4.30(2.29) | 1.63(1.61) | 2.53(1.78) | 2.97(1.98) | 2.53(1.87) | 3.97(2.22) | 3.97(2.22) | 3.43(2.05) | 0.132 | 0.4 |
| *Isachne miliacea* | 2.30(1.82) | 1.40(1.52) | 1.60(1.61) | 1.30(1.51) | 1.73(1.65) | 1.00(1.38) | 1.53(1.58) | 2.10(1.75) | 0.121 | NS |
| *Leptochloa chinensis* | 2.97(1.95) | 1.07(1.43) | 1.20(1.46) | 1.87(1.68) | 1.87(1.68) | 2.40(1.83) | 2.77(1.93) | 4.43(2.33) | 0.124 | 0.377 |
| *Oryza sativa* | 1.83(1.68) | 1.83(1.68) | 1.40(1.55) | 0.53(1.22) | 1.33(1.53) | 1.60(1.61) | 2.23(1.80) | 2.37(1.83) | 0.083 | 0.251 |
| **Sedges** |
| *Cyperus difformis* | 1.07(1.42) | 0.53(1.22) | 0.53(1.22) | 0.63(1.27) | 0.83(1.34) | 0.77(1.31) | 0.30(1.13) | 1.43(1.55) | 0.128 | NS |
| *Cyperus iria* | 1.73(1.65) | 0.73(1.31) | 1.07(1.43) | 1.20(1.45) | 1.10(1.45) | 1.20(1.48) | 1.77(1.66) | 0.93(1.38) | 0.104 | NS |
| *Monochoria vaginalis* | 0.77(1.31) | 1.07(1.42) | 0.43(1.18) | 0.77(1.31) | 0.87(1.35) | 0.87(1.32) | 1.40(1.54) | 1.00(1.41) | 0.138 | NS |
| *Fimbristylis miliacea* | 0.97(1.37) | 0.73(1.29) | 0.97(1.39) | 1.07(1.43) | 0.63(1.25) | 0.97(1.39) | 0.77(1.31) | 1.53(1.59) | 0.142 | NS |
| **Broad leaf weeds** |
| *Eclipta prostrata* | 0.63(1.27) | 0.60(1.24) | 0.30(1.13) | 0.63(1.25) | 0.73(1.30) | 0.87(1.35) | 0.73(1.30) | 0.77(1.31) | 0.133 | NS |
| *Sphenoclea zeylanica* | 0.10(1.04) | 0.30(1.13) | 0.53(1.22) | 1.07(1.40) | 0.53(1.22) | 0.40(1.18) | 0.43(1.17) | 0.53(1.22) | 0.125 | NS |
| *Limnocharis flava* | 0.77(1.31) | 0.63(1.27) | 0.10(1.04) | 0.20(1.08) | 0.20(1.09) | 0.30(1.13) | 0.73(1.31) | 0.87(1.34) | 0.095 | NS |
| *Lindernia grandiflora* | 0.87(1.34) | 0.20(1.09) | 1.07(1.42) | 0.33(1.13) | 0.87(1.36) | 0.73(1.29) | 0.40(1.18) | 0.30(1.13) | 0.115 | NS |

**Table 7.** **Species composition of major weeds at 40 DAT**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments****Table 7.** **Species composition of major weeds at 40 DAT****40 DAT** | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **T8** | **SEm (±)** | **CD (0.05)** |
| **Grasses** |
| *Echinohloa colona* | 1.87(1.68) | 1.87(1.61) | 2.53(1.87) | 2.17(1.74) | 1.43(1.54) | 1.43(1.51) | 1.43(1.51) | 2.93(1.96) | 0.243 | NS |
| *Echinochloa crusgalli* | 1.30(1.47) | 1.83(1.67) | 2.07(1.74) | 2.30(1.80) | 2.30(1.82) | 2.63(1.89) | 1.97(1.69) | 0.43(1.17) | 0.147 | NS |
| *Isachne miliacea* | 2.40(1.82) | 1.30(1.47) | 1.60(1.61) | 1.83(1.67) | 1.97(1.71) | 1.00(1.38) | 1.60(1.61) | 2.10(1.75) | 0.151 | NS |
| *Leptochloa chinensis* | 1.50(1.58) | 2.07(1.72) | 1.17(1.45) | 1.93(1.70) | 1.77(1.65) | 1.73(1.62) | 2.20(1.77) | 0.77(1.29) | 0.174 | NS |
| *Oryza sativa* | 1.63(1.61) | 1.73(1.65) | 1.30(1.51) | 0.53(1.22) | 1.20(1.44) | 1.83(1.67) | 1.63(1.60) | 2.67(1.91) | 0.142 | NS |
| **Sedges** |
| *Cyperus difformis* | 0.20(1.09) | 0.30(1.13) | 0.77(1.31) | 0.43(1.18) | 0.20(1.09) | 0.60(1.26) | 0.53(1.22) | 0.83(1.34) | 0.098 | NS |
| *Cyperus iria* | 0.43(1.18) | 0.43(1.18) | 0.53(1.22) | 0.60(1.26) | 0.60(1.26) | 0.50(1.22) | 0.10(1.04) | 0.87(1.36) | 0.084 | NS |
| *Monochoria vaginalis* | 0.97(1.39) | 0.77(1.29) | 0.20(1.09) | 0.30(1.13) | 0.83(1.33) | 0.30(1.13) | 1.17(1.46) | 0.10(1.04) | 0.118 | NS |
| *Fimbristylis miliacea* | 0.63(1.27) | 0.63(1.27) | 0.50(1.22) | 0.87(1.36) | 0.53(1.22) | 0.63(1.26) | 0.40(1.17) | 0.53(1.22) | 0.100 | NS |
| **Broad leaf weeds** |
| *Eclipta prostrata* | 0.10(1.04) | 0.33(1.13) | 0.20(1.09) | 0.33(1.13) | 0.20(1.08) | 0.77(1.32) | 0.77(1.31) | 0.77(1.32) | 0.100 | NS |
| *Sphenoclea zeylanica* | 0.63(1.27) | 0.40(1.18) | 0.40(1.18) | 0.30(1.13) | 0.30(1.13) | 0.10(1.04) | 0.40(1.18) | 0.30(1.13) | 0.052 | NS |
| *Limnocharis flava* | 0.53(1.22) | 0.40(1.18) | 0.20(1.08) | 0.63(1.27) | 0.10(1.04) | 0.30(1.14) | 0.30(1.13) | 0.20(1.08) | 0.079 | NS |
| *Lindernia grandiflora* | 0.30(1.13) | 0.20(1.08) | 0.33(1.13) | 0.20(1.09) | 0.73(1.29) | 0(1.00) | 0(1.00) | 0.30(1.13) | 0.09 | NS |

**Conclusion:**

It can be concluded from the present study that Zn nutrition had a significant influence on weed population in rice. Nutri priming with Nano Zn at 0.05% followed by foliar application of Nano Zn at 0.05% at maximum tillering stage was found superior for weed competitiveness in transplanted rice.

**REFERENCES**

Alloway, B.J. 2001. *Zn-the vital micronutrient for healthy, high-value crops.* (VOL.). Brussels, Belgium: Zn in Soils and Crop Nutrition. *20th October 2024.*

Ashraf U, Hussain S, Sher A, Abrar M, Khan I., and Anjum SA. 2018. Planting geometry and herbicides for weed control in rice: implication and challenges, grasses as food and feed, Zerihun Tadele, *Intech Open* doi:10.5772/intechopen.79579

Barman, H., Das, S.K., and Roy, A. 2018. Zn in soil environment for plant health and management strategy. *Universal Journal of Agricultural Research.* 6(5):149-154.

Broadley, M., Brown, P., Cakmak, I., Rengel, Z., and Zhao, F. 2012. Function of nutrients: micronutrients. In: Marschner, P (Ed.), Marschner’s mineral nutrition of higher plants, 3rd edn. Academic Press, *San Diego*, pp. 191–248.

Chauhan, B.S and Johnson, D.E. 2011. Row spacing and weed control timing affect yield of aerobic rice. *Field Crops Research*. 121 (2):226–231.

Chauhan, B.S., Awan, T.H., Abugho, S.B., Evengelista, G., and Sudhir-Yadav. 2015. Effect of crop establishment methods and weed control treatments on weed management, and rice yield. *Field Crops Research*. 172; 72–84.

Das, S.K., Avasthe, R.K., Singh, M., Dutta, S.K.& Roy, A. 2018. Zn in plant-soil system and management strategy*. Agrica, 7(1)*,1-6.

Directorate of Economics and Statistics (DES). 2019. Directorate of economics and statistics DAC&FW, department of agriculture, cooperation and farmers welfare ministry of agriculture and farmers welfare. Govt. of India. https://www. agricoop.nic.in/directorate-economics-and-statistics

El-Metwally, I.M., and Saudy, H.S. 2020.Interactive Application of Zinc and Herbicides Affects Broad-leaved Weeds, Nutrient Uptake, and Yield in Rice. *Journal of Soil Science and Plant Nutrition.* 21(1):1-11.

Han, J.L., Li, Y.M., and Ma, C.Y. 2004. The impact of zinc on crop growth and yield (review). Journal of Hebei Normal university of science and technology. 18: 72–75.

Hasanain, M., Shukla, D.K., Singh, R.K., Gouda, H.S., Sadhukhan, R., Singh, V.K., and Kumar, J. 2019. Effect of fertility levels and weed-management practices on weed-control efficiency, yield and nutrients uptake in summer mung bean (*Vigna radiata*). *Indian Journal of Agronomy.* 64 (3): 418-421.

Jehangir, I.A., Hussain, A., Sofi, N.R., Wani, S.H., Ali, O.M., Abdel Latef, A.A.H., Raja, W., and Bhat, M.A. 2021. Crop Establishment Methods and Weed Management Practices Affect Grain Yield and Weed Dynamics in Temperate Rice. *Agronomy.* 11: 2137.

Mahajan, G and Timsina, J. 2011. Effect of nitrogen rates and weed control methods on weeds abundance and yield of direct-seeded rice. *Archives of Agronomy and Soil Science*. 57:3, 239-250.

Malhotra, H., Vandana, Sharma, S., and Pandey, R. 2018. Phosphorus Nutrition: Plant Growth in Response to Deficiency and Excess. In: Hasanuzzaman, M., Fujita, M., Oku, H., Nahar, K., Hawrylak-Nowak, B. (eds) Plant Nutrients and Abiotic Stress Tolerance. *Springer, Singapore.*

Nongbet, A., Mishra, A.K., Mohanta, Y.K., Mahanta, S., Ray, M.K., Khan, M., Baek, K.H., and Chakrabartty, I. 2022. Nanofertilizers: A Smart and Sustainable Attribute to Modern Agriculture. *Plants.* 11: 2587.

Rao, A.N., Wani, S.P., Ramesh, M., and Ladha, J.K. 2015. Weed and weed management of rice in Karnataka state, India. *Weed Technology*. 29(1):1–17.

Sánchez-Rodríguez, A.R., del Campillo, M.C., and Torrent, J. 2017. Phosphorus reduces the zinc concentration in cereals pot-grown on calcareous Vertisols from southern Spain. Journal of The Science of Food and Agriculture. 97: 3427–3432.

Sasaki, H., Hirose, T., Watanabe, Y., and Ohsugi, R. 1998. Carbonic anhydrase activity and CO2 transfer resistance in Zn–deficient rice leaves. *Plant Physiology.* 118:929–934.

Saudy, H.S., El–Metwally, I.M., and Shahin, M.G. 2021. Co–application effect of herbicides and micronutrients on weeds and nutrient uptake in flooded irrigated rice: Does it have a synergistic or an antagonistic effect. *Crop Protection*. 149: 105755.

Sharma, A., Patni, B., Shankhdhar, D., and Shankhdhar, S.C. 2013. Zn - An Indispensable Micronutrient. *Physiology and Molecular Biology of Plant.* 19(1):11–20.

Storey, J.B. 2007. Zinc. In: Barker AV, Pilbeam DJ (eds) Handbook of plant nutrition. CRC Press, Taylor& Francis Group, Boca Raton, pp 411–436.

Watts-Williams, S.J., Turney, T.W., Patti, A.F., and Cavagnaro, T.R. 2014. Uptake of zinc and phosphorus by plants is affected by zinc fertilizer material and arbuscular mycorrhizas. *Plant Soil*. 376: 165–175.

Yadav, A., Yadav, K., and Abd-Elsalam, K.A. 2023. Nanofertilizers: Types, Delivery and Advantages in Agricultural Sustainability. *Agrochemicals.* 2: 296–336.

 Zhang, Y.Q., Deng, Y., Chen, R.Y., Cui, Z.L., Chen, X.P., Yost, R., Zhang, F.S., and Zou, C.Q. 2012. The reduction in zinc concentration ofwheat grain upon increased phosphorus-fertilization and its mitigation by foliar zinc application. *Plant Soil*. 361: 143–152.