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Levels of Zinc Application on the Agronomic Characteristics and Yield Performance of Lowland Rice

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ABSTRACT

Since Rice is indispensable to almost all Filipino as their primary food, it is necessary to aim an additional greater harvest as an ultimate objective. The study was conducted to determine if there were significant differences in growth performance and on the yield of lowland rice applied with zinc sulfate at different levels. The experimental area was divided into four blocks for the number of replications and each block was further divided into 5 plots for the number of treatments adopting the Randomized Complete Block Design (RCBD). The following treatments were: T_0-control-without application of zinc sulfate, T_1-5kg of zinc sulfate, T_2-10kg of zinc sulfate, T_3-15kg of zinc sulfate and T_4 -20kg of zinc sulfate. Results showed significant differences in the plant height, the number of tillers, percentage of bearing culm, length of the panicle, percentage of filled and unfilled grains, grain yield per hill, grain yield per treatment, the weight of 1000 grains, except the number of grains per panicle. Maximum paddy yield was achieved in Treatment $_4$ (20kg zinc sulfate) and the minimum paddy yield was noted in treatment control (no zinc sulfate application). Zinc application increases the crop growth rate and yield of rice.

Keywords — Zinc sulfate, Growth performance, lowland Rice, Agronomic Characteristics, Plant nutrition, Basal Application, Philippines

INTRODUCTION

Rice (Oryza sativa L.) is the most important staple food crop worldwide for nearly half of the world population. In the Philippines, most of the Filipino depend on rice as their principal food. More is consumed compared to other foodstuffs, especially in Asia, where rice is eaten in large quantities (Watson & Center, 1995). Population in most rice consuming nation are among the highest in the world and in many of them the rate of population increase is alarming (Srivastava & Mahapatra, 2012). If the world's population continues to grow as predicted for the next 20 years, global cereal yield must increase 80% over the 1990 average to feed these additional people. Demands for the rice are expected to increase approximately in line with population increases and countries that have traditionally exported rice may face difficulty in producing food enough for their own population (De Datta, 1981). Compounding the problem is that areas of productive farmland continue to be lost through urbanization and degradation of existing agricultural soils (IRRI, 2002).

An adequate and balanced supply of plant nutrient is a pre-requisite to maximize rice production. The maximum utilization of plant nutrients either derived from inherent soil fertility or supplied through fertilizer for optimum growth and yield (Srivastava & Mahapatra, 2012). In addition to adequate irrigation water, balanced supply of macro and micronutrients is vital for bridging this yield gap. After nitrogen (N), phosphorus (P) and potassium (K), widespread zinc (Zn) deficiency has been found responsible for yield reduction in rice (Fageria, Baligar, & Clark 2002; Quijano-Guerta, Kirk, Portugal, Bartolome, & McLaren, 2002). Zinc is a micronutrient and is essentially required in traces for the proper growth of rice plants (Jones and Jarvis, 1981). Zn deficiency is the most widespread micronutrient disorder in lowland rice and application of Zinc along with NPK fertilizer increase the grain yield dramatically in most cases (Fageria, Slaton, & Baligar, 2003; Singh, Meena, & Bharati 2011).

To feed the ever-rising world population, which is estimated to be 10 billion by the end of this century, an increase in rice production per unit area is direly needed. Although high-yielding input-responsive varieties are available, a large yield gap exists between the farmers' fields and research station in developing countries

Development of modern technology alone, however, may not increase yields and production of rice in a given country. The technology must be tested and adopted on farms and any constraints at the farmer's level determined. In some instances, technology will need to be modified based on the results from the farm level testing. On the other hand, limited study has been done on zinc application and on its supplementation at a different level to rice, hence, the study was conducted.

OBJECTIVES OF THE STUDY

Keeping in view of the role of micronutrients in present-day agriculture, the study was; therefore, conducted to evaluate the difference in growth performance and to determine the significant difference in the yield of lowland rice applied with different levels of zinc.

METHODOLOGY

The experimental field was divided into 4 blocks for the number of replication and each block was divided into 5 plots for the number of treatments adopting the randomized complete block design (RCBD) having a net plot size of 2m x 10m.There were 15 representative plants in every treatment. The field experiment was conducted at the agricultural farm at Namnama, Titay, Province of Zamboanga Sibugay Philippines during the dry season of 2017. All the facilities necessary for cultivation, including labor, irrigation was readily available.

Soil samples were taken randomly in the area before land preparation and soil samples were submitted to the Bureau of Soils Department of Agriculture Zamboanga City for Analysis. The experimental field was prepared thoroughly by plowing and harrowing twice. Leveling was done before planting to ensure even distribution of water on the experimental field. Wet bed method of seedling preparation was adapted. It was prepared by alternate plowing and harrowing the soil. After the soil was puddled, slight elevated seedbed were made and slope along the side to allow surface drainage. The seeds were loosely placed in two sacks soaked in clean fresh water for 36 hours. The sacks were removed from the water and laid flat on the dry shaded place for another 24 hours for the incubation of seed to enhance uniform germination, the pre-germinated seeds were broadcasted in the seedbed.

Pulling the seedlings was done 21 days after sowing. The seedbed was flooded with water to soften the soil and facilitate the pulling of young seedlings. Zinc sulfate was applied basally during the last harrowing to allow incorporation of fertilizers in the soil. The recommended application of zinc sulfate per treatments were as follows: T_0- no application, T_1- 5 kg/ha of zinc sulfate, T_2- 10 kg/ha of zinc sulfate, T_3- 15 kg/ha of zinc sulfate, T_4- 20 kg/ha of zinc sulfate while the application of urea (46-0-0), muriate of potash (0-0-60) and complete fertilizer (14-14-14) was applied following the recommended rate.

Transplanting was done manually at the rate of 1seedling per hill with a distance of 20 cm between rows and 20 cm between hills to obtain maximum plant population throughout the area. Proper spacing at transplanting was done by using a wooden marker. Three (3) days after transplanting, all missing hills were replanted using the extra seedlings. Three days after transplanting the experimental area was flooded at 3-5 cm depth. Water was provided and drained intermittently as necessary during the vegetative and productive growth stages of rice plants. At the ripening stage, water was gradually withdrawn from the field and finally drained at the last week of the ripening stage.

The experimental field was kept clean throughout the growing period of the rice plants and the presence of weeds was minimized by manual weeding. The infestation of insect pest and fungal diseases were prevented from the start-up to the harvest. Application of the appropriate chemicals was done by following the recommended dosage. Bird pest was prevented with a scarecrow, noisemaker and etc.

Rice was harvested when they reached its physiological maturity when approximately 85% of grains of the panicles are matured. This was done by cutting the rice straw below the panicle using the sickle and the harvested rice was bundled. All representative plants were harvested ahead and carefully labeled for data gathering. Threshing of the representative plants was done manually. The chaffs were removed through the fanning method for further separation of the filled and unfilled grains. Filled grains were weighed as a basis for total harvested grains. Yield collected from the representative plants was placed in a labeled container for the data collection. Data were taken from sundried grains at 14% moisture content.

RESULTS AND DISCUSSION

Table 1. Summary of the Height of the Representative Plants, Number of Tillers, Percentage of Bearing Culm, Number of Grains Per Panicle, Length of the Panicle

Treatment	Height of Representative Plants (cm)			Number of tillers			Percentage of bearing culm (%)[G]	Number of grain per Panicle[H]	Length of Panicle (cm)[I]
	30[A] days	60 [B] Days	DBH[C]	30[D] Days	60[E] Days	DBH[F]			
T_0- Control	76.88 [b]	93.72[b]	95.55[b]	14.70[c]	13.98[c]	11.67[b]	88.84[c]	143.65	22.96[b]
T_1- 5 kg of zinc sulfate	77.55[b]	95.15[ab]	96.19[b]	15.05[c]	13.98[c]	12.30[ab]	91.84[bc]	153.47	23.13[b]
T_2- 10 kg of zinc sulfate	77.81[b]	95.66[ab]	97.37[b]	15.70[bc]	14.78[bc]	12.83[ab]	95.69[abc]	146.42	23.19[b]
T_3- 15 kg of zinc sulfate	77.98[b]	95.14[ab]	96.73[b]	16.33[b]	15.02[ab]	12.25[ab]	97.15[ab]	161.3	23.91[ab]
T_4- 20 kg of zinc sulfate	81.39[a]	97.70[a]	98.48[a]	17.83[a]	15.75[a]	13.78[a]	99.83[a]	162.7	24.82[a]
F- test	**	*	**	**	**	**	**	Ns	**
CV%	1.65	1.36	4.17	3.61	3.04	4.14	3.64	6.32	2.34

Note: Treatment means with the same letter superscript do not significantly differ using ANOV and DMRT.

Height of the representative plants. Plant height is an important morphological attribute; it is a function of combined effects of the genetic makeup of a plant, soil nutrient status, seedling vigor and the environmental conditions under which it is grown. As shown in Table 1.0 the height of plants at 30, 60 and a day before harvest were significantly affected by the application of the different levels of zinc sulfate.

At 30 days after transplanting, the rice plants that were in T_4 were significantly the tallest with an average height of 81.31 cm. No significant difference was observed in rice plants in T_3 with an average height of 78.89 cm, T_2 with an average height of 77.81 cm and T_1 with an average height of 77.55 cm including the T_0 control which gave the shortest height of 76.88cm.

At 60 days after transplanting, T_4 resulted to the tallest average height of 97.70 cm, which statistically differed in T_0 which gave the shortest average height of 93.72 cm but do not have a significant difference with treatments 1, 2 and 3 respectively.

On a day before harvest, the heights of the rice plants statistically differed, plants in T_4 were the tallest with 98.48 cm and it differs significantly to those in T_3 with 96.73 cm, followed by those plants in T_2 and T_1 which had an average height of 97.37 cm and 96.19 cm, respectively. The shortest was obtained by plants in T_0 with an average height of 95.55 cm.

The result above finds support from the findings of Cheema, Noor, & Khan (2006) who noted an increase in the rice plant height with the application of zinc sulfate. A similar result was reported by Khan (2007), Salam and Subramanian (1993), Sakal, Sinha, Singh, and Bhogal (1993), Kausar, Ali, & Iqba (2001), Bodruzzuman et al., (2002) and Mehla, Singh, Sekhon, Sihag, & Bhardwaj (2006).

Number of tillers. The number of tillers was significantly different at 30, 60 and a day before harvest and is presented in Table 1.0. At 30 days after transplanting, results showed that plants in T_4 significantly had the highest number of tillers with an average of 17.83, and differed statistically from plants in T_3 of 17.83, with an average number of 16.33 but also statistically did not vary to those plants in T_2 which gave an average number of tillers of 15.70. Results further show that this is comparable with plants in T_1 with an average of 15.05. The fewest tillers were obtained by plants in T_0 with an average tiller of 14.70.

At 60 DAT, data showed that T_4 produced more tillers with an average of 15.75 which did not significantly different to those in T_3 with an average of 15.02. No significant difference was also observed between those plants in T_3 and T_2 with an average number of 15.02 and 14.78, respectively. Plants in T_2 were also statistically similar with those of plants in T_1 with 13.98 including those without zinc application T_0 which obtained the fewest number of average tillers with 13.98.

A day before harvest (DBH), plants in T_4 obtained the greatest number of tillers in an average of 13.78 but did not differ to those plants in $_{T3}$ and T_2 which obtained an average tiller of 13.25 and 12.83, respectively. No significant difference was also observed between plants in T_2 and T_1. The fewest number of tillers was obtained in T_0 with an average number of tillers of 11.67 and did not differ to those plant in T_1 which obtained an average of 12.30. Similar results were observed by Ghoneim (2016), Cheema, Noor, & Khan (2006) and Ahmad (1988) who stated that the number of tillers per hill markedly increased when zinc sulfate was applied to the soil in combination with N, P and K. Similarly, Slaton, Gbur, Wilson, and Norman (2005) reported that application of zinc significantly affected total numbers of tillers.

Percentage of bearing culm. The application of different levels of zinc sulfate shows a significant difference in the percentage of bearing culm as shown in Table 1.0. T_4 obtained the highest percentage of bearing culm of 99.83, comparable to those plants in T_3 with the average of 97.15 figuratively, and T_2 with 95.69 percent, and differed significantly to those plants in T_0 which obtained the lowest percentage of bearing culm but it did differ statistically to those plants in T_2 and T_3 respectively. The yield of rice crop depends on the growth history and other yield contributing factors such as a number of productive tillers and grain weight (Sarwar, Ali, Ahmad, Ullah, Ahmad, Mubeen, & Hill, 2013). Increasing doses of zinc with irrigation improve crop performance. These results are in accordance with Naik and Das (2007); who reported that an adequate supply of zinc produced a greater number of productive tillers per m^2.

Number of grains per panicle. The number of grains per panicle is presented in Table 1.0. Results showed that plants in T_4 obtained the highest number of grains per panicle with an average of 162.70, followed by those plants in T_3, T_2 and T_1 of zinc sulfate application with an average of 161.30, 146.42 and 153.47, respectively. The least number of grains per panicle was obtained by those plants in T_0 with an average of 143.65. However, analysis of variance (ANOV) revealed that there were no significant differences among treatment means. The result implied that the application of zinc sulfate did not affect the number of grains per panicle.

Length of Panicle. The length of a panicle of rice plants in response to the different levels of zinc sulfate application is shown in Table1.0. Results showed that plants in T_4 significantly have the longest length of panicle with an average of 24.82cm but did not differ significantly with those plans in T_3. No significant differences were observed between those plants in T_3, T_2 and T_1 with an average length of 23.91 cm, 23.19, and 23.13 cm respectively. The shortest length of panicle was obtained by those plants without zinc sulfate application T_0 with an average length of 22.96 cm. The result implies that the application of zinc sulfate had significantly affected the length of a panicle of the rice plant. This result is supported by the investigation of Ghoneim (2016), who found that the application of zinc sulfate significantly produced longer panicle length than control. These results are in line with the findings of Hung, Beltaran, Muniz and Estrada (1990) and Maqsood, Irshad, Wajid, and Hussain, (1999) they reported that an adequate supply of Zinc to rice increased its panicle length.

Table 2. Summary of the Percentage of Filled Grains, Unfilled Grains, Grain Yield per Treatment and Weight of 1000 Grains

Treatment	Percentage of filled Grains (%) ^{A}	Percentage of unfilled grains (%) ^{B}	Grain yield per hill (g) ^{C}	Grain yield per Treatment (kg) ^{D}	Weight of 1000 Grains (g) ^{E}
T_0- Control	80.18^{c}	19.80^{b}	21.48^{c}	3.56^{b}	27.25^{d}
T_1- 5 kg of zinc sulfate	81.25^{bc}	18.73^{b}	22.05^{c}	3.73^{ab}	27.25^{d}
T_2- 10 kg of zinc sulfate	81.24^{bc}	19.43^{b}	22.78^{abc}	3.87^{ab}	28.75^{c}
T_3- 15 kg of zinc sulfate	82.79^{ab}	17.20^{ab}	23.90^{ab}	3.82^{ab}	29.50^{b}
T_4- 20 kg of zinc sulfate	84.24^{a}	15.75^{a}	25.05^{a}	4.28^{a}	30.25^{a}
F-test	**	**	**	*	**
CV (%)	1.16	7.66	3.55	7.21	1.19

Note: Treatment means with the same letter superscript do not significantly differ using ANOV and DMRT.

<u>Percentage of filled grains.</u> As shown in Table 2.0 result shows significant differences in the percent filled grains. Plants in T_4 obtained the highest percentage of 84.34 but did not differ to those plants in T_3 with an average of 82.79 percent. No significant difference was also observed between plants applied with 15 kg, 10 kg and 5kg of zinc sulfate application with an average of 82.79, 81.24, and 81.25 percent, respectively. The lowest percentage of filled grains was obtained by those plants in T_0 with an average of 80.18. The result implies that the application of different levels of zinc sulfate had affected the average percentage of filled grains of rice plants.

This result is in conformity with the findings of Ravikiran and Reddy (2004); Khan, Qasim, Subhan, Jamil, & Ahmad (2003); Ram, Chauhan, and Singh (1995) who stated that among different treatment, the lowest number of filled grains was produced with the treatment T_0.

<u>Percentage of unfilled grains.</u> The application of the different levels of zinc sulfate shows a significant difference among treatments on the percentage of the unfilled grains as shown in Table 2.0. T_0 obtained the highest percentage of unfilled grains of 19.80 but did not differ to those plants in T_2 of 19.43, followed by T_1 with 18.73, and by T_3 with 17.20 percent. The result shows further that the lowest percentage of unfilled grains was obtained by plants in T_4 with an average percentage of 15.75 and comparable to T_3 with 17.20.

Grain yield per hill. Based on the result of the study, the grain yield per hill of rice plant was significantly affected by the different levels of zinc sulfate application as presented in Table 2.0. Plants in T_4 (20 kg of zinc sulfate application) obtained the heaviest weight of grains with 25.05 g but did not differ to plants in T_3 with 23.90 g. Plants in T_2 with 22.78g did not significantly differ with those plants in T_1 with 22.05 including T_0 which give the lightest weight of grains with 21.48. The result implied that the grain yield per hill of rice was significantly affected by the application of the different levels of zinc sulfate. The result is in accordance with Shivay, Kumar, Prasad, and Ahlawat, (2008) who reported that the application of zinc sulfate had increased the grain and straw yield of rice crop. These findings are in line with that of Rahman et al. (2011) who reported an improvement in the grain weight with the soil application of zinc sulfate in rice crop.

Weight of 1000 grains (g). The weight of 1000 grain of rice in response to the application of the different levels of zinc sulfate is presented in Table 2.0. Results showed that the plants in T_4 had significantly obtained the heaviest weight of 30.25 g followed by those plants in T_3, T_2 with 29.50 g and 28.75 g respectively. The lightest was obtained by those plants in T_0 with 27.25g, the comparable weight of 1000 grains to T_1. The result implies that on the weight of 1000 grains of rice were significantly affected by the application of zinc sulfate. This finding is in line with that Rahman et al. (2011) who reported an improvement in the grain weight with the soil application of zinc sulfate in rice crop. These findings are in line with results of Ghani, Shah, & Khan (1990) Naik and Das (2007); who reported that soil application of Zinc increased 1000-grain weight of rice.

Grain yield per treatment (kg). The application of the different levels of zinc sulfate to the rice plants resulted in a statistical difference in grain yield per treatment as presented in Table 2.0 Plants in T_4 obtained the heaviest weight of 4.28 kg but did not differ significantly to those plants in treatments T_3, T_2, and T_1 with 3.73 kg in that order and the lightest weight of grain yield per treatment was obtained by plants in T_0. The results implied that the grain yield per treatment of the rice plants significantly affected by the application of the different levels of zinc sulfate.

The result is in accordance with the findings of Harris, Rashid, Miraj, Arif, and Shah (2007) Obrador, Novillo, and Alvarez (2003) and Biswapati (2002). Similarly, Shivay, Kumar, Prasad, and Ahlawat, (2008) who reported that the application of zinc sulfate increased the grain and straw yield of rice crop. These results are in line with the findings of Gupta and Kala; Rehman et at. They reported that soil application of Zinc increased paddy yield. Although, the application of zinc sulfate significantly affected the growth and yield parameters of rice then it did not obtain the average expected yield. The blast was observed in tillering and flowering stages of rice growth. On leaves, the diseases first appear as small lesions. The center of the spot becomes pale green or dull greyish green and margin of the spot turn's dark brown. Similar spot developed on the sheath. The node of the culm becomes infected towards maturity and becomes blackened just below the panicle. Often most of the grain in the infected panicle become chaffy. PhilRice (2012) mentioned that rice pest, big or small, can cause massive yield loss of up to 100%.

Rice blast is known approximately 60% to 100% yield losses. It is caused by an ascomycete a fungus called Magnafortheoryzae (Kihoro, Bosco, Murage, Ateka, & Makihara 2013). Disease lesion was observed on node infection occurs in banded pattern, it turns into blackish or grayish brown, the infected nodes can cause rice culm on the part of the plant that holds the panicle to break, lesion in the neck are also grayish brown and can cause girdling, making the neck and the panicle fall over. According to (Shahijahan et al. 2010) paddy blast generally considered as the principal disease of rice. Kihoro (2013) revealed that the disease is the most destructive disease compare to other diseases.

Heavy yield losses have been reported in many rice-growing countries for example 75, 50 and 40 percent grain loss may occur in India (Padmanabhan, 1965), Philippines and Nigeria (Awoderu & Esuruoso, 1974), and in serious outbreaks of the disease up to 100 percent of yield could be lost.

CONCLUSIONS

The present study aimed to provide the most suitable technology to overcome Zn deficiency in rice, by comparing the effects of different levels of Zn application on rice growth and yield. Treating the soil with Zn fertilizer has been found to enrich it with utilizable plant nutrients associated with enhancing the yield of rice crop. It can be concluded from these results that amending the soil with Zn fertilizer at 20 kg. per ha. was found the most appropriate dose for higher yield of the rice crop.

TRANSLATIONAL RESEARCH

The findings of the study may be best translated to various media of communication for information dissemination and promotion through extension

(RD&E) programs and activities of the agriculture sector. Results also can be made available to relevant government agencies related to rice production program to augment the production of rice and to alleviate the economic condition of the local rice growers and to help them stay afloat.

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