Plant Archives Vol. 19, Supplement 2, 2019 pp. 2181-2184 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IMPROVING RICE GRAIN QUALITY BY FOLIAR APPLICATION OF PLANT GROWTH REGULATORS UNDER VARIOUS MODE OF Zn APPLICATION

Suresh Kamboj and Bhupendra Mathpal*

School of Agriculture, Lovely Professional University, Phagwara, Punjab, India, 144411

Corresponding author: Dr. Bhupendra Mathpal

Assistant Professor, School of Agriculture

Lovely Professional University, Phagwara, Punjab, India, 144411

E-mail: mathpal.88@gmail.com

Abstract

Zinc (Zn) deficiency was found as an important aspect for the production of rice in many parts world as well as of India. To evaluate the effect of different plant growth regulators on translocation and Zn content in the grains, two rice varieties namely PB1509 and PB1121, were examined under different zinc application methods i.e. control (no zinc), soil application (5mg Zn/kg of soil) and foliar application (0.5% $ZnSO_4$ at 30, 60 and 90 DAT). Plant growth regulators i.e. gibberellic acid (GA_3) (20 ppm) and cytokinin (20 ppm), were used to enhance translocation of the Zn from vegetative parts to the grains of the rice. Among all the treatments tested in study, a combined foliar application of 0.5% $ZnSO_4$ solution along with 20 ppm cytokinin was found most effective in increasing grain yield, 100 seed weight and protein content while enhanced Zn content of grains was recorded at a combination of 0.5% $ZnSO_4$ and 20 ppm GA_3. Thus, results clearly indicated that application of plant growth regulators can be helpful to improve Zn and grain protein content, so need further testing.

***Keywords*: Zinc, plant growth regulators, translocation, Zn accumulation in grains.**

Introduction

Zinc (Zn) is considered as one of the important micronutrient for the better growth of plants, humans and animals. Zinc deficiency severely affects growth and development of nearly all the organism (Mathpal *et al.,* 2014). For normal growth of rice plants, sufficient amount of Zn is required. Zinc plays an important role in chlorophyll formation, protein biosynthesis and carbohydrate metabolism in plants (Begum *et al.,* 2003). Applying Zn through soil, seed treatment or spraying on leaves of plants will increase the yield of plant. Rice with flood irrigation is highly susceptible for deficiency of Zn (Rehman *et al.,* 2012). Irrespective of its deficiency in soil, post harvest processing of rice grain makes it very poor source of Zn. Around 47% of Indian soils are deficient in Zn. Its critical limit varies according to soil, different crops and with various varieties of a crop. For rice, the critical limit was 0.74±0.18 ppm across different agro-ecological regions of India (Mathpal *et al.,* 2015b).

Zinc insufficiency is quite severe in plants as well in humans. More than 30% population of the world is suffering from the Zn deficiency (Welch, 2002). Zinc deficiency in plants can be seen in many ways such as stunted height, reduction in tiller number, smaller leaves and increase in crop maturity time, bad quality of produce or products (Hafeez *et al.,* 2013). The most common Zn deficiency symptoms in rice is chlorosis in the midrib of young leaves after 2-3 weeks of transplanting and appearance of brownish spots on older leaves. In case of no severe deficiency plants might recover within 4-5 weeks, but under severe deficiency conditions delayed maturity and reduced yield was recorded (Neue *et al.,* 1998). Deficiency of the Zn is cured by many ways such as Zn fertilizers application (as soil application and foliage spray or seed treatment/coating or dipping seedling roots in Zn solution), recycling crop residue, organic manures and cultivation of Zn efficient genotypes (Singh, 2008). In high pH soils, surface application is more effective than its soil incorporation (Dobermann and Fairhurst, 2000).

There are many barriers which inhibit the uptake of Zn at root surface and its further translocation to various plant parts. Most of the applied Zn accumulated at nodes of the stem and its loading into grain is also a rate limiting step (Sawmy *et al.,* 2016). Plant growth regulators, especially kinetin and gibberellic acid (GA) help in the translocation of the nutrients into different plant parts. Gibberellic acid and kinetin were reported to significantly increase the Zn, iron (Fe) and manganese (Mn) content in the barley. Nutrient uptake from the roots can be enhanced by the application of GA (Akman, 2009). Both the plant growth regulators were found to enhance growth in plants, chlorophyll content and yield attributes. A foliar spray of GA and kinetin increased solute accumulation, grain assimilate deposit and also found to increase soluble protein content in the rice (Khan *et al.,* 2016).

Therefore, an attempt has been made through this study to understand the effect of GA and kinetin to enhance translocation of Zn from vegetative parts towards grains of two rice genotypes.

Materials and Methods

Soil for the experiment was collected from agricultural field of Lovely Professional University, Punjab, India. Soil taken for experiment was sandy loamy in texture, 7.9 pH, 0.53 dS/m EC, 0.3% organic carbon, 368 kg/ha available nitrogen (N), 21 kg/ha available phosphorus (P), 270 kg/ha available potassium (K) and 2.3 mg/kg soil of Zn. Cemented pots of having 8 inches diameter and of 4 kg capacity were used. 22.3 mg of N, 18.5 mg of K and 11.6 mg of P/kg soil was applied in all the pots as a basal dose by using urea, KCl and KH_2PO_4, respectively. The experiment was conducted in three replications and detail of treatments tested in study is presented in table1. After the application Zn, soil was mixed thoroughly and irrigated while foliar spray of $ZnSO_4$ was done at 30, 60 and 90 days after transplanting. Plant growth regulators were applied 7 days after each foliar spray of $ZnSO_4$. In the later stages of crop growth, two doses of nitrogen were given through top dressing at 30 and 60 days of transplanting. Seedlings of both the varieties (PB1509 and PB1121) were raised in Zn deficient soil and three seedlings were transplanted in each pot after 21 days of sowing.

At maturity crop was harvested and separated into straw and grain part. Grain yield, straw yield and 100 seed weight was recorded and expressed as g/pot. Dehusking of grains was done manually and to remove surface contamination further washing was done sequentially by tap water, 0.1 N HCl and finally by distilled water. One gram of dehusked grains were digested in di-acid (HNO_3:$HClO_4$ in 4:1 v/v) and final volume was prepared 25 ml by distilled water. Atomic absorption spectrophotometer was used to determine Zn concentration in dehulled grains and expressed as µg/g dry weight of plant sample. Simultaneously protein content was estimated in dehulled grains after harvesting. Extraction and further quantification of protein was done by using the method used by (Mathpal *et al.,* 2015b). All the parameters were statistically analyzed by using analysis of variance (ANOVA) using SPSS16 and means were tested at 0.05% level of significance.

Results and Discussion

Grain yield, straw yield and seed index

Effect of different zinc application methods in combination with foliar spray of plant growth regulators on the grain weight, straw weight and seed index is presented in fig 1, fig 2 and fig 3 respectively. Variety PB1509 produced more grain yield and showed higher seed index in comparison to PB1121. Regarding effect of Zn application methods foliarly allied $ZnSO_4$ was found most useful in enhancing all the yield parameters in both varieties. Foliar application (0.5% $ZnSO_4$) and soil applied $ZnSO_4$ (5 mg Zn/kg soil) significantly enhanced the grain yield by 51.06% and 34.60% respectively, as compared to control. Foliarly applied Zn improved the straw yield by 10.18% followed by soil application which increased the straw yield by 8.21% in comparison to control. As compared to no zinc application, soil application method increased the average 100 grain weight by 3.5% while the foliar application enhanced the average 100 grain weight by 5.34%.

In regards effect of plant growth regulators on yield parameters of both the rice varieties foliar spray of 20 ppm cytokinin was found to increase grain yield and seed index more effectively while 20 ppm GA_3 was found more effective in increasing straw yield. Cytokinin application significantly increased average grain yield and seed index by 5.0% & 6.79% respectively as compared to without plant growth regulator application, whereas a percent increment of 41.73% was recorded by the application of 20 ppm GA_3. A combination of foliarly applied $ZnSO_4$ and 20 ppm cytokinin was found to be best to produce maximum average grain yield and 100 seed weight of both the varieties whereas, foliar spray of $ZnSO_4$ along with 20 ppm GA_3 was found more effective to increase average straw yield of both rice varieties.

A favorable effect of Zn application methods was revealed on grain yield, straw yield and seed index of both the rice varieties. An increment in grain weight and straw weight of both rice varieties was observed which might be due to possible role of Zn in chlorophyll biosynthesis, maintaining an optimum ratio of chl 'a' to chl 'b' and maintaining integrity of photosynthetic apparatus, which determine remobilization of carbohydrates from leaves to the grains (Mathpal *et al.,* 2015a). Higher grain yield and seed index of variety PB1509 showed better translocation efficiency in comparison to PB1121. These results are supported by findings of (Mathpal *et al.,* 2014) and (Mathpal *et al.,* 2015a), who reported maximum grain yield, straw yield and total dry matter by soil + foliar application of Zn. Regarding effect of plant growth regulator application on yield attributes, foliar spray of cytokinin was found more effectual in escalating grain yield and seed index. Increased grain filling by the application of cytokinin is might be due to its favorable effect on leaf longevity so that more and more carbohydrates will be translocated towards grains upto later stages of crop life cycle (Kaur *et al.,* 2015). These results found in accordance of (Khan *et al.,* 2016), who recorded a significant improvement in yield attributes by the foliar application of cytokinin.

Grain Zn content and total grain protein

Concentration of Zn and Protein content of rice grains was significantly affected by different zinc application methods and different plant growth regulator spray as shown in fig 4 and fig 5 respectively. Regarding effect of variety on grain Zn content, PB1121 accumulated significantly more Zn in grains as compared to variety PB1509 but no significant difference was found in average grain protein of both the rice varieties. Amongst all the Zn application methods, foliar spray of $ZnSO_4$ was found to be most effective in improving both Zn as well as protein content of grains of both the varieties. An increase in the average grain zinc content of 57.19% and 36.54% was recorded by the foliar spray and soil application of $ZnSO_4$ as compared to control, respectively. Among all the combinations used in study, foliarly applied 0.5% $ZnSO_4$ solution and spray of 20ppm GA_3, resulted maximum Zn content in grains of both the varieties.

In comparison to no Zn application, foliar application of $ZnSO_4$ significantly increased the average grain protein content by 20.31% while soil application increased the average protein content of grains by 14.04%. Both Zn level and protein content of grains was significantly affected by the application of plant growth regulators. Application of GA_3 was found to be more effective in increasing grain Zn content and enhanced the same by 34.7% while an increment of 23.06% was recorded by the foliar spray of cytokinin in comparison to no plant growth regulator application. A higher percent increment of 14.71 in grain protein content was recorded by foliar spray of cytokinin while foliar application of GA_3 enhanced protein content in grain by 8.2%. Both the rice varieties responded well under combined foliar application of 0.5% $ZnSO_4$ with 20 ppm cytokinin in improving grain protein content.

Zinc (Zn) concentration in grains showed an increment with increasing levels of Zn and maximum content was estimated by foliar application of $ZnSO_4$ + 20 ppm GA_3. Although, applied plant growth regulators showed favourable response in increasing accumulation of Zn in grains as compared to control but GA_3 was found more effective in increasing average Zn content in grains. Gao *et al.* (2012) attributed the difference in physiological processes in rice determining the Zn accumulation in grains to genotypic variation in grain zinc concentration. Recently, highest Zn concentration in grains of wheat was also reported under soil along with foliar application of $ZnSO_4$ (Mathpal *et al.,* 2015a).

Irrespective to the results of Zn content in grains maximum grain protein content was recorded at foliar application of $ZnSO_4$ with 20 ppm cytokinin. It might be due to that Zn regulates gene expression by being a part of many regulatory proteins, hence increase transcription and translation (Roy *et al.,* 2012). Regarding favourable effect of cytokinin, it might increases translocation of synthesised proteins towards grain by increasing longevity of leaves thus resulted in higher grain protein content. Mathpal *et al.* (2015b) reported maximum protein concentration in wheat grains under soil+foliar application of $ZnSO_4$. A positive relationship between increasing Zn doses and grain protein content of wheat was also reported by (Roy *et al.,* 2014).

Conclusion

In present study, foliar application of 20 ppm GA_3 was found best to facilitate better translocation of Zn and its further accumulation in dehusked rice grains while 20 ppm cytokinin was reported most effective in increasing grain protein content. Many studies revealed that applied Zn accumulated at nodes of plant shoot and husk part of the rice grains. Therefore, results of present study can be useful to increase translocation and to enhance concentration of Zn and proteins in rice grains by the application of plant growth regulators.

Appendix 1 : Detail of treatments tested in study.

Treatments	Zinc	PGRs
T1	Control (0 Zn)	Control (0 PGRs)
T2	Control (0 Zn)	Foliar spray of GA (20 ppm)
T3	Control (0 Zn)	Foliar spray of cytokinin (20ppm)
T4	Soil application of Zn (5 mg/kg soil)	Control (0 PGRs)
T5	Soil application of Zn (5 mg/kg soil)	Foliar spray of GA (20 ppm)
T6	Soil application of Zn (5 mg/kg soil)	Foliar spray of cytokinin (20ppm)
T7	Foliar application of Zn (0.5% $ZnSO_4$)	Control (0 PGRs)
T8	Foliar application of Zn (0.5% $ZnSO_4$)	Foliar spray of GA (20 ppm)
T9	Foliar application of Zn (0.5% $ZnSO_4$)	Foliar spray of cytokinin (20ppm)

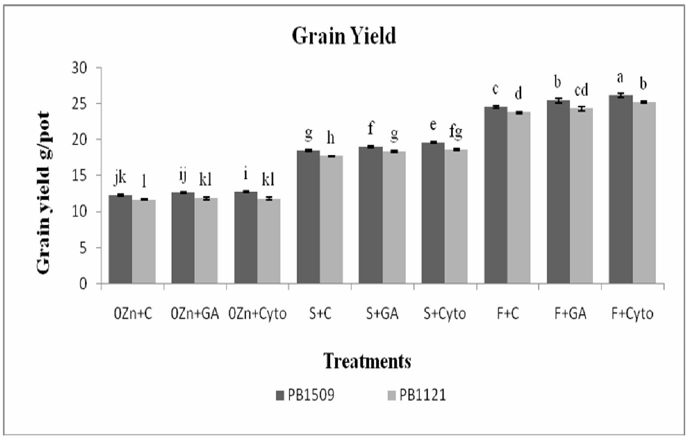

Fig. 1 : Effect of zinc application methods and plant growth regulators on grain yield of two rice genotypes.

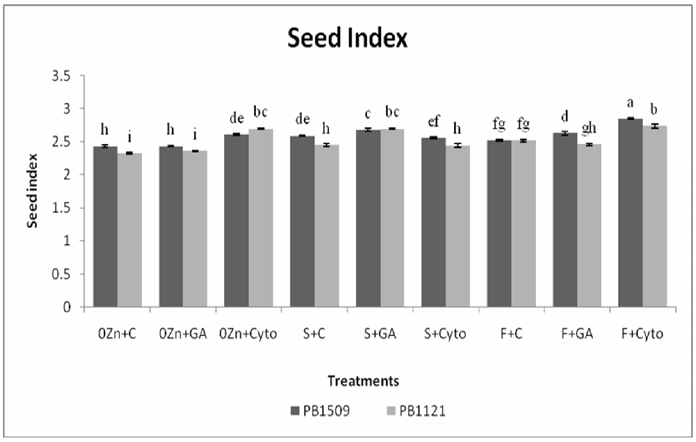

Fig. 3 : Effect of zinc application methods and plant growth regulators on seed index of two rice genotypes.

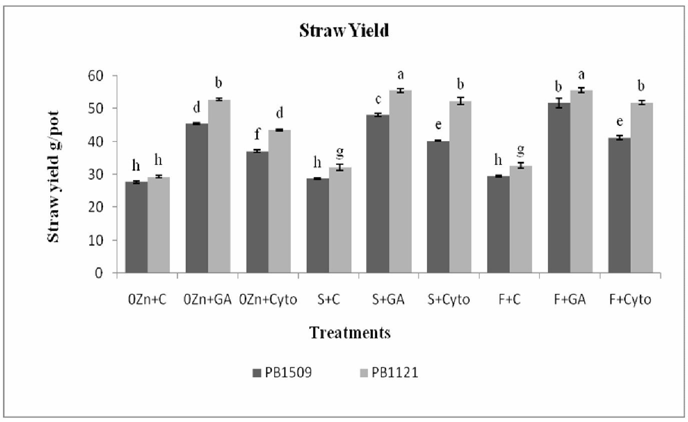

Fig. 2 : Effect of zinc application methods and plant growth regulators on straw yield of two rice genotypes.

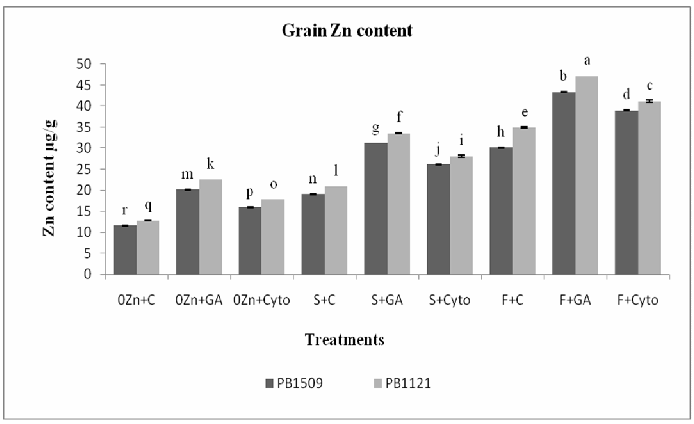

Fig. 4 : Effect of zinc application methods and plant growth regulators on zinc content in grains of two rice genotypes.

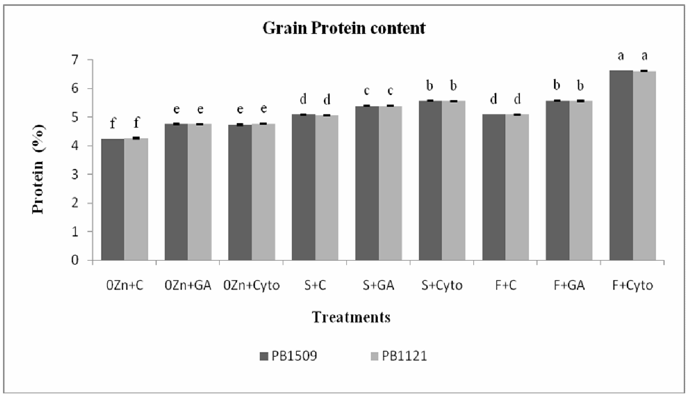

Fig. 5 : Effect of zinc application methods and plant growth regulators on protein content in grains of two rice genotypes.

Acknowledgement

All the facilities and financial support provided by University is duly acknowledged. We are also thankful for support and AAS facility provided by CCS Haryana Agriculture University, Haryana, India.

References

Akman, Z. (2009). Effect of plant growth regulators on nutrient content of young wheat and barley plants under saline conditions. J. Anim. Vet. Adv., 8(10): 2018-2021.

Begum, M.; Noor, M.; Miah, H. and Basher, M.M. (2003). Effect of rate and method of zinc application on growth and yield of Aus rice. Pak. J. Bio. Sci., 6(7): 688-692.

Dobermann, A. and Fairhurst, T. (2000). Rice: nutrient disorders and nutrient management. ISBN: 981-04-2742-5.

Gao, X.; Hoffland, E.; Stomph, T.J.; Grant, C.A.; Zou, C. and Zhang, F. (2012). Improving zinc bioavailability in transition from flooded to aerobic rice. A review: Agron. Sustain. Dev., 32: 465-478.

Hafeez, B.; Khanif, Y.M. and Saleem, M. (2013). Role of zinc in plant nutrition- A Review Amer. J. Exp. Agri., 3(2): 374-391.

Kaur, R.; Singh, K.; Deol, J.S.; Dass, A. and Choudhary, A.K. (2015). Possibilities of improving performance of direct seeded rice using plant growth regulators: A Review. Proc. Natl. Acad. Sci., India, Sect. B Biol Sci DOI 10.1007/s40011-015-0551-8.

Khan, S.U.; Gurmani, A.R.; Qayyum, A.; Abbasi, K.S.; Liaqua, M. and Ahmad, Z. (2016). Exogenously applied gibberellic acid, indole acetic acid and kinetin as potential regulators of source-sink relationship, physiological and yield attributes in rice (*Oryza sativa* L.) genotypes under water deficit conditions. Int J Agri Bio., 18: 139-145.

Mathpal, B.; Srivastava, P.C.; Shankhdhar, D. and Shankhdhar, S.C. (2015b). Improving key enzyme activities and quality of rice under various methods of zinc application. Physiol. Mol. Biol. Plants, 21(4): 567-572.

Mathpal, B.; Srivastava, P.C.; Shankhdhar, D. and Shankhdhar, S.C. (2015a). Zinc enrichment in wheat genotypes under various methods of zinc application. Plant Soil Environ 61(4): 171-175.

Mathpal, B.; Srivastava, P.C.; Shukla, A.K.; Shankhdhar, D. and Shankhdhar, S.C. (2014). Enrichment of ^{65}Zn in two contrasting rice genotypes under varying methods of zinc application. Plant Soil Environ, 60(3): 111-116.

Neue, H.U.; Quijano, C.; Senadhira, D. and Setter, T. (1998). Strategies for dealing with micronutrient disorders and salinity in lowland rice systems. Field Crops Res., 56: 139-155.

Rehman, H.; Aziz, T.; Farooq, M.; Wakeel, A. and Rengel, Z. (2012). Zinc nutrition in rice production systems: A review. J. Plant Soil, 361: 203-226.

Roy, P.D.; Narwal, R.P.; Malik, R.S.; Saha, B.N. and Kumar, S. (2014). Impact of zinc application methods on green gram (*Vigna radiata* L.) productivity and grain zinc fertilization. J. Environ. Biol., 35: 851-854.

Roy, S.; Duttay, S.; Khanna, K.; Singla, S. and Sundar, D. (2012). Prediction of DNA-binding specificity in zinc finger proteins. J. Bio. Sci., 37(3): 483-491.

Singh, M.V. (2008). Micronutrients deficiencies in crops and soils in India. Springer Science+Business Media 93-125.

Swamy, B.P.M.; Rahman, M.A.; Inabangan-Asilo, M.A.; Amparado, A.; Manito, C.; Chadha-Mohanty, P.; Reinke, R. and Slamet-Loedin, I.H. (2016). Advances in breeding for high grain zinc in rice. Rice 9(49): 1-16.

Welch, R.M. (2002). The impact of mineral nutrients in food crops on global human health. J. Plant Soil 247: 83-90.