



## Enhancing Wheat Productivity, Profitability, Nutrient Use Efficiency, and Carbon yield through Foliar Application of Zinc Sulphate in Western India

Babloo Sharma<sup>1,2</sup>, Bhupender Singh<sup>2,3</sup>, Reena Kumari<sup>4</sup>, Pratibha Kumari<sup>5,\*</sup>, Shaukat Ali<sup>2,6</sup>, Seema Chawla<sup>2</sup>

<sup>1</sup>Krishi Vigyan Kendra Jaisalmer-1, Swami Keshwanand Rajasthan Agricultural University, Jaisalmer-345001, (Rajasthan), India

<sup>2</sup>Krishi Vigyan Kendra Sri Ganganagar, Swami Keshwanand Rajasthan Agricultural University, Padampur, Sri Ganganagar-335041, (Rajasthan), India

<sup>3</sup>AICRP on salt affected soil & use of saline water in agriculture, Agriculture Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner-334006, India

<sup>4</sup>Department of agricultural engineering, N.M. College of Agriculture, Navsari Agricultural University, Navsari 396450, Gujarat, India.

<sup>5</sup>Krishi Vigyan Kendra (Bihar Agricultural University), Araria 854312 Bihar, India

<sup>6</sup>Krishi Vigyan Kendra Churu-II, Swami Keshwanand Rajasthan Agricultural University, Chandgothi, Churu – 331305 (Rajasthan), India

### ARTICLE INFO

**Keyword:** Carbon yield, Efficiencies, Zinc application, Wheat

### ABSTRACT

This study was carried at farmer's fields to evaluate the recommended technology enhanced the yield, return, input use and carbon yield of wheat during winter season of season 2022-23 in the Sri Ganganagar district of Rajasthan. In this region, wheat growers were mainly applied nitrogen and phosphorous based fertilizer, while the Zinc (Zn) deficiency was also reported in soil. So, we demonstrated 100% recommended dose of fertilizer (RDF) i.e. 120 N: 40 P kg/ha+ foliar application of Zn sulphate @ 6.0 kg/ha at 40 DAS at randomly selected farmer's field and compared with farmers practices field under wheat crop. The average of examined data revealed that the wheat yield was enhanced under demonstrated fields as compared to farmers' practices. Similarly, net realization was also recorded higher under demonstrated fields. The efficiency of applied fertilizer use, production and economics were also recorded superior with 100% recommended dose of fertilizer (RDF) i.e. 120 N: 40 P kg/ha+ foliar application of Zn sulphate @ 6.0 kg/ha at 40 DAS than farmer practices. The grain and straw yield were improved with application of balance fertilizer treated field as compared to farmer practice. This study concluded that the application of balance fertilizer not only improved the productivity but also enhanced the efficacy of critical input by the wheat crop.

### INTRODUCTION

Wheat is the staple food in many countries of the world and provides the necessary calories and proteins. It's micronutrient content is extremely low (e.g., Zn about 20–40 mg/kg). Therefore, the use of only staple food in daily diet is a major cause of widespread micronutrient deficiency in

under-develop countries. Wheat occupies a central position for the provision of micronutrients and 70% daily calories in world countries. Among micronutrients, deficiency of Zn is most common and widespread in wheat-growing regions. Worldwide, about 50% of cultivated soils are found deficient in bioavailable Zn (Cakmak, 2011). The problem of Zn deficiency is associated with poor availability and higher Zn

Corresponding author;

E-mail: pratibha.sona@gmail.com (Pratibha Kumari)

[Copyright @ Journal of Extension Systems \(acspublisher.com/journals/index.php/jes\)](http://www.acspublisher.com/journals/index.php/jes)

adsorption on soil particles owing to the higher pH of soils (Hussain *et al.*, 2011).

Although micronutrients are required in small amounts, they play crucial roles in plant production at critical growth stages (Janmohammadi *et al.*, 2016). Zn has been found useful in improving yield and yield components of wheat (Ma *et al.*, 2017) and adequately applied Zn has been shown to improve the resource use efficiency of wheat plants. Low availability of Zn in alkaline soils is one of the largest edaphic factor affecting wheat production throughout the globe, particularly in Australia, China, India, Pakistan, Turkey and Iran. It has been reported that more than two billion people in developing countries suffer from Zn deficiency (Grote *et al.*, 2021). Among cereals, wheat are more susceptible to Zn deficiency, and a decrease in seed yield up to 80% along with a reduction in seed Zn content has been observed under Zn deficiency conditions. Pre-sowing soil application of Zn sulfate is the most common approach to correct Zn deficiency in wheat (Cakmak, 2008) and rice (Singh and Singh Shivay, 2015). In salt affected soils, Zn availability is usually very low and Zn deficiency widespread. Foliar Zn application under such conditions could be more effective than any other forms of Zn applications. Foliar fertilization has the advantages of low application rates, uniform distribution, and quick plant responses to enrich essential micronutrients in crop grains (Zhao *et al.*, 2014). Accordingly, fertilizer management with macro and micronutrients in plant nutrition is very imperative for crop productivity and plants' resistance (Janmohammadi *et al.*, 2016).

Previous studies was conducted under controlled condition and examined the foliar application of Zn increased the grain yield traits of wheat play an important role in biofortification (Ramzan *et al.*, 2020). While, very less scientific evidence were observed at farmer's fields or uncontrolled condition. Therefore, the recent study was carried out with the hypothesis that foliar Zn application would enhance the productivity and net realization of wheat. We also aimed to evaluate the efficacy of applied input and carbon yield of wheat through foliar application of Zn sulphate alongwith recommended fertilization.

## MATERIALS AND METHODS

The frontline demonstration conducted at farmers' fields with wheat crop during winter season 2022-23 in the Sri Ganganagar district of Rajasthan. The climate is arid subtropical with large variation of temperature where maximum temperature recorded up to 50 °C during summer season (may, June and July) and lowest temperature sometime observed as low as 0°C or even less during winter season (December-January). The average annual rainfall is

261mm with a coefficient of variation of 50%. The soil was loamy-sand, alkaline in reaction (pH >8.2) having low level of available nitrogen and phosphorus, medium in available potassium, low level of sulphur and Zn content. Twenty five farmers' fields were randomly selected for the demonstration. The demonstration were consisted 100% recommended dose of fertilizer (RDF) i.e. 120 N:40 P kg/ha+ foliar application of Zn sulphate @ 6.0 kg/ha at 40 DAS. Farmers were also advised to use 100% RDF as a farmers' practice. The size of selected fields for experiment was one acre (4000 m<sup>2</sup>) at each farmer's fields. Wheat was sown at end of October to mid of November with recommended seed rate i.e. 100 kg/ha. Row spacing was maintained at 22.5 cm wide. Application of Recommended dose of fertilizer was 100:40 kg/ha, out of 50% dose of N and 100 % P were applied as basal dose at the time of sowing. Rest N were applied at first irrigation. Other cultivation processes were kept similar for all the treatments. Yield of wheat was recorded after harvesting and converted in hectare basis.

Applied quantities of N, P and K through different fertilizers were calculated (Kumari *et al.*, 2021). Then, the yield was divided by total applied quantity of each nutrient (N, P and K) to estimate the partial factor productivity (Sharma *et al.*, 2023).

A simple economic analysis took into the cost of inputs and return from selling of yield, which was computed using the minimum support price of produce fixed by government of India (GOI, 2023). The net income (INR./ha) and net realization were calculated by using the following formula given in eq. 1& 2, respectively.

$$\text{Net returns} = \text{Gross returns (INR./ha)} - \text{cost } \delta \text{ cultivation (INR./ha)} \dots 1$$

$$\text{B : C ratio} = \frac{\text{Gross returns (INR./ha)}}{\text{Cost } \delta \text{ cultivation (INR./ha)}} \dots 2$$

Production efficiency of different treatments was calculated as a ratio of crop grain yield and crop duration (Days) (Saini *et al.*, 2019). The crop duration of 124 days was considered for estimating the production efficiency of wheat. Economic efficiency was determined by dividing net return (Rs/ha) from crop, under different fertilizer treatments by crop duration (days) (Saini *et al.*, 2019). The crop duration was kept same as for the estimation of production efficiency. The concentration of carbon in wheat grain and straw were assumed to be 400 and 352 g/kg (Singh *et al.*, 2021). The carbon yield in grain and straw were estimated by grain or straw yield multiply by carbon concentration. The total carbon yield was estimated by the sum of grain and straw

carbon yield.

The observed data of the investigation were statistically analyzed by SPSS 20.0 version (SPSS Inc., Chicago, IL). Statistical analysis and interpretation of observed data were evaluated by using ANOVA technique of RBD and critical difference (CD) at 5% level of significance.

## RESULTS AND DISCUSSIONS

The data revealed that the wheat yield was significantly affected through foliar application of Zn sulphate with 100% RDF as compared to the farmer practice. The grain yield was reported 9.41% higher with 100% RDF+Zn sulphate at farmers' field over than farmer practice. Similarly straw yield under 100% RDF+Zn sulphate treated field was improved 740.79 Kg/ha as compared to farmer practice (Table 1). The biological yield was also enhanced with application of 100% RDF+Zn sulphate in treated field than farmer practice. Anwer *et al.* (2021) found significantly enhanced plant growth with Zn application. Arough *et al.* (2016) reported that Zn increases chlorophyll content, enhances photosynthetic activity, and improves overall plant growth. Bhat *et al.* (2017) suggested that increased carbonic anhydrase activity due to Zn application contributes to higher photosynthesis, biomass, and yield. Additionally, Zn sulfate application (both foliar and soil) was found to increase leaf number, leaf area, and Chlorophyll Content Index in wheat, as noted by Qamari *et al.* (2022).

**Table 1:** Yield of wheat influenced through foliar application of Zn sulphate.

Treatment	Yield (kg/ha)		
	Grain	Straw	Biological
100% RDF+Zn sulphate	4765.88	6174.12	10940.00
100% RDF	4356.00	5433.32	9789.32
SEm(±)	18.80	50.52	62.55
C.D. (p=0.05)	53.42	143.56	177.76

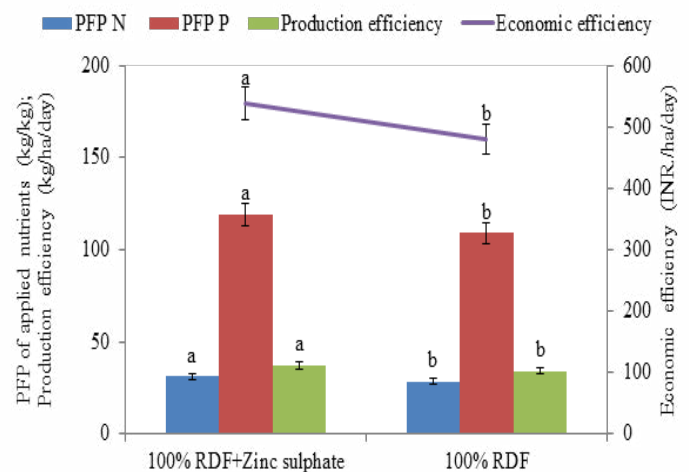
Economics of the study revealed that the cultivation cost was recorded higher in 100% RDF+ Zn sulphate treated field because of Zn sulphate was applied as foliar application with the 100% RDF. Gross and net returns were recorded INR. 98367 and 68796/ha under 100% RDF+ Zn sulphate treated field which was significantly higher than farmer practice (Table 2). Similar trend of net realization was also observed, the net realization obtained 2.34 under 100% RDF+ Zn sulphate treated field which was significantly higher than farmer practice (2.18). The economic feasibility of a technology or recommendation is the key determinant of its adoption by farmers.

**Table 2:** Profitability of wheat crop influenced through application of Zn sulphate

Treatment	Cultivation cost (INR./ha)*	Return (INR./ha)		Net realization
		Gross	Net	
100% RDF+Zn sulphate	29571	98367	68796	2.34
100% RDF	28321	89726	61405	2.18
SEm(±)	-	450.09	450.09	0.02
C.D. (p=0.05)	-	1279.14	1279.14	0.04

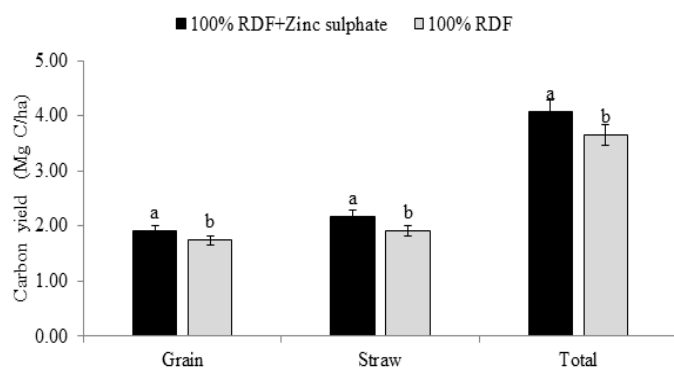
\*INR./ha= Indian Rupees per hectare.

The nutrient use efficiency of applied nutrients was statistically improved through foliar application of Zn sulphate in wheat crop. The PFP of N and P were improved and recoded 2.68 and 10.25 kg/kg, respectively, in 100% RDF+ Zn sulphate treated field as compared to farmer's practice (Figure 1). The findings of this study align with previous research, which has reported higher nutrient use efficiency indices in rice and barley with lower nutrient doses when fortified with Zn fertilizers (Reshma and Meena, 2021). The production efficiency was recorded lower under farmer's practice and significantly improved with application of Zn sulphate with 100% RDF (37.23 kg/ha/day). Dass *et al.* (2022) reported a significant improvement in the production efficiency of soybean with foliar Zn application. On average, Zn-treated crops exhibited a 30% higher production efficiency compared to the control. The economic efficiency was also shown similar pattern and obtained 537.47 INR./ha/day under 100% RDF+ Zn sulphate applied farmers' field which was significantly superior 57.74 INR./ha/day than farmer practice (Figure 1). The increased economic efficiency in Zn-treated plots is attributed to higher grain yield and greater gross returns (Dass *et al.*, 2022).



**Figure 1:** Changes in fertilizer use, production and economic efficiency of wheat crop through application of Zn sulphate (significance at  $p=0.05$ )

Application of Zn sulphate with 100 % RDF was significantly improved the above ground biomass carbon yield (Figure 2). The carbon yield of grain and straw were obtained 1.91 and 2.17 Mg C/ha, respectively under 100% RDF+Zn sulphate treated field which were 9.77 and 13.61% higher than farmer's practice (Table 4). Total carbon yield of above ground biomass was obtained 4.08 and 3.65 under 100% RDF+Zn sulphate and 100% RDF treated field, respectively. The higher carbon yield of wheat under 100% RDF+Zn sulphate treated field compared with 100% RDF treated field indicates that balance fertilizer application had the highest potential to fix carbon per unit of the amount of carbon loss as GHG emission.



**Figure 2:** Effect of Zn sulphate on above ground biomass carbon yield in wheat (significance at  $p=0.05$ )

## CONCLUSION

The wheat is the major winter crop in irrigated region of Rajasthan but the productivity is low due to imbalance use of fertilizer which is the one major factor. The Sri Ganganagar soil belongs to low level fertility. So, the application of 100% RDF alongwith foliar application of Zn sulphate @ 6.0 kg/ha at 40 DAS was demonstrated at farmers' fields and recorded higher productivity and return per unit cost as compared to farmer practice. This demonstration was also shown that the application of 100% RDF alongwith foliar application of Zn sulphate @ 6.0 kg/ha at 40 DAS enhanced the use efficiency of applied fertilizer by the selected wheat growers. So, our study recommended the application of 100% RDF alongwith foliar application of Zn sulphate @ 6.0 kg/ha at 40 DAS which help to improve the productivity of crop.

## ACKNOWLEDGEMENT

The authors thankful to ICAR-Agricultural Technology Application Research Institute, Zone-II, Jodhpur, Rajasthan for financial support and the valuable assistance of the scientific and technical staff at Krishi Vigyan Kendra Sri Ganganagar, which ensured the smooth execution of this research.

## References

- Anwar, S., Khalilzadeh, R., Khan, S., Nisa, Z., Bashir, R., Pirzad, A. & Malik, A. (2021). Mitigation of Drought Stress and Yield Improvement in Wheat by Zinc Foliar Spray Relates to Enhanced Water Use Efficiency and Zinc Contents. *International Journal of Plant Production*, 15, 377–389. <https://doi.org/10.1007/s42106-021-00136-6>
- Arough, Y. K., Sharifi, R. S., Sedghi, M., & Barmaki, M. (2016). Effect of zinc and bio fertilizers on antioxidant enzymes activity, chlorophyll content, soluble sugars and proline in triticale under salinity condition. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 44(1), 116–124.
- Bhat, F. A., Ganai, B. A., & Uqab, B. (2017). Carbonic anhydrase: Mechanism, structure and importance in higher plants. *Asian Journal of Plant Science Research*, 7(3), 17–23.
- Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? *Plant and Soil*, 302, 1–17. <https://doi.org/10.1007/s11104-007-9466-3>
- Cakmak, I. (2011). Zinc Plays Critical Role in Plant Growth. Available online: [http://www.zinc.org/crops/resourceserve/zinc/plays\\_critical\\_role\\_in\\_plant\\_growth](http://www.zinc.org/crops/resourceserve/zinc/plays_critical_role_in_plant_growth) (accessed on 17 April 2011).
- Dass, A., Rajanna, G. A., Babu, S., Lal, S. K., Choudhary, A. K., Singh, R., Rathore, S. S., Kaur, R., Dhar, S., Singh, T., Raj, R., Shekhawat, K., Singh, C., & Kumar, B. (2022). Foliar Application of Macro- and Micronutrients Improves the Productivity, Economic Returns, and Resource-Use Efficiency of Soybean in a Semiarid Climate. *Sustainability*, 14(10), 5825. <https://doi.org/10.3390/su14105825>
- GOI (2023). Report on minimum support prices 2023. Directorate of Economics and statistics, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India (GOI). <https://desagri.gov.in/wp-content/uploads/2023/10/English.pdf>
- Grote, U., Fasse, A., Nguyen, T. T. & Erenstein, O. (2021). Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Frontiers in Sustainable Food Systems*, 4, 617009. <https://doi.org/10.3389/fsufs.2020.617009>
- Hussain, S., Maqsood, M. A. & Rahmatullah. (2011) Zinc release characteristics from calcareous soils using di-ethylene-tri-aminepentaacetic acid and other organic acids. *Communications in Soil Science and Plant Analysis*, 42, 1870–1881
- Janmohammadi, M., Amanzadeh, T., Sabaghnia, N., & Dashti, S. (2016). Impact of foliar application of nano micronutrient fertilizers and titanium dioxide nanoparticles on the growth and yield components of barley under supplemental irrigation. *Acta Agriculturae Slovenica*, 107, 265–276. <https://doi.org/10.14720/aas.2016.107.2.01>
- Kumari, P., Sharma, P. K., Kumari, R. & Singh, U. P. (2021). Effect of tillage and crop establishment practices on performance

- of rice (*Oryza sativa*) under rice-wheat cropping system. *Annals of Plant and Soil Research*, 23(2): 170-174. <https://doi.org/10.47815/apsr.2021.10051>.
- Ma, D., Sun, D., Wang, C., Ding, H., Qin, H., Hou, J., Huang, X., Xie, Y., & Guo, T. (2017). Physiological responses and yield of wheat plants in zinc-mediated alleviation of drought stress. *Frontiers in Plant Science*, 8, 1–12. <https://doi.org/10.3389/fpls.2017.00860>
- Ramzan, Y., Hafeez, M. B., Khan, S., Nadeem, M., Batool, S., & Ahmad, J. (2020). Biofortification with zinc and iron improves the grain quality and yield of wheat crop. *International Journal of Plant Production*, 14, 501-510. <https://doi.org/10.1007/s42106-020-00100-w>
- Reshma, Z. & Meena, K. (2021). Foliar application of biosynthesised zinc nanoparticles as a strategy for ferti-fortification by improving yield, zinc content and zinc use efficiency in amaranth. *Heliyon* 8 (10) e10912. <https://doi.org/10.1016/j.heliyon.2022.e10912>
- Saini, S. P., Singh, P. & Brar, B. S. (2019). Nutrient management improves productivity and economic returns by increasing nutrient use efficiency in floodplain soils under maize-wheat cropping system. *Indian Journal of Agricultural Sciences* 89(10):1589–1593
- Sharma, B., Vyas, K. G., Sharma, S. K., Kumari, R., Meena, C. P., Singh, B. & Sharma, P. (2023). Performance of Indian mustard as influenced by plant growth regulator brassinosteroid under the Western Arid Region of Rajasthan. *Journal of Oilseed Brassica*, 14(2): 154-158.
- Singh, A., & Singh Shivay, Y. (2015). Zinc application and green manuring enhances growth and yield in basmati rice (*Oryza sativa* L.). *Indian Journal of Plant Physiology*, 20(3), 1–8. doi:10.1007/s40502-015-0167-2.
- Singh, P., Benbi, D.K. & Verma, G. (2021) Nutrient Management Impacts on Nutrient Use Efficiency and Energy, Carbon, and Net Ecosystem Economic Budget of a Rice–Wheat Cropping System in Northwestern India. *Journal of Soil Science and Plant Nutrition*, 21, 559–577 (2021). <https://doi.org/10.1007/s42729-020-00383-y>
- Zhao, A., Tian, X., Cao, Y., Lu, X., & Liu, T. (2014). Comparison of soil and foliar zinc application for enhancing grain zinc content of wheat when grown on potentially zinc-deficient calcareous soils. *Journal of the Science of Food and Agriculture*, 94, 2016–2022.
- Qamari, P., Shekari, F., Afsahi, K., Tavakoli, A., Samimifard, R., Shekari, K. & Mastinu, A. (2023). Response of wheat cultivars to zinc application for seed yield and quality improvement. *The Journal of Agricultural Science* 161, 549–562. <https://doi.org/10.1017/S0021859623000473>